

Creativity, innovation and entrepreneurship: The learning science towards higher order abilities

Edited by

Zehui Zhan, Patrick S. W. Fong, Harrison Hao Yang,
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Creativity, innovation and entrepreneurship: The learning science towards higher order abilities

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Editorial: Creativity, innovation, and entrepreneurship: The learning science toward higher order abilities

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Editorial on the Research Topic

Creativity, innovation, and entrepreneurship: The learning science toward higher order abilities

Creativity, innovation, and entrepreneurship are emphasized as the major power in driving the development of our fast-changing world. Especially in the era of Industry 4.0, where intelligent manufacturing plays an important role, creative and entrepreneurial talents have gained more attention than ever before. Cultivating and educating those talents has become a key issue that needs to be solved. However, creativity, innovation, and entrepreneurship, as higher-order abilities of talents, are not achieved overnight, because they may be affected by a variety of complex factors, including innate and acquired. Available knowledge about the teaching and learning of students' higher order abilities is still insufficient and the challenges of linking theories and practices claim more research efforts into mature pedagogies, effective teaching aids, and accurate evaluation tools. Hence, the present Research Topic on "Creativity, innovation, and entrepreneurship: The learning science toward higher order abilities" contributes with updates and different perspectives on innovation-oriented education, representing the effort of 29 academic papers from 91 authors in total. The following section will elaborate contributions of these papers to the Research Topic.

Creativity and innovation

Creativity is regarded as the fountainhead of human civilizations, different strategies, and technologies were introduced to facilitate it.

Game playing is seen as a potential way to engender greater fun and thus more creativity may be facilitated. Mun conducted two experiments on university students

to explore the effect of game playing and goal orientation on creativity. Results showed that the cognitive game that engendered the greatest degree of fun led to more creative outcomes. In Experiment 1, the cognitive game that engendered greater degree of fun resulted in more creative outcomes on a subsequent new product development task, compared with the control group and the cognitive game that did not engender as much fun. Results of Experiment 2 showed the effects of goal orientations on creative outcomes (i.e., focus on the process of playing the game vs. focus on the outcome of winning) in terms of novelty, usefulness, and overall creativity. It confirmed that individuals who participated in the process of goal-oriented cognitive game that engendered a high degree of fun were more creative on the subsequent toy design task than those who were given an outcome goal orientation.

Zhan et al. explored the effectiveness of product-based pedagogy (PBP) on high school students' creativity and innovative thinking in an artificial intelligence course. After employing a seven-step teaching model (i.e., phenomenon, problem, plan, prototype, product, presentation, price) in accordance with PBP, in which the key function of the product as a linkage between creativity and innovation was emphasized, positive results were found in the treatment group students' project management skills, creativity, and innovative thinking. In future, more AI curriculum are expected to be developed for students to participate easily in the process of product creation, and learn more effectively to develop creativity and innovative thinking.

To cultivate senior high school students' creativity, Wang et al. conducted a study about maker teaching activity design in general technology course. By three rounds of action research, a teaching model was proposed to improve students' creativity effectively, which synthesized the Four Periods of Creative Process (i.e., preparation, gestation, enlightenment and verification) and the Five Stages of Creative Problem Solving (i.e., discovering facts, discovering problems, seeking ideas, seeking solutions and seeking acceptance). Finally, according to the comparative experimental study, it was found that the teaching model could improve students' creativity significantly and effectively. Significant positive improvement was also found on students' adventurous, curiosity, imagination and challenge.

Yan et al. addressed that it was a worthy topic on developing sustainable interventions to promote students' self-efficacy in creativity without generating excessive workload for teachers. In their study, the self-assessment mind maps were employed as instructional intervention, and their effects on students' self-efficacy in creativity, self-efficacy in learning English, and academic performance in English language tests were examined. Empirical study was conducted in a Hong Kong primary school. Results showed that, after the intervention, while students' self-efficacy and test performance in English learning were not improved, there was significant positive effect on self-efficacy in creativity.

Fan and Ye focused on the application of inquiry-based teaching and learning in project design courses at university level in Taiwan. Quasi-experimental design method was adopted to examine the effect of two inquiry models. Results of five questionnaire surveys during the design project process showed positive effect on students' curriculum interest, curriculum value perception, and curriculum confidence.

Zhang et al. conducted a review on problem-based learning (PBL) research conducted over the past 40 years (from 1981 to 2021). They analyzed a total of 2,790 articles and reviews, and concluded that current research hotspots focus on the extensions of PBL teaching mode, application of PBL teaching method, and reform of PBL. Major contributors, key researchers and publishers were also listed. Overall, research on PBL has continued to increase over the past few decades. The authors highlighted that setting the right questions are the core of PBL, setting up the curriculum, and designing the questions according to the learning objectives are the key issues in PBL.

According to Chen et al., while students' creative behaviors were not significantly improved, the argument map (AM)-supported online group debate activities were helpful for college students' critical thinking, including their depth and phases of critical thinking. They also emphasized on teachers' real-time feedback for students' improvements of high-level thinking skills and progress of the activity.

Referring to the theory of planned behavior, Tzeng et al. adopted self-evaluation as an intermediate variable to predict college students' adoption of technology for self-directed learning. In total of 285 college students participated in their survey, and the authors found that self-evaluation enhanced the influence of intentions on behavior and improved the accuracy of predictions of college students' adoption of technology for self-directed learning. They highlight the importance of students' attitudes and perceived behavioral control on intention.

Based on self-determination theory, Han et al. proposed that psychological safety positively affects students' creativity through psychological empowerment, and fault-tolerant culture also played a positive role in it. They conducted questionnaire survey on 238 students in China, and confirmed a positive correlation between psychological safety and creativity. The mediating role of psychological empowerment in the relationship between them was also revealed. Moreover, results showed that a fault-tolerant culture played a moderating role between psychological safety and psychological empowerment. Specifically, the fault-tolerant culture enhanced the direct influence of psychological safety on psychological empowerment and the indirect influence of psychological safety on creativity.

Creative role identity is also seen as an important antecedent for the encouragement of individuals to produce innovative behaviors. Deng et al. analyzed the psychological mechanism (flow as a mediator) of the influence of innovation climate on individual creative role identity of university students. Results

of the questionnaire survey data collected from 226 students confirmed that an innovation climate has a significant positive impact on the identity of individual creative roles, and flow mediated the relationship between innovation climate and creative role identity.

Cui et al. formed a research framework to explore the correlations among hands-on making attitude, Interest type Epistemic Curiosity (IEC) and Deprived type Epistemic Curiosity (DEC), and career interest. They collected data from 220 participants in the 2021 Taiwan International Exhibition of Young Inventors (IEYI), in which young students were encouraged to make innovative projects by applying STEM (science, technology, engineering, and mathematics) knowledge and collaborative design. Results showed positive correlations between hands-on making attitude and the two types of epistemic curiosity. There were also positive correlations between STEM career interest and the two types of epistemic curiosity, and DEC had a higher coefficient on STEM career interest than IEC. In addition, both types of epistemic curiosity had a mediating role between hands-on making attitude and STEM career interest.

Jónsdóttir and Macdonald introduced a model that could help teachers to identify and analyze their teaching and learning process to support students' creativity at any school level and in any subject. The model was found based on the sociologist, Basil Bernstein's concepts, and drew on sociological concepts such as "framing and classification" and "power and control" in school settings.

Combining microcomputer interfaces and network communication technologies as well as virtual instrumentation, Wang designed an internet-based psychophysiological response testing and analysis system for creative learning. Differed from questionnaires and self-assessments, the system could be used to collect information on learners' psychophysiological responses and real-time performance of student participants during creative learning; especially when stress might affect creativity, the system was designed to investigate the relationship between different stress levels and performance on different creative learning tasks.

In addition to individuals' creativity, team creativity was also investigated in this Special Issue. To investigate the impact of leadership behavior to team creativity in startup teams, Antonio et al. proposed two mediator variables: Team Climate and Team Ambidexterity, and conducted an empirical quantitative research with more than 434 participants, aggregated into 145 teams. Samples are early startup teams in several cities in Indonesia, ran and led by young people. The result showed that Team Climate and Team Ambidexterity are good mediators of Servant and Transformational leadership behaviors to Team Creativity in startup teams. Kim and Kim discussed the public innovation capacity in Korea. They topologized public innovation capacity in terms of individuals, middle managers, and organizations' levels through mini-round Delphi

analysis. They validated public innovation capacity through a questionnaire survey of 477 public employees from 30 agencies.

Considering that creativity does not always lead to positive outcomes, Dou et al. conducted a qualitative comparative analysis of negative and malevolent creativity. They concluded that negative creative thinking is a kind of native thinking based on personal interests that are developed to emphasize the benefits of an individual's interests, while malevolent creative thinking is a kind of native thinking based on the value-added of personal interests and is deliberately harmful. Identify the similarities (e.g., share a value orientation, environmental stimulation, and subjective motivation) and differences (e.g., differ in terms of value goals, ways of thinking, and the scale of the subject) in connotations among them, they proposed the Negative-Malevolent Thinking Interconnection Model (NMTIM), a linkage model of negative creative thinking and malevolent creative thinking to better show the bidirectional linkage mechanism.

Entrepreneurship

Exploring the factors influencing entrepreneurial intention is crucial to entrepreneurial practices and education.

Luo et al. studied the mediation effects of social capital and human capital on the relationship between proactive personality and entrepreneurial intentions in college students. After testing a sample of 300 Chinese college students, results showed that college students' proactive personality exerted a significant and positive impact on their entrepreneurial intentions. Social capital and human capital both played a partial mediating role between the proactive personality and entrepreneurial intentions. In addition, the study further discovered the chain mediating role of social capital and human capital between proactive personality and entrepreneurial intention. It was believed that Chinese college students' social capital will significantly influence their human capital. In other words, college students with a higher level of proactive personality will have more social capital and human capital, facilitating their generation of entrepreneurial intentions.

Considering personal values in an entrepreneurial process, Li et al. explored the relationship between materialism and college students' entrepreneurial intention through a serial mediation model. In total of 1,002 Chinese university students participated in the online survey and completed the measurement of entrepreneurial intention, entrepreneurial attitude, materialism, and achievement motivation. The study found that materialism positively predicted college students' entrepreneurial intention, and this relationship was serially mediated through achievement motivation and entrepreneurial attitude.

Mei et al. studied the mediating role of commitment and moderating role of family support on university students'

successive development from entrepreneurial intention to behavior. In total of 469 valid responses were obtained by a survey conducted among university students from six major universities in South China. Results showed both direct and indirect positive effects between entrepreneurial intention and entrepreneurial behavior, while entrepreneurial commitment and family support played mediating and moderating role between them respectively. It was concluded that entrepreneurial commitment bridged the path from entrepreneurial intention to behavior, and family support created the boundary effect.

Wang and Huang analyzed the mediating role of entrepreneurial self-efficacy and prosocial tendency in the relation between college students' post-traumatic growth and entrepreneurial intention in the post-COVID-19 era. They collected data from 690 Chinese undergraduates, and concluded that in the post-COVID-19 era, the post-traumatic growth of college students would have a significant and positive effect on their entrepreneurial intentions. Besides, results indicated the mediation role of students' entrepreneurial self-efficacy and prosocial tendencies between post-traumatic growth and entrepreneurial intentions, and the chain mediating effect between students' entrepreneurial self-efficacy and prosocial tendencies was also established.

Li et al. focused the effect of university entrepreneurship education on independent student entrepreneurship. They discussed the correlation between three factors (i.e., entrepreneurship education, entrepreneurial opportunity identification, entrepreneurial experience) and independent entrepreneurship. The authors collected questionnaire survey data from 1,424 fresh graduates who have received entrepreneurship education in China. Results showed that entrepreneurship theory-based courses could promote independent entrepreneurship, but entrepreneurship practice training surprisingly failed to promote. It reflected that graduates who have received entrepreneurial practice training might be more objective to evaluate the risks and difficulties of entrepreneurship, leading to more cautious considerations in choosing independent entrepreneurship. They also indicated that entrepreneurial opportunity identification mediated only between theory-based courses and independent entrepreneurship.

Li et al. explored the mediating role of creativity on the relationship between personality traits and entrepreneurial intention. In total of 674 valid questionnaires were collected from college students in China. Results showed that neuroticism in personality traits had significant negative impact on entrepreneurial intention and creativity, while conscientiousness, openness, and extraversion had significant positive impact. Creativity had significant positive impact on entrepreneurial intention, it had partial mediating role between neuroticism, conscientiousness, extraversion, and entrepreneurial intention along with complete mediating

role between openness and entrepreneurial intention. Gao and Huang studied the mediation role of entrepreneurial self-efficacy between narcissistic personality and entrepreneurial intention. By conducting questionnaire survey sampled from 252 vocational college students in China, they found that narcissistic personality had a significant positive effect on entrepreneurial intention and entrepreneurial self-efficacy. Entrepreneurial self-efficacy had a significant positive effect on entrepreneurial intention and played a partial mediation role in the relationship between narcissistic personality and entrepreneurial intention.

Shadiev et al. studied students' creativity, innovation, and entrepreneurship in a telecollaborative project. Participants were at different age levels; one group was junior high school students from China ($n = 15$) and another group was university students from Indonesia ($n = 10$). Supported by the 360-degree video technology, students created cultural learning content and communicated with their international partners through a telecollaborative platform. Results showed that participants' creativity, innovation, and entrepreneurship were improved, and positive learning experiences were perceived.

Peng et al. studied the impact of resource bricolage on entrepreneurial orientation in startups. The moderating roles of top management team (TMT) heterogeneity and TMT behavioral integration were tested from the data of 295 startups. Results showed that the entrepreneurial orientation was positively correlated with the strategy of resource bricolage, and the relationship is positively moderated by TMT heterogeneity, while negatively moderated by TMT behavioral integration.

Yu et al. discussed the influence of knowledge management process and intellectual capital on innovation with the mediating effect of entrepreneurial orientation and moderating role of leaders' education levels. Based on the data of 393 IT firms in Pakistan, they discovered that innovation was positively correlated with knowledge management process and intellectual capital, and confirmed that entrepreneurial orientation partially mediated the relationship between knowledge management and intellectual capital on innovation. Moreover, it was confirmed that the moderation effect of leaders' education on intellectual capital and innovation relationship was insignificant.

Considering the gap in knowledge sharing in information system integration service industry, Hong et al. developed a research model to explore the mediating role of four types of knowledge sharing (i.e., automatic response, rational reflection, ridiculed reflection, and stolen reflection) in the relationship between problem solving self-efficacy (PSSE) and IT workers' job performance. Questionnaire results from 307 system integration IT workers showed that PSSE could positively predict four knowledge sharing types. Except for stolen reflection, job performance was positively predicted by the other three knowledge sharing types. It was concluded that supported by PSSE, job performance could be enhanced by

automatic response systems and rational reflection systems in knowledge sharing.

New product development is a creative activity that requires to empathize users' needs. To this end, [Chen et al.](#) explored the impact of scenarios on the performance of entrepreneurial imaginativeness. Results confirmed that familiar scenarios that matched designers' background (including knowledge, expertise, and experience) could inspire entrepreneurial imaginativeness more than unfamiliar scenarios. They suggested that individuals utilize different familiar scenarios to foster their entrepreneurial imaginativeness. For team compositions, they proposed leaders to select members who were familiar with the task scenarios and had high entrepreneurial imaginativeness to ensure that the knowledge, expertise, and experience of the members could benefit the creative tasks.

[Peljko and Antončič](#) focused on entrepreneurial openness and creativity on entrepreneurial level relative to business growth. Structural equation modeling was employed to analyze survey data obtained from 851 entrepreneurs of small and medium-sized enterprises' (SMEs) in three countries. Results indicated that creativity of the entrepreneur was positively correlated with entrepreneurial openness and creative personality, and the growth of the firm was positively correlated with the entrepreneur's creativity. In addition to direct effects, some smaller indirect effects were detected in the model for the indirect effect of entrepreneurial openness and creative personality on growth through the creativity of the entrepreneur. The three cross-national comparative study contributes to comparative international entrepreneurship research.

Based on previous research results, we believe that these researches solve some important research gaps and have important contributions in the field of creativity, innovation, and entrepreneurship. However, some good research suggestions for further studies are also proposed in these researches. It is suggested that we could make more efforts based on these valuable research suggestions. Lastly, we extend

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The Relationship Between Personality Traits and Entrepreneurial Intention Among College Students: The Mediating Role of Creativity

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Significant research has been conducted on the influence of entrepreneurial intention on entrepreneurial education and entrepreneurship practice. Similarly, this study aims to explore how creativity plays a mediating role in the influence of personality traits on entrepreneurial intention. As many as 674 valid questionnaires were collected from college students in China, allowing the relationship between personality traits, creativity, and entrepreneurial intention to be analyzed in detail. The following results are found through a series of explorations. First, neuroticism in personality traits has a significant negative impact on entrepreneurial intention, while conscientiousness, openness, and extraversion have a significant positive impact. Second, neuroticism has a significant negative impact on creativity, while conscientiousness, openness, and extraversion have a significant positive impact. Third, creativity has a significant positive impact on entrepreneurial intention, it has a partial mediating role between neuroticism, conscientiousness, extraversion, and entrepreneurial intention along with a complete mediating role between openness and entrepreneurial intention. The research results further provide a reference value for the improvement and optimization of entrepreneurial practice.

Keywords: entrepreneurial intention, personality traits, creativity, college students, mediation

INTRODUCTION

Entrepreneurship has a significant impact on a country or region's economic, political, and social environment (Montiel and Clark, 2018). Entrepreneurship is a process that goes from idea to practice and from intention to implementation. A significantly positive correlation exists between entrepreneurial intention and entrepreneurial behavior (Kong et al., 2020). College students are often considered to be the potential targets of entrepreneurship. It is consequently necessary to improve their entrepreneurial intention (Veciana et al., 2005). The term entrepreneurial intention refers to the belief that an individual plans to start a new company in the future (Thompson, 2009), which exerts a significant predictive effect on entrepreneurial behavior (Boubker et al., 2021; Elnadi and Gheith, 2021).

Among the factors that influence entrepreneurial intention, personality traits are a significant one (Şahin et al., 2019; Ndovela and Chinyamurindi, 2021). Personality traits refer to the unchanging and stable psychological traits that individuals possess (Costa and McCrae, 1992). According to the existing research, the Big-Five Personality is one of the most comprehensive personality classifications available (Singh and DeNoble, 2003). Relevant empirical research has also found that personality traits have a significant impact on entrepreneurial intention (Şahin et al., 2019; Wu and Wu, 2020; Awwad and Al-Aseer, 2021; Khan et al., 2021). Research on the influence of personality traits on entrepreneurial intention has a great impact on improving university students' entrepreneurial intention.

Previous studies on entrepreneurial intentions have reported a mediating role of creativity (Imran et al., 2018; Danish et al., 2019; Chaubey et al., 2021). Murad et al. (2021) found that creativity significantly and positively impacts entrepreneurial intentions. Hu et al. (2018) found that entrepreneurial alertness exerts a mediating effect on the relationship among creativity, proactive personality, and entrepreneurial intention. Hamidi et al. (2008) suggested that creativity should be included as a predictor variable in empirical research on entrepreneurial intentions. Different personality traits may have different effects on creativity. For example, neuroticism has a significant negative impact on creativity. Influential people with high openness are more creative but exhibit less agreeableness (Karwowski and Lebeda, 2016). Moreover, conscientiousness, extroversion, and agreeableness positively and significantly impact creativity (Mumford, 2011). Openness has a positive and significant impact on creativity (Grohman et al., 2017; Jirásek and Sudžina, 2020; Theurer et al., 2020). Creative people can maintain a positive attitude and a high degree of self-confidence when starting a business (Zhao et al., 2005). Some empirical studies have shown that creativity positively and significantly impacts entrepreneurial intentions (Shi et al., 2020; Murad et al., 2021; Tantawy et al., 2021). Personality traits may influence entrepreneurial intentions through creativity. Considering research gaps and practical needs, this research intends to explore the influence of personality traits on entrepreneurial intentions and the mediating role of creativity between personality traits and entrepreneurial preferences.

In summary, the present study has two objectives. First, considering that most of the previous research samples were from Western countries (Şahin et al., 2019; Awwad and Al-Aseer, 2021; Khan et al., 2021) and the vast differences between Chinese and Western cultures, the current study utilizes Chinese samples for verification. Second, this research explores the influence path of personality traits on entrepreneurial intentions from the perspective of mediation. Therefore, this research uses personality traits as the independent variable, creativity as the mediating variable, and entrepreneurial intention as the dependent variable to explore the influence mechanism between personality traits, creativity, and entrepreneurial intentions. The study not only provides suggestions for improving college students' entrepreneurial intention but also summarizes the limitations and future directions, providing a solid foundation for future research.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A Cross-Cultural Cognitive Model of New Venture Creation

This research uses a cross-cultural cognitive model of new venture creation as the theoretical basis to understand the influence of personality traits, creativity, and entrepreneurial intentions. The model highlights that the social background, cultural value, and personal factors can affect cognition, cognition can affect entrepreneurial intention, and cognition can affect entrepreneurial intentions through personal factors (Busenitz and Lau, 1996). The personality traits in this study can be regarded as personal factors. Studies have indicated that cognition is closely related to creativity (Sternberg and Lubart, 1999). Studies have also pointed out that cognition is the process of creativity formation (Runco and Chand, 1995; James et al., 2010). Therefore, creativity can be regarded as cognition. Empirical studies have shown that the personality traits significantly affect cognition (Schaie et al., 2004), and cognition has a positive and significant impact on entrepreneurial intentions (Bian et al., 2021). An empirical study by Liu and Wei (2003) found that the personal factors can significantly affect cognition, and cognition can significantly affect entrepreneurial **organization** and expansion intentions. Therefore, this study concludes that the personality traits can significantly affect creativity, thus significantly affecting entrepreneurial intentions. In other words, creativity may have an intermediary effect between personality traits and entrepreneurial intentions. The results of this research can extend the application of cross-cultural cognitive models of startups and enhance the richness of their theoretical models and provide empirical research support for this theoretical model.

Personality Traits and Entrepreneurial Intention

Previous studies have found that the personality traits are closely related to entrepreneurial intentions (Şahin et al., 2019; Arru, 2020; Bazkiaei et al., 2020). Personality traits are suitable for evaluating suitability for entrepreneurship (Zhao et al., 2010). Wang et al. (2016) proposed that the personality traits significantly impact individuals aiming to become entrepreneurs. Moreover, personality traits significantly impact the cognitive model of entrepreneurial intention (Karabulut, 2016; Fragoso et al., 2020). Different personality traits have different effects on entrepreneurial intentions. For example, neuroticism has a significant negative impact on entrepreneurial intentions, conscientiousness, extraversion, and agreeableness, whereas openness has positive and significant effects on entrepreneurial intentions (Israr and Saleem, 2018; Khan et al., 2021). High extroversion, openness, and conscientiousness have a strong impact on entrepreneurial intentions, whereas neuroticism and agreeableness have a weak impact on entrepreneurial intentions (Zhao et al., 2010; Brandstatter, 2011; Liang et al., 2015). Therefore, this research proposes the following hypothesis:

H1: The personality traits of college students significantly impact entrepreneurial intentions.

Personality Traits and Creativity

Many empirical studies have found that the personality traits are closely related to creativity (Hamedinasab and Azizi, 2021; Sarma and Borooah, 2021). Among these traits, neuroticism has a significant negative impact on creativity (Amin et al., 2020; Shokrkon and Nicoladis, 2021), whereas conscientiousness, extraversion, and agreeableness positively and significantly impact creativity (Mumford, 2011). Openness has a positive and significant impact on creativity (Jirásek and Sudzina, 2020; Theurer et al., 2020). Extraversion has a positive and significant impact on creativity (Russ, 2003). In addition, a study by Amin et al. (2020) found that neuroticism has a negative and significant impact on creativity, whereas openness, extroversion, and agreeableness have a positive and significant impact on creativity. People with high openness are more creative but exhibit less agreeableness (Feist, 1999; Silvia et al., 2012; Karwowski et al., 2013; Karwowski and Lebuda, 2016). In conclusion, personality traits are an essential factor for creativity (Woodman et al., 1993). Therefore, this research proposes the following hypothesis:

H2: The personality traits of college students have a significant impact on creativity.

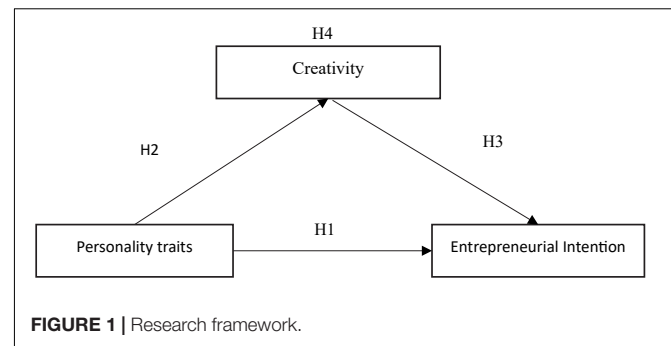
Creativity and Entrepreneurial Intention

Creativity has been found to be highly correlated with entrepreneurial intentions (Bellò et al., 2018; Entrialgo and Iglesias, 2020). Moreover, some researchers have pointed out that creativity should be considered an essential resource for entrepreneurs (Ahlin et al., 2014; Khedhaouria et al., 2015). Zhao et al. (2005) proposed that the highly creative people can maintain a positive attitude and confidence in entrepreneurship. At the same time, creativity is an essential factor that affects entrepreneurial intentions (Tantawy et al., 2021). Hu et al. (2018) pointed out that creativity is a significant predictor variable in entrepreneurship, and creativity is beneficial to individual entrepreneurship. Feldman and Bolino (2000) found that creative people have high entrepreneurial intentions. Moreover, some researchers have proposed through empirical research that creativity has a positive and significant impact on entrepreneurial intentions (Smith et al., 2016; Bellò et al., 2018; Shi et al., 2020; Murad et al., 2021). Therefore, this research proposes the following hypothesis:

H3: The creativity of college students exerts a significant positive effect on entrepreneurial intention.

The Mediating Role of Creativity Between Personality Traits and Entrepreneurial Intention

The evidence cited in this study on the relationship between personality traits, creativity, and entrepreneurial intentions indicates that creativity may be one of the mediating variables between personality traits and entrepreneurial intentions. However, this factor has not received enough attention in the



past. In previous studies, creativity was used as a mediating variable to explore the mediating role of creativity between the knowledge process and corporate performance (Imran et al., 2018). Creativity plays a mediating role between reform, openness, and the self-efficacy of innovative culture (Danish et al., 2019). Abdulaal and Nordin (2020) found that creativity has a mediating role between knowledge and human resource management. Creativity also plays a significant mediating role between training and organizational innovation (Chaubey et al., 2021). In addition, creativity plays a mediating role between participatory management and teacher job satisfaction (Zavvar et al., 2021). In summary, creativity has played a critical mediating role in past empirical research. Moreover, Fatoki (2010) pointed out that creativity is the key driving force for entrepreneurial intentions and an essential process for the formation of entrepreneurship. Based on the arguments of Hypotheses 1 and 3 and the aforementioned discussion, the present research provides a preliminary understanding of the relationship between personality traits, creativity, and entrepreneurial intention. This research aims to verify that the relationship between personality traits and entrepreneurial intentions may affect the mediating role of creativity. Therefore, this research puts forward the following hypothesis:

H4: The creativity of college students plays a mediating role between personality traits and entrepreneurial intention.

MATERIALS AND METHODS

Research Framework

In this study, college students' personality traits, entrepreneurial intention, and creativity were used as independent variable, dependent variable, and mediating variable, respectively. Based on the research hypotheses, we propose a research framework (Figure 1).

Data Collection and Sample

In this study, we conducted a questionnaire survey on the personality traits, creativity, and entrepreneurial intention of college students in two universities in Kunming, Yunnan Province. Notably, it should be noted that both the universities are the typical experience demonstration universities of

innovation and entrepreneurship in China (The State Council the People's Republic of China, 2019).

Pilot Test Sample Adopted in the Study

A preliminary questionnaire was developed based on the existing validated scale, and convenience sampling was adopted in two universities in Yunnan Province, China, from 1 September, 2020 to 10 September, 2020. The personality traits, creativity, and entrepreneurial intention were determined through the questionnaire survey. According to the principle of 3–5 times of the most subscale questions in the questionnaire (DeVellis, 2016), because the most topic in this study is the personality trait quality scale, a total of 40 questions, therefore, 200 volunteers were selected for a pilot study, which was in line with the sampling The standard of the number of people. The pilot-test analysis revealed the following results: In terms of the Big Five Personality Scale, the exploratory factor analysis results showed that after excluding questions with factor loading less than 0.4, a total of 35 questions after deleting the questions, factor loading between 0.410–0.805, in line with Guadagnoli and Velicer (1988) proposed that the factor loading > 0.4 can be regarded as a stable standard, the cumulative percentage of variance was 67.951%, and the validity was good; the reliability analysis results showed the following Cronbach's α of neurotic = 0.918, Cronbach's α of conscientiousness = 0.907, Cronbach's α of agreeableness = 0.866, Cronbach's α of open = 0.931, Cronbach's α of extraversion = 0.920, with good reliability. In terms of creating a power scale, the results of exploratory factor analysis showed that: excluding the questions with factor loading less than 0.4, a total of 14 questions were deleted, factor loading = 0.418–0.792, in line with the standard, the cumulative percentage of variance was 68.346%, and the validity was good. Reliability analysis results showed: Cronbach's α of divergent thinking = 0.842, Cronbach's α of intelligence application ability = 0.863, Cronbach's α of personality trait = 0.726, good reliability. In terms of the entrepreneurial intention vector table, the exploratory factor analysis results showed: factor loading = 0.488–0.770, which met the standard, the cumulative percentage of variance was 61.797%, and the validity was good. The reliability analysis result showed that Cronbach's α of entrepreneurial intention = 0.928, with good reliability.

Sampling and Subjects

The formal questionnaire in this study was completed between 20 October, 2020 and 30 October, 2020. Teachers assisted in the study by providing electronic questionnaires to the participants in the class. Additionally, necessary information such as research purpose, voluntariness, and anonymity was provided to the participants.

A total of 700 questionnaires were distributed. According to the proportion, 50% of the college students from each of the two universities were selected as the interviewees. After excluding invalid questionnaires, the number of final valid questionnaires was 674, and the effective response rate was 96%. According to a study in Israel (1992), the sample size was calculated using the following formula: $\text{Sample size} = z^2 \times p[1 - p]/e^2/1 + [z^2 \times p(1 - p)/e^2N]$, $z = 1.65$, $N = 62,000$, $p = 0.5$,

$e^2 = 0.0025$. The sample size of the study is approximately 382, which met the standard sample size. Of the total participants, 357 (53%) participants were men and 317 (47%) participants were women. Additionally, 95 (14.1%) participants were in the freshman year, 145 (21.5%) participants were in the sophomore year, and 168 (24.9%) participants were in the junior year. There were 266 (39.5%) seniors; 324 (48.1%) participants were from liberal arts background and 350 (51.9%) participants were from science background.

Measurement

The questionnaire comprised multiple factors containing personality traits scale, creativity scale, and entrepreneurial intention scale.

Big-Five Personality Scale

The Big Five Personality Simplified Scale (John et al., 1991) was used in this study and revised from Wang et al. (2011) to the Chinese Big Five Personality Inventory brief version, suitable for Chinese college students. The scale comprised 40 questions, which involved five dimensions, namely neuroticism, conscientiousness, agreeableness, openness, and extroversion. Likert's six-point scale was used for scoring, and reverse questions were used for reverse scoring.

After deleting the questions, the formal scale comprised a total of 35 questions. The collected data were subjected to confirmatory factor analysis. The results showed the following: RMR = 0.056, GFI = 0.815, NFI = 0.874, IFI = 0.900, CFI = 0.899, RMSEA = 0.083, PNFI = 0.808, and PGFI = 0.711, indicating that the fitness of the measurement model was acceptable (McDonald and Ho, 2002). Furthermore, CR of neuroticism = 0.932, CR of conscientiousness = 0.909, CR of agreeableness = 0.869, CR of openness = 0.930, and CR of extroversion = 0.920, representing the values greater than the reference CR of 0.6 (Fornell and Larcker, 1981). In addition, AVE of neuroticism = 0.660, AVE of conscientiousness = 0.589, AVE of agreeableness = 0.572, AVE of openness = 0.628, and AVE of extroversion = 0.593, which represented the values greater than the reference AVE of 0.5 (Anderson and Gerbing, 1988), indicating good convergence validity. Reliability analysis results showed that the Cronbach's α of neuroticism = 0.931, Cronbach's α of conscientiousness = 0.907, Cronbach's α of agreeableness = 0.866, Cronbach's α of openness = 0.937, and Cronbach's α of extroversion = 0.906, which indicated good reliability.

Creativity Scale

This study used the creativity scale (He et al., 2015), which comprises 16 questions and the following three dimensions: divergent thinking, intellectual application ability, and personality characteristics. The scale uses a five-point scoring method.

After deleting the questions, the formal scale had 14 questions. The collected data were subjected to confirmatory factor analysis. According to the results, RMR = 0.035, GFI = 0.917, NFI = 0.930, IFI = 0.942, CFI = 0.942, RMSEA = 0.081, PNFI = 0.756, PGFI = 0.646, indicating that the fitness of the measurement

model is acceptable. Moreover, CR of divergent thinking = 0.851, CR of intellectual application ability = 0.862, CR of personality characteristics = 0.850, AVE of creative thinking = 0.493, AVE of intelligence application ability = 0.568, and AVE of personality traits = 0.653, thereby conforming to the Fornell and Larcker (1981) recommendation that $AVE > 0.36$ is the barely acceptable standard. Cronbach's α of divergent thinking = 0.828, Cronbach's α of intellectual application ability = 0.872, Cronbach's α of personality characteristics = 0.843, in all dimensions of the creative power scale demonstrated good reliability.

Entrepreneurial Intention Scale

This study used the individual entrepreneurial intention scale (Thompson, 2009), which comprises 10 questions. The scale utilizes a five-point scoring method, where reverse scoring is applied for reverse questions.

The formal scale comprised 10 questions. Confirmatory factors were used to analyze the collected data. According to the results, RMR = 0.049, GFI = 0.931, NFI = 0.947, IFI = 0.955, CFI = 0.954, RMSEA = 0.094, PNFI = 0.737, PGFI = 0.742, which indicated that the fitness of the measurement model was acceptable. The CR of entrepreneurial intention = 0.930 and AVE of entrepreneurial intention = 0.578, and the convergence validity was good. The entrepreneurial intention vector table Cronbach's α = 0.928, which indicated good reliability.

Data Analysis

SPSS software was used to analyses the common method deviation of personality traits, creativity, and entrepreneurial intentions. Then, by using the correlation analysis, the relationship among these three main variables was determined. Finally, the direct influence of personality traits and creativity on entrepreneurial intentions was determined, and the mediating effect of creativity under the influence of personality traits on entrepreneurial intentions was analyzed.

Common Method Deviation Test

To test common method bias, single-factor testing is used (Harman, 1976). The characteristic roots of 9 factors in the present study are greater than 1. the first factor can only explain 11.324%, which is far less than the critical value of 40%. Therefore, no serious common method bias problem exists in this study.

RESULTS

Descriptive Statistics and Correlation Analysis

Descriptive statistics suggest that college students' personality traits, creativity, and entrepreneurial intention are all at the upper-middle level. A Pearson correlation analysis indicates the existence of a significant correlation among the variables. The correlation analysis variables between openness and extraversion, openness and creativity, and conscientiousness and entrepreneurial intention are relatively high and consequently require further discriminative validity analysis.

The results of this study demonstrate that the AVE value of the two variables is greater than the square value of the correlation coefficient between the two variables. This satisfies the criteria for evaluating the validity of the difference (Fornell and Larcker, 1981). As shown in **Table 1**, any two variables are characterized by good discriminative validity.

Regression Analysis

Multiple regression analyses serve to verify the hypothesis. Variance inflation factor (VIF) is used to test for multicollinearity. The results of previous empirical studies suggest that differences in gender, majors, and grades can cause significant differences in personality traits (Russo and Stol, 2020), including creativity (Vedel et al., 2015; Zia and Rouhollahi, 2020; He and Wong, 2021; Said-Metwaly et al., 2021) and entrepreneurial intention (Abba et al., 2021; Dao et al., 2021; Gurel et al., 2021). The *t* test and ANOVA test yield the following results. There is initially a significant difference between gender in entrepreneurial intention, where boys have higher results than girls. Second, there is a significant difference in entrepreneurial intention in majors where science students score higher than liberal arts. Third, significant differences exist in entrepreneurial intention in grades ($F = 49.789$, $p < 0.001$), among which a freshman is higher than a sophomore, a junior is higher than a sophomore, a junior is higher than a senior, and a senior is higher than a sophomore. Gender, major, and grade are therefore chosen as control variables in this study.

The mediating role of creativity in college students between personality traits and entrepreneurial intention was tested by controlling the influence of gender, major, and grade. As shown in **Table 2**, in Model 1, neuroticism has a significant negative effect on entrepreneurial intention ($\beta = -0.143$, $p < 0.001$). Conversely, conscientiousness exerts a significant positive effect on entrepreneurial intention ($\beta = 0.367$, $p < 0.001$). agreeableness on the other hand has no significant effect on entrepreneurial intention ($\beta = 0.054$, $p > 0.05$). Openness generates a significant positive effect on entrepreneurial intention ($\beta = 0.117$, $p < 0.01$). Extraversion has a significant positive effect on entrepreneurial intention ($\beta = 0.229$, $p < 0.001$). H1 is consequently established.

As presented in Model 2, neuroticism has a significant negative effect on creativity ($\beta = -0.066$, $p < 0.05$). Conscientiousness has a significant positive effect on creativity ($\beta = 0.198$, $p < 0.001$). Further, agreeableness has no significant effect on creativity ($\beta = 0.036$, $p > 0.05$). Openness exerts a significant positive effect on creativity ($\beta = 0.417$, $p < 0.001$). Extraversion shows a significant positive effect on creativity ($\beta = 0.141$, $p < 0.001$). H2 is established as a result.

The mediator creativity is added in Model 3. Creativity has a significant positive effect on entrepreneurial intention ($\beta = 0.247$, $p < 0.001$), thus establishing H3. When the β value of neuroticism on entrepreneurial intention decreases from -0.143 to -0.126 , it reaches a significant level ($\beta = -0.126$, $p < 0.001$). Therefore, creativity plays a partial mediating role between neuroticism and entrepreneurial intention. The β value of conscientiousness on entrepreneurial intention reaches a significant level when it decreases from 0.367

TABLE 1 | Descriptive analysis and correlation analysis.

	M	SD	1	2	3	4	5	6	7
1	2.081	1.089	0.812						
2	5.089	0.869	−0.718***	0.767					
3	5.046	0.865	−0.595***	0.716***	0.756				
4	5.001	4.985	−0.676***	0.782***	0.746***	0.792			
5	4.985	0.988	−0.696***	0.748***	0.712***	0.832***	0.770		
6	4.287	0.643	−0.649***	0.742***	0.669***	0.810***	0.757***	0.808	
7	4.945	0.996	−0.719***	0.814***	0.694***	0.779***	0.789***	0.790***	0.760

*** $p < 0.001$; Bolded fonts are AVE root values; 1 = Neuroticism, 2 = Conscientiousness, 3 = agreeableness, 4 = Openness, 5 = Extraversion, 6 = Creativity, 7 = Entrepreneurial Intention.

to 0.318 ($\beta = 0.318$, $p < 0.001$). Therefore, creativity plays a partial mediating role between conscientiousness and entrepreneurial intention, and the significant effect of openness on entrepreneurial intention disappears ($\beta = 0.014$, $p > 0.05$). Creativity plays a complete mediating role between openness and entrepreneurial intention. The β value of extraversion on entrepreneurial intention reaches a significant level when it decreases from 0.229 to 0.194 ($\beta = 0.194$, $p < 0.001$). Therefore, creativity plays a partial mediating role between extraversion and entrepreneurial intention. H4 is thus established.

In this study, The Sobel test is used in this study to further test the mediation effect (Sobel, 1982), which calculates the unstandardized regression coefficients and standard errors. A value of Z greater than 1.96 represents a significant mediation effect. The results show that $Z = 23.317$, $p < 0.001$, indicating that creativity plays a mediating role between personality traits and entrepreneurial intention. In Model 3, VIF is between 1.254–5.128, which is lower than the standard value of 10. This result suggests a lack of a serious collinearity problem (Hair Jr., Anderson et al., 1995), as shown in Table 2.

DISCUSSION AND CONCLUSION

Theoretical Contributions

First, the results of this study indicated that college students' neuroticism has a significant negative impact on their entrepreneurial intentions. Besides, conscientiousness, openness, and extraversion have a significant positive impact on entrepreneurial intention, which is similar to the results obtained by Western empirical studies (Murugesan and Jayavelu, 2017; Israr and Saleem, 2018; Şahin et al., 2019; Kristanto and Pratama, 2020; Liu D. et al., 2021). The following conclusions can therefore be inferred. College students with low neuroticism have relatively fewer negative emotions such as anxiety and depression and are more able to withstand the obstacles brought by entrepreneurship. Furthermore, those with high conscientiousness have high self-demand, self-control, execution along a cautious attitude toward entrepreneurship. Students with high openness show strong curiosity, imagination, and cooperation and have innovative and open thinking about entrepreneurship. They are also talented at accepting suggestions

from others. Students with high extroversion are passionate and fond of social activities, which allows them to make a wide range of entrepreneurial connections. Agreeableness has no significant effect on entrepreneurial intention, which is different from the conclusions of Western studies. Due to the cultural differences between China and the West, Chinese college students with high agreeableness show characteristics such as compassion and willingness to help others, which are not conducive to entrepreneurship.

Furthermore, the results of this study indicated that college students' neuroticism has a significant negative impact on their creativity. Additionally, conscientiousness, openness, and extraversion have a significant positive impact on creativity. This is in line with the results of Western empirical studies (Jirásek and Sudzina, 2020; Sadana et al., 2021; Sarma and Borooah, 2021). This study concludes that college students with low neuroticism are characterized by compulsive dependence and are more capable of using their creativity (Albert and Runco, 1987). In other words, college students with low neuroticism do not rely on help from others. Active thinking is conducive to divergent thinking and increases creativity. College students with high conscientiousness pay attention to details, do their work thoroughly and pursue achievement with creativity (McCrae, 1987). Agreeableness has nothing to do with creativity (Silvia et al., 2011). Furthermore, the higher the agreeableness, the lower the creativity (King et al., 1996). Conversely, negative qualities such as arrogance and hostility accompany high creativity (Feist, 1999). Being open-minded and curious makes it easier to gain new ideas (Goldberg, 1990). People with openness are characterized by flexible thinking and are willing to accept new ideas (Zhao and Seibert, 2006). Moreover, they are more capable of getting rid of traditional customs and adopting new and unique ways of thinking (Sung and Choi, 2009). People with extraversion are usually enthusiastic and sociable, which contributes to inspiring creativity (Prabhu et al., 2008).

Second, the results of this study indicated that the creativity of college students has a significant positive effect on entrepreneurial intentions, which is consistent with the results of Western empirical research (Hu et al., 2018; Entrialgo and Iglesias, 2020). This study concludes that college students with high creativity have novel ideas and innovative abilities. Innovative thinking can effectively develop available resources, while creative ideas make a positive contribution to

TABLE 2 | Examination of the mediating role of creativity in the influence of personality traits on entrepreneurial intention.

Variable	Model 1	Model 2	Model 3
	EI	Creativity	EI
	β	β	β
Gender (Boys)	−0.067**	0.001	−0.067**
Major (liberal arts)	0.029	0.026	0.022
Grade 1 (Freshman)	0.007	0.114***	−0.021
Grade 2 (Sophomore)	−0.066**	−0.038	−0.057**
Grade 3 (Junior)	0.037	0.150***	0.000
Neuroticism	−0.143***	−0.066*	−0.126***
Conscientiousness	0.367***	0.198***	0.318***
Agreeableness	0.054	0.036	0.045
Openness	0.117**	0.417***	0.014
Extraversion	0.229***	0.141**	0.194***
Creativity			0.247***
R^2	0.764	0.730	0.780
Adj R^2	0.760	0.725	0.776
F	214.137***	178.853***	213.425***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Gender, major, and grade are dummy variables.

Boys are the experimental group within the gender group, while the girls are the reference group.

Liberal arts are the experimental group, while sciences are the reference group.

Freshmen, sophomores, and juniors are the experimental group in the grade group, while seniors are the reference group; EI, Entrepreneurial Intention.

entrepreneurial intention (Biraglia and Kadile, 2017; Murad et al., 2021).

Finally, the study results of the study also suggest that creativity plays a partial mediating role between neuroticism, conscientiousness, extraversion, and entrepreneurial intention, while creativity plays a complete mediating role between openness and entrepreneurial intention. This result is consistent with the conclusions of previous empirical studies (Wang et al., 2018). College students with high creativity thus have divergent thinking and innovative thinking, consequently having more ideas to start new companies (Anjum et al., 2021).

Practical Implications

The research results further provide a reference value for the improvement and optimization of entrepreneurial practice. First, colleges and universities should perform relevant tests to understand personality traits when college students enroll. For college students with neuroticism, teachers can relieve their psychological pressure through psychological counseling. College students with conscientiousness should be encouraged to give lectures in class to strengthen their divergent logical thinking skills. In terms of college student's openness, teachers can motivate them to participate in the planning of class activities and the design of classroom training. In addition, activities such as scenario simulation and role-playing can train openness thinking and strengthen creativity. For college students with extraversion, they should be encouraged to participate in social activities, class organizations, or clubs. Through the above-mentioned teaching of personality traits in accordance with their aptitude, the entrepreneurship and creativity of college students can be significantly enhanced. Secondly, Colleges

and universities should therefore create a diversified and open learning environment, conduct lectures that cultivate creativity and promote reading education. Furthermore, teachers should encourage students' enthusiasm by designing interesting educational interactions, such as group discussions, and affirm their uniqueness by encouraging students. At last, teachers should focus on students' different neuroticism, conscientiousness, extraversion, and openness to promote entrepreneurial intention and cultivate creativity.

Limitations and Suggestions for Future Research

It is necessary to expand the sample range for future research. The relationship among personality traits, creativity, and entrepreneurial intention of college students can be deeply explored through qualitative in-depth interviews or a combination of quantitative and qualitative studies. Past research results show that goal orientation theory has been applied to creativity-related research (Huang and Luthans, 2015; Lee and Yang, 2015; Kaspi-Baruch, 2019). Therefore, follow-up research can apply goal orientation theory as well to explore the relationship among personality traits, creativity, and entrepreneurial intention. This study adopts the Big-Five Personality Traits Scale. A subjective personality has a positive and significant effect on entrepreneurial intention (Hu et al., 2018; Kumar and Shukla, 2019; Li et al., 2020), while a narcissistic personality has a positive and significant effect on entrepreneurship (Al-Ghazali and Afsar, 2021; Liu H. C. et al., 2021). Future research can consider other specific personality trait scales to provide more empirical evidence for related research in the field of entrepreneurship.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Dhurakij Pundit University. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication

of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

L-NL conceived the study idea, edited the data, performed the analysis and interpretation, drafted the skeleton of the manuscript, and critically reviewed the manuscript. J-HH contributed to constructing the model, interpreting the model results, and intensively editing the language of the manuscript. S-YG participated in the revision of the manuscript. All authors read and approved the final manuscript and participated in the critical appraisal as well as revision of the manuscript.

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Effect of Narcissistic Personality on Entrepreneurial Intention Among College Students: Mediation Role of Entrepreneurial Self-Efficacy

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Exploring the factors influencing entrepreneurial intention is crucial to entrepreneurial practice and education. For a comprehensive understanding of the influence of narcissistic personality on entrepreneurial intention, this study analyzed the relationship between narcissistic personality, entrepreneurial self-efficacy, and entrepreneurial intention in college students sampled from three higher vocational colleges in Beijing, China. A total of 252 valid questionnaires were collected. The results show that the narcissistic personality of the college students has a significant positive effect on entrepreneurial intention and entrepreneurial self-efficacy. Entrepreneurial self-efficacy of the college students has a significant positive effect on entrepreneurial intention and plays a partial mediation role in the relationship between narcissistic personality and entrepreneurial intention. Thus, the study results provide some reference for further improving entrepreneurial practice and education.

Keywords: entrepreneurial intention (EI), narcissistic personality, entrepreneurial self-efficacy (ESE), college students, mediation role

INTRODUCTION

With rapid global advancement of technology, entrepreneurial abilities are gaining increasing prominence. Work of domestic and foreign researchers on entrepreneurial intention has borne fruit (Wang et al., 2020; Huang et al., 2021; Hoang and Le, 2021; Shahin et al., 2021). Other studies have shown that entrepreneurial intention of college students affects their future entrepreneurial behaviors (Boubker et al., 2021; Elnadi and Gheith, 2021). Thus, the key factors and influencing mechanisms that affect entrepreneurial intentions must be explored.

Some specific personality traits are prerequisites for entrepreneurship and can influence entrepreneurial intentions (Utsch and Rauch, 2000). Narcissistic personality, one such personality trait, describes the structure of behavior patterns in an individual's life. Koh (1996) defined the following prerequisites for narcissistic personality: internal control, need for achievement, moderate levels of risk-taking, innovation, great self-confidence, and high tolerance of ambiguity. Research has shown that narcissistic personality affects entrepreneurial intention (Mathieu and St-Jean, 2013; Wu et al., 2019a; McLarty et al., 2021), and this impact has been the focus of current research. However, results of empirical studies are scarce. Therefore, investigating this topic further to obtain additional evidence to remedy deficiencies in past research is worthwhile.

In addition, being an important topic in entrepreneurship-related research, entrepreneurial self-efficacy has attracted the attention of many researchers (Chen et al., 1998; DeNoble et al., 2007; Borchers and Park, 2010). Entrepreneurial self-efficacy is a concept derived from self-efficacy. Some studies have suggested that entrepreneurial self-efficacy has a significant positive effect on entrepreneurial intention (Chen et al., 1998; DeNoble et al., 2007; Borchers and Park, 2010). Some have also found that narcissistic personality significantly and positively affects entrepreneurial self-efficacy (Wu et al., 2019a; Al-Ghazali and Afsar, 2020; Hegde and Shetty, 2020). Moreover, entrepreneurial self-efficacy often plays a mediation role in entrepreneurial intention-related studies. For example, Zhao et al. (2005) found that entrepreneurial self-efficacy mediates the relationship between entrepreneurial experience and entrepreneurial intention. Prabhu et al. (2012) found that entrepreneurial self-efficacy acts as a mediator in the relationship between positive personality and entrepreneurial intentions. Wu et al. (2019a) found that entrepreneurial self-efficacy plays a mediation role in the relationship between the narcissistic dimension of the dark triad and entrepreneurial intention. Therefore, we believe that entrepreneurial self-efficacy also plays a mediation role in the relationship between narcissistic personality and entrepreneurial intentions.

The aims of the study are twofold: first, most studies on narcissistic personality and entrepreneurial intention are based on samples from the United States (O'Reilly et al., 2014; Hmieleski and Lerner, 2016). Therefore, we used Chinese college students as the study sample to compensate for the shortcomings of past studies. Second, among the factors related to entrepreneurial intention, personality traits are critical predictors of entrepreneurial intention. Few researchers conducted research on college students in China's vocational colleges. However, a more diverse sample must test the association between narcissistic personality and entrepreneurial intentions. Third, the current research applies narcissistic personality, entrepreneurial self-efficacy, and entrepreneurial intention to the theory of self-efficacy to understand the mediating role of entrepreneurial self-efficacy in the relationship between narcissistic personality and entrepreneurial intention. However, the influence mechanism of this relationship is still unclear. Therefore, the current study uses Chinese vocational college students as the research sample, narcissistic personality as the independent variable, entrepreneurial self-efficacy as the intermediary variable, and entrepreneurial intention as the dependent variable to explore the three aspects of the narcissistic personality entrepreneurial self-efficacy, and entrepreneurial intention. The inter-influence mechanism provides a new direction for improving college students' entrepreneurial intentions and further enriches self-efficacy theory.

The research questions of the current study are as follows:

1. Does the narcissistic personality of college students in Beijing, China affect their entrepreneurial intentions?
2. Does the narcissistic personality of college students in Beijing, China affect entrepreneurial self-efficacy?
3. Does the entrepreneurial self-efficacy of college students in Beijing, China affect their entrepreneurial intentions?
4. Does the entrepreneurial self-efficacy of college students in Beijing, China play a mediating role in the influence of narcissistic personality on entrepreneurial intention?

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Self-Efficacy Theory

Based on self-efficacy theory, we seek to understand the influence mechanism among narcissistic personality, entrepreneurial self-efficacy, and entrepreneurial intention. This theory states that self-efficacy is an individual's judgment, beliefs, or feelings about their ability to complete an activity at a certain level. Self-efficacy is related to an individual's ability level and personality traits; however, it does not represent their true ability level (Bandura, 1997). Narcissistic personality is an individual trait (Brown et al., 2009). Mature narcissism in good shape produces humorous and creative behaviors; thus, narcissistic traits can be beneficial for the career of narcissists (Furnham and Crump, 2014). On the other hand, the higher the degree of entrepreneurial self-efficacy of an individual, the higher their entrepreneurial intention and the greater their chance of starting their own businesses (Boyd and Vozikis, 1994; Trevelyan, 2011).

Narcissistic Personality and Entrepreneurial Intention

Narcissism is not necessarily pathological, but a separate chronological order, from infancy to adulthood, exists (Kohut, 1966). Narcissists tend to glorify themselves, displaying overconfidence, capriciousness, high-level histrionic personality, and intense aggression, but they are sensitive and anxious and have a strong sense of insecurity (Wink and Donahue, 1997). Moreover, some researchers have argued that narcissistic personality actually combines cognition, emotion, and behavior, jointly conveying an exaggerated, crucial, and unique self-concept (Rhodewalt and Eddings, 2002). Pincus and Lukowitsky (2010) considered narcissism as an aggressive, arrogant, and self-righteous personality trait. Bender (2012) suggested that narcissistic personality forms a part of our mental development and individual personality. Dhillon (2019) has put forward a fascinating view that narcissism refers to excessive admiration and interest in oneself and one's appearance. In the current study, we adopted the definition of Dhillon (2019) and defined narcissistic personality as having or showing an extreme interest in or admiration of oneself and one's physical appearance.

Some college students have a strong desire to start their own business, and some even put their ideas into practice while being still in school. Some differences can be observed in the personalities between these students and other students who seek employment after graduation. They are self-confident, like to try new things, and are ready to take risks (Mathieu and St-Jean, 2013). Based on a sample of respondents from high-tech companies in the United States, a relevant study found

that narcissistic personality coincides with some characteristics of leaders. A person with narcissistic personality is generally dominant and has a strong sense of control and self-awareness (O'Reilly et al., 2014). A study (Hmieleski and Lerner, 2016) showed that narcissistic personality significantly influences entrepreneurs' establishing their businesses and that people with high narcissistic personalities can live in the now and can quickly become leaders by starting a business. Narcissists have a higher drive to pursue, constantly seek advancement, and exhibit better decision-making ability (Zia et al., 2020). Consequently, we proposed hypothesis H1 of this study.

H1: College students' narcissistic personality significantly and positively affects their entrepreneurial intention.

Narcissistic Personality and Entrepreneurial Self-Efficacy

Entrepreneurial self-efficacy is the strength of an individual's belief that they can successfully play different entrepreneurial roles and start their businesses (Boyd and Vozikis, 1994; McGee et al., 2009). It is also an individual's belief in their ability to achieve goals, control positive and negative cognition when starting a business (Drnovšek et al., 2010), and perform new tasks successfully. It also refers to their expectations for establishing a new business (Pihie and Bagheri, 2013). This study defined entrepreneurial self-efficacy as the degree of an entrepreneur's confidence and expectation that they can start a business to control the events in their lives after they knew their abilities and that they will be able to succeed in their ventures.

People with high narcissistic personalities tend to perform positive self-evaluations because they believe that they will achieve positive results, which in turn affects entrepreneurial self-efficacy (Campbell et al., 2004). These people generally have a strong motivation to pursue goals, are eager to seek attention and improve themselves, and are good at seizing opportunities (Forsyth et al., 2012; Do and Dadvari, 2017). They also believe they will be able to encounter obstacles, setbacks, and failures of starting businesses better than others (Mathieu and St-Jean, 2013). A study conducted by Brookes (2015) among psychology college students reported that people with high narcissism are more confident about achieving their goals, and the higher narcissistic personalities, the higher entrepreneurial self-efficacy. Some empirical studies have suggested that narcissistic personality has a significant positive impact on entrepreneurial self-efficacy (Al-Ghazali and Afsar, 2020; Hegde and Shetty, 2020). Thus, we proposed hypothesis H2 of this study.

H2: College students' narcissistic personality significantly and positively affects their entrepreneurial self-efficacy.

Entrepreneurial Self-Efficacy and Entrepreneurial Intention

Beck and Ajzen (1991) argued that entrepreneurial intention can be a plan to start a new business, an intention to predict future personal behavior and organizational outcomes, and an entrepreneurial belief that they intend to create a company or organization during the preparation period before starting a

business (Souitaris et al., 2007). A person with thoughts and attitudes about the desire to own their business or establish a new business is believed to have entrepreneurial intention, which is a necessary core to understand the entrepreneurial process (Krueger and Carsrud, 1993). People more inclined to start businesses have a greater desire for achievement and greater self-confidence (Koh, 1996). Entrepreneurial activity involves a series of planned ideas and behaviors; therefore, an entrepreneur's ideas and intentions are the basis for creating a new business and the starting point of the entrepreneurial process (Krueger et al., 2000). This study defines entrepreneurial intention as a person's idea that they are prepared to start a business and have a plan to do so.

Entrepreneurial self-efficacy largely influences an individual's intentions and behaviors of becoming an entrepreneur; their efforts to establish a new business; and perseverance in the face of new things, changes, and challenges in the process of establishing a new business (Trevelyan, 2011). Several researchers have found that entrepreneurial self-efficacy positively affects entrepreneurial intention. For example, in college students from Malaysia, Pihie and Bagheri (2013) found that students' self-efficacy has a significant positive impact on their entrepreneurial intention. Liu et al. (2019) found that entrepreneurial self-efficacy has a significant positive effect on Entrepreneurial Intention in Chinese college students. A study conducted by Aima et al. (2020) among college students in Indonesia found that entrepreneurial self-efficacy has a significant positive impact on entrepreneurial intention. Through a sample survey of college students, Neneh (2020) found that entrepreneurial self-efficacy positively influences entrepreneurial intention. Results of the current study show that college students' entrepreneurial self-efficacy significantly and positively affects entrepreneurial intention. Therefore, we proposed hypothesis H3 of this study.

H3: College students' entrepreneurial self-efficacy significantly and positively affects their entrepreneurial intention.

The Mediation Role of Entrepreneurial Self-Efficacy in the Relationship Between Narcissistic Personality and Entrepreneurial Intention

Based on the analysis of previous studies, we found that entrepreneurial self-efficacy often plays a mediation role in the relationship between individuals' cognitive abilities. In master degree candidates from five Chinese universities, Zhao et al. (2005) found that entrepreneurial self-efficacy acts as a mediator in the effect of entrepreneurial experience on entrepreneurial intention and that of risk intention on entrepreneurial intention. Through a study on graduate and undergraduate students from four universities in China, Finland, Russia, and the United States, Prabhu et al. (2012) found that entrepreneurial self-efficacy mediates the relationship between proactive personality and entrepreneurial intention.

On combining hypotheses H1 and H3 and the results of the aforementioned analysis, we found that narcissistic personality

can not only directly influence entrepreneurial intention but also indirectly affect it through entrepreneurial self-efficacy. Specifically, people with high narcissistic personalities will have higher entrepreneurial intentions because their personality traits have a higher drive to pursue and constantly seek advancement and they exhibit better decision-making ability (Zia et al., 2020). The higher entrepreneurial self-efficacy of a person, the higher their entrepreneurial intention and the higher odds of their starting their businesses (Boyd and Vozikis, 1994). By investigating Chinese college students, some researchers found that entrepreneurial self-efficacy mediates the relationship between narcissism and entrepreneurial intention (Wu et al., 2019a). Therefore, individuals with high levels of narcissistic personality tend to have higher entrepreneurial self-efficacy in the entrepreneurial process, which may further spawn entrepreneurial intention. Therefore, we proposed hypothesis H4 of this study.

H4: College students' entrepreneurial self-efficacy plays a mediation role in the relationship between their narcissistic personality and entrepreneurial intention.

METHODS

Research Framework

In this study, college students' narcissistic personality, entrepreneurial intention, and entrepreneurial self-efficacy were used as independent, dependent, and mediating variables, respectively. Based on the research hypotheses, we proposed the research framework (Figure 1).

Participants and Procedures

The study was divided into pre-test and formal phases. Complete data were tested and retrieved twice. Questionnaires were distributed to different participants.

Pilot-Test Sample Used in the Study

The pre-test questionnaire was distributed on September 3, 2020 and returned on September 21, 2020. Using purposive sampling, we circulated 85 questionnaires to 85 college students in a higher vocational college in Beijing. Of them, 80 questionnaires were valid, so the questionnaire efficiency was 94.1%. After analyzing the reliability and validity of the questionnaires' content, we

deleted some items, revised the initial questionnaires, and finalized the official ones.

Formal Sample Used in the Study

The formal questionnaire was distributed on October 4, 2020 and returned on October 25, 2020. Using purposive sampling, we conducted a questionnaire survey of college students in three higher vocational colleges in Beijing; these institutions are considered models of entrepreneurship education. We followed Ghiselli et al. (1981)'s proposed sampling criteria: if the study involves the use of scales, the study sample size should be at least 10 times the total number of questions. According to these criteria, the three scales used in this study had 25 questions and over 250 items of data that should be validly collected. The results of Israel (1992), the formula for calculating the sample size: $\text{Sample size} = z^2 \times p(1-p)/e^2/1 + [z^2 \times p(1-p)/e^2N]$, $z = 1.65$, $N = 15300$, $p = 0.5$, $e^2 = 0.0025$, The sample size of the study is approximately 268. It was expected that 300 questionnaires will be distributed. According to the proportion, 30, 30, and 40% of college students in each of the three higher vocational colleges were selected separately as respondents. We circulated the questionnaires on Wenjuanxing, an online questionnaire platform, and received 260 questionnaires. Finally, a total of 252 valid questionnaires were obtained. The effective recovery was 97%, which met the sampling criteria. We set two background variables, gender and grade, for the basic information of the students. Gender was categorized as male and female, and grade was classified as freshman, second-year university, and junior. Because senior students were on placement, they were not included as the study sample. In total, the study had 199 men (79% of the sum total) and 53 women (21% of the sum total). Overall, there were 136 freshmen (54% of the sum total), 61 second-year universities (24.2% of the sum total), and 55 juniors (21.8% of the sum total).

Test Process

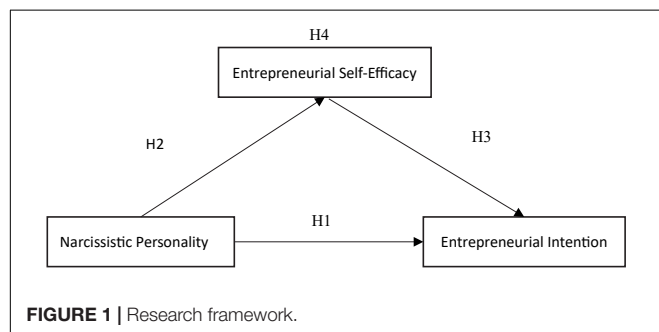
This study was carried out in accordance with the commendations of the Human Ethics Committee of the Dhurakij Pundit University. Before the test, the teachers of the respondents were informed of the study intention. With their assistance, we asked students to fill out the questionnaire in a uniform manner. To ensure the objectivity and authenticity of the questionnaire data, we explained the confidentiality of the questionnaire results and the study purpose to the respondents.

MEASURES

The questionnaire used in the present study consisted of 25 items: 2 items measuring basic information about the respondents, 13 items of the narcissistic personality scale, 4 items of the entrepreneurial self-efficacy scale, and 6 items of the entrepreneurial intentions scale.

Narcissistic Personality Scale

This study used the narcissistic personality Inventory-16 of Ames et al. (2006), which has 16 one-dimensional questions.



We conducted an exploratory factor analysis of the pre-test results, eliminated questions with factor loadings of <0.4 , and finalized 13 questions. According to the results, KMO was 0.851; factor loadings was 0.626–0.813, indicating good validity; and Cronbach's α value was 0.913, indicating good reliability.

Entrepreneurial Self-Efficacy Scale

This study used the entrepreneurial self-efficacy scale of Krueger et al. (2000), which has 4 one-dimensional questions. We conducted an exploratory factor analysis of the pre-test results. According to the analysis results, KMO was 0.814; factor loadings was 0.852–0.901, indicating good validity; and Cronbach's α value was 0.900, indicating good reliability.

Entrepreneurial Intention Scale

This study used the entrepreneurial intention scale of Liñán and Chen (2009), which has 6 one-dimensional questions. We conducted an exploratory factor analysis of the pre-test results. The results showed KMO was 0.832; factor loadings was 0.645–0.890, indicating good validity; and Cronbach's α value was 0.895, indicating good reliability.

DATA ANALYSIS

We used SPSS software was used to test the common method bias of the narcissistic personality scale, entrepreneurial self-efficacy scale, and entrepreneurial intentions scale. Then, we explored the relationship between these three main variables in SPSS through correlation analysis. Finally, we explored the specific relationship between pairs of the three variables and examined the mediation role of entrepreneurial self-efficacy in the impact of narcissistic personality on entrepreneurial intention.

Common Method Bias

Harman's single-factor test was performed to test common method bias based on the results of the formal questionnaire Harman's single-factor (Podsakoff and Organ, 1986). The result meets the Common method bias test standard proposed by Hair et al. (1998). There are 4 factors with feature values greater than 1 extracted. The explanatory variance of the first factor is 42.539%, which is lower than the reference value is 50%. We can conclude that no Common method bias problem exists in the current study's data.

RESULTS

Descriptive Statistics and Correlation Analysis

Table 1 presents the descriptive statistics and correlations of the variables. According to the results, college students' "NP" mean was 3.041, their "ESE" mean was 3.357, and their "EI" mean was 3.433. The level of narcissistic personality, entrepreneurial self-efficacy, and entrepreneurial intention of the college students was above average.

TABLE 1 | Descriptive analysis and correlation analysis of the variables.

Variable	M	SD	NPI	ESE	EI
NP	3.041	0.700	1		
ESE	3.571	0.620	0.632***	1	
EI	3.433	0.700	0.544***	0.688***	1

*** $p < 0.001$.

NP, Narcissistic Personality; ESE, Entrepreneurial Self-Efficacy; EI, Entrepreneurial Intention.

A significant positive correlation was observed between college students' narcissistic personality and their entrepreneurial self-efficacy ($r = 0.632$, $p < 0.001$). Narcissistic personality was significantly and positively correlated to entrepreneurial intention among the college students ($r = 0.544$, $p < 0.001$). Entrepreneurial self-efficacy and entrepreneurial intention of college students were significantly and positively correlated ($r = 0.688$, $p < 0.001$). The correlation coefficients between the variables ranged from 0.544 to 0.688, with no high correlation and no serious collinearity. Details are given in Table 1.

Regression Analysis

Empirical studies have shown that male college students' entrepreneurial intention is considerably higher than their female counterparts' (Yukongdi and Lopa, 2017; Molino et al., 2018; Jena, 2020); entrepreneurial intention of second-year universities is considerably higher than that of juniors and freshmen (Wang and Huang, 2019). The results of t-check and ANOVA check showed a large gender gap in terms of entrepreneurial intention ($t = 4.764$, $p < 0.001$), that is, the entrepreneurial intention of male students was higher than that of female students. Moreover, the results revealed a large grade gap ($F = 290.200$, $p < 0.001$), that is, the entrepreneurial intention of freshmen was higher than that of juniors, and the entrepreneurial intention of second-year universities was higher than that of juniors and freshmen. Therefore, this study included the demographic variables of gender and grade in the hierarchical regression analysis.

This study examined the mediating effect of college students' entrepreneurial self-efficacy on the relationship between narcissistic personality and entrepreneurial intention based on the premise that the effects of demographic variables, that is, gender and grade, are controlled. As shown in Table 2, the narcissistic personality of college students significantly and positively impacted entrepreneurial intention ($\beta = 0.234$, $t = 6.750$, $p < 0.001$) in Model 1, and therefore, hypothesis H1 checks out. The narcissistic personality of college students significantly and positively affected entrepreneurial self-efficacy ($\beta = 0.483$, $t = 9.880$, $p < 0.001$) in Model 2; therefore, hypothesis H2 is valid. In Model 3, after adding the mediating variable entrepreneurial self-efficacy, college students' narcissistic personality had a significant positive effect on entrepreneurial intention ($\beta = 0.114$, $t = 2.975$, $p < 0.01$) and their entrepreneurial self-efficacy significantly and positively influenced entrepreneurial intention ($\beta = 0.247$, $t = 5.846$, $p < 0.001$), and hence, hypothesis H3 checks out. The β value for the effect of the narcissistic personality of college students

TABLE 2 | Test of the mediation role of entrepreneurial self-efficacy in the effect of narcissistic personality on entrepreneurial intention.

Variable	Model 1		Model 2		Model 3		VIF
	EI		ESE		EI		
	β	t	β	t	β	t	
Male Students	0.081	2.486*	0.012	0.259	0.078	2.551*	1.071
Freshmen	0.567	13.750***	0.209	3.582***	0.516	12.979***	1.815
Second-year universities	0.915	20.840***	0.456	7.352***	0.803	17.627***	2.384
NP	0.234	6.750***	0.483	9.880***	0.114	2.975**	1.700
ESE					0.247	5.846***	2.061
R ²	0.756		0.515		0.786		
Adj R ²	0.752		0.507		0.782		
F	191.701***		65.497***		180.795***		

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

β is the standardized regression coefficient.

Gender and grade are dummy variables, in which male students are the experimental group and female students are the reference group, and freshmen and second-year universities form the experimental group and junior students are the reference group, respectively.

NP, Narcissistic Personality; ESE, Entrepreneurial Self-Efficacy; EI, Entrepreneurial Intention.

TABLE 3 | Testing the mediation model of entrepreneurial self-efficacy.

Variables	Model1			Model2			Model3		
	EI			ESE			EI		
	B	SE	t	B	SE	t	B	SE	t
Male Students	0.138	0.056	2.486*	0.18	0.070	0.259	0.133	0.052	2.551*
Freshmen	0.794	0.058	13.750***	0.259	0.072	3.582***	0.722	0.056	12.979***
Second-year universities	1.491	0.072	20.840***	0.659	0.090	7.352***	1.308	0.074	17.627***
NP	0.235	0.035	6.750***	0.431	0.044	9.880***	0.115	0.039	2.975**
ESE							0.279	0.048	5.846***
R ²	0.756			0.515			0.786		
F	191.701***			65.497***			180.795***		

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

B is the unstandardized regression coefficient.

Gender and grade are dummy variables, in which male students are the experimental group and female students are the reference group, and freshmen and second-year universities form the experimental group and junior students are the reference group, respectively.

NP, Narcissistic Personality; ESE, Entrepreneurial Self-Efficacy; EI, Entrepreneurial Intention.

on entrepreneurial intention decreased from 0.234, up to the significant level, in Model 1 to 0.114, up to the significant level, in Model 3. Thus, entrepreneurial self-efficacy plays a partial mediation role in the effect of narcissistic personalities on entrepreneurial intention in college students, and so, hypothesis H4 is valid. Furthermore, this study used the Sobel test to verify the mediating effect and used unstandardized regression coefficients and standard errors to calculate it. The formulae for Sobel test which is $z\text{-value} = a \times b / \sqrt{b^2 \times s_a^2 + a^2 \times s_b^2}$, a = raw (unstandardized) regression coefficient for the association between the Narcissistic Personality and the Entrepreneurial Self-Efficacy. s_a = standard error of a . b = raw coefficient for the association between the Entrepreneurial Self-Efficacy and the Entrepreneurial Intention (when the Narcissistic Personality is also a predictor of the Entrepreneurial Intention). s_b = standard error of b . Z value of > 1.96 represents a significant mediating effect (Sobel, 1982), and the present study showed that entrepreneurial self-efficacy ($Z = 9.714$, $p < 0.001$) has a

significant mediating effect. In Model 3, the VIF was < 10 and no covariance problem was noted. Details are given in Table 2.

Revalidation of the Mediating Role of Entrepreneurial Self-Efficacy

This study further uses PROCESS macro model 4 to test the mediating role of entrepreneurial self-efficacy in the relationship between narcissistic personality and entrepreneurial intention. Controlling gender and grade as covariates, the results show that narcissistic personality significantly predicts entrepreneurial intention ($B = 0.235$, $t = 6.750$, $p < 0.001$). After adding entrepreneurial self-efficacy as an intermediary variable, narcissistic personality is still an important predictor of entrepreneurial intention ($B = 0.115$, $t = 2.975$, $p < 0.01$). In addition, narcissistic personality positively predicts entrepreneurial self-efficacy ($B = 0.431$, $t = 9.880$, $p < 0.001$), entrepreneurial self-efficacy positively predicts entrepreneurial

intention ($B = 0.279$, $t = 5.846$, $p < 0.001$), see **Table 3** for details. In addition, according to the bootstrap test, entrepreneurial self-efficacy has a significant indirect effect ($CI = 0.067\text{--}0.184$, effect size = 0.120). Thus, entrepreneurial self-efficacy plays a partial mediation role in the effect of narcissistic personalities on entrepreneurial intention in college students.

DISCUSSION AND CONCLUSION

Theoretical Contributions

First of all, the results of this study found that the narcissistic personality of Chinese Beijing university students significantly positively affects entrepreneurial intentions. The result of this study is consistent with the findings of Mathieu and St-Jean (2013), O'Reilly et al. (2014), Hmieleski and Lerner (2016), Zia et al. (2020), and Cai et al. (2021). This study concludes that such college students like to try new things and take risks (Mathieu and St-Jean, 2013); narcissists are considerably more motivated to pursue their goals and thus show better decision-making abilities (Zia et al., 2020). Because college students with a high narcissistic personality care more about what others think of them, want to be praised and recognized, and believe that they outshine others in all aspects, they will prove themselves by starting their own businesses to sharpen their sense of superiority. Narcissistic personality can further entrepreneurial intention, that is, a high narcissistic personality can promote the formation of entrepreneurial intention among college students. However, the results of this study are inconsistent with Wu et al. (2019b). The reason may be that the narcissistic personality is divided into two parts, positive and negative (Wu et al., 2019b).

Immediately afterward, the results of this study revealed that the narcissistic personality of Chinese Beijing university students significantly positively affects entrepreneurial self-efficacy. The result of this study is consistent with the findings of Mathieu and St-Jean (2013) and Brookes (2015). This study concludes that college students with high narcissism aspire to improve themselves and are confident of their abilities (Forsyth et al., 2012). They believe they can perform better than others even when they fail in their efforts to start businesses (Mathieu and St-Jean, 2013). Furthermore, highly narcissistic college students pay close attention to themselves, overrate their importance, and believe that they are capable of doing anything. The recognition of themselves boosts their self-confidence. Therefore, entrepreneurial self-efficacy, that is, one's degree of confidence in being able to successfully start a business, benefits entrepreneurial intentions. Hence, we argue that an increase in narcissistic personality increases entrepreneurial self-efficacy.

Secondly, this study found that the entrepreneurial self-efficacy of Chinese college students in Beijing significantly positively affects entrepreneurial intentions. The result of this study is consistent with the findings of Boyd and Vozikis (1994), Chen et al. (1998), Naktiyok et al. (2010), Pihie and Bagheri (2013), and Liu et al. (2019). This study concludes that entrepreneurial self-efficacy largely influences an individual's intention to become an entrepreneur, their efforts to establish a new business, and their persistence in facing new challenges

and changes in the entrepreneurial process (Trevelyan, 2011). In addition, college students with high entrepreneurial self-efficacy are confident of their entrepreneurial abilities and in their ability to succeed in starting businesses. The increase in self-efficacy, in turn, further helps to increase entrepreneurial intention.

Finally, this study found that the entrepreneurial self-efficacy of Chinese college students in Beijing plays a partial mediating role between narcissistic personality and entrepreneurial intention. The study results show that the higher the degree of college students' narcissistic personality, the more it strengthens their entrepreneurial self-efficacy, which further helps to increase their entrepreneurial intention. The results are consistent with previous findings that entrepreneurial self-efficacy mediates the relationship between personality traits and entrepreneurial intentions (Zhao et al., 2005; Prabhu et al., 2012; St-Jean and Mathieu, 2015; Darmanto and Yuliari, 2018; Wu et al., 2019a), which confirms that entrepreneurial self-efficacy also mediates the relationship between narcissistic personality and entrepreneurial intentions. This study concludes that self-efficacy is closely related to the level of competence and personality traits of a person (Bandura, 1997). Therefore, narcissistic personality can be considered an individual characteristic and can affect entrepreneurial intentions through entrepreneurial self-efficacy. The higher the narcissistic personality of a college student, the better they think they are and the more confident they feel about themselves. This increases their entrepreneurial self-efficacy and they believe that they can establish their own businesses, which ultimately increases their entrepreneurial intention. Therefore, a narcissistic personality can indirectly affect entrepreneurial intention through entrepreneurial self-efficacy. In addition, this study suggests that entrepreneurial self-efficacy is an influential key mediating variable in entrepreneurship-related empirical studies. The finding provides empirical evidence for the use of self-efficacy theory in exploring college students' entrepreneurial intention.

Practical Implications

The study results provide higher vocational colleges with inspiration to carry out entrepreneurship education. First, when providing entrepreneurship education, higher vocational colleges should pay attention to students' narcissistic personalities. The role of narcissistic personality in influencing entrepreneurial intention has been confirmed. Therefore, the institutions should improve the narcissistic personalities of college students by providing them opportunities to present themselves in teaching. Teachers and all walks of life should respect and recognize college students, etc. Entrepreneurship research groups can be formed to study effective methods to improve narcissistic personality. Besides, higher vocational colleges can make more efforts to help college students develop the skills and abilities needed for starting businesses and develop their ability to accept defeat. Furthermore, when assigning homework, teachers can appropriately assign some open-ended tasks to students for improving their open-mindedness and allowing them to report and summarize. Second, the impact of entrepreneurial self-efficacy on entrepreneurial intention has also been confirmed. Therefore, higher vocational colleges can conduct regular lectures

of entrepreneurs and alumni who have succeeded in starting businesses and ask them to share their experiences. The institutions can make these speakers as role models for college students with entrepreneurial intention and strengthen their entrepreneurial self-efficacy. Furthermore, higher vocational colleges can provide these students with targeted training in the skills and abilities needed for starting businesses. When students have a positive and high entrepreneurial self-efficacy, that is, they adopt positive attitudes toward starting businesses and facing challenges, their development of entrepreneurial intention is enhanced.

Limitations and Future Research Directions

This study has its limitations that inspire for future research. First, this study only considers the mechanisms influencing narcissistic personality, entrepreneurial self-efficacy, and entrepreneurial intention, but many factors affect entrepreneurial intention. For example, self-esteem has a significant impact on entrepreneurial intention in terms of an individual's psychology (Laguna, 2013; Chen et al., 2016); social environment plays a mediation role in the relationship between self-esteem and entrepreneurial intention in terms of an external environment (Elali and Al-Yacoub, 2016; Hockerts, 2017). Therefore, we suggest that future researchers can explore other variables that affect entrepreneurial intentions, or add predictors of theory of planned behavior to their research models, such as attitude, performed behavioral control, behavior, etc (Ajzen and Madden, 1986). Moreover, this

study was conducted only with college students from three higher vocational colleges in Beijing, China, and so, the inferences are relatively restricted. Expansion of the scope of respondents by investigating college students from other types of schools would further raise the value of relevant research.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Dhurakij Pundit University. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

S-YG designed the study, analyzed the data, and drafted the manuscript. JH assisted in analyzing and interpreting the data and participated in the revision of the manuscript. Both authors contributed to the study and approved the submitted version.

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Moderated Mediating Mechanism Effects of Chinese University Entrepreneurship Education on Independent Student Entrepreneurship

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Entrepreneurship education plays a mediating moderating role in independent entrepreneurship, especially for the fresh graduates where entrepreneurial knowledge charms. Based on the mediating effect model, this study explores the correlation between three factors and independent entrepreneurship. A set of hypotheses was established by investigating the theoretical background within the field of interest. Such hypotheses were later assessed by an online-offline mix study conducted among graduates. The result found that entrepreneurship theory-based courses can promote independent entrepreneurship, but entrepreneurship practice training surprisingly failed to promote. Entrepreneurial opportunity identification mediated only between theory-based courses and independent entrepreneurship. The findings found could be highly beneficial in organizing entrepreneurship syllabus, scientifically arranging a theory-based course, and practicing a training course. Moreover, it could be further developed into a pedagogical model.

Keywords: moderated mediating mechanism, independent entrepreneurship, entrepreneurship education, entrepreneurship opportunity identification, entrepreneurial experiences

INTRODUCTION

Our generation is currently confronting huge challenges such as disease controls, poverty threatens, and economic unsustainability. The promotion of independent entrepreneurship can play a vital role in addressing these challenges (Stephan et al., 2016). Since 2015, the Chinese government has successively issued a number of documents and then launched work plans related to the reform of entrepreneurship education in the universities, aiming at gradually improving the entrepreneurship assistance policy. Meanwhile, the entrepreneurship education system has been reformed, attempting to transfer its main character from academic training to cultivated independent entrepreneurs. According to the *Employment Report of Chinese College Students (Employment Blue Book)*, Chinese university students who have chosen to start their own businesses during a postgraduation period of 3 years have risen from 5.7% in 2015 to 8.1% in 2019. Achievements have been made, whereas the self-employment rate of Chinese university students is not optimistic, and independent entrepreneurship right after graduation has dropped from 3.0% in 2015 to 2.7% in 2019

(Mycos Research Institute, 2016, 2017, 2018, 2019, 2020). Students were able to achieve a better understanding of a panorama with decisions that were not a decent match for their personalities or goals in life. It would be a beneficial effect despite the drop in entrepreneurial activity.

Regarding independent entrepreneurship, scholars have explored the possibility to reveal a certain relationship between entrepreneurship factors and independent entrepreneurship. The studies have focused on entrepreneurship education (Huang et al., 2020), entrepreneurship policy (Graevenitz et al., 2010), and entrepreneurship culture. The entrepreneurship education featured the least flexibility to meet the requirement of cultivating a successful independent entrepreneur due to the technical, administrative, and legal problems in entrepreneurship education reform at the national level. However, based on the logical relationship between entrepreneurial education and entrepreneurial opportunity identification, it is rare to explore the moderating mechanism of entrepreneurial education on independent entrepreneurship. This study analyzes the mechanism of entrepreneurial education on independent entrepreneurship from the mediating effect of entrepreneurial opportunity identification and the moderating mechanism of entrepreneurial experience between entrepreneurial opportunity identification and independent entrepreneurship. The current pandemic has had a wide range of negative impacts on public health, social structure, and economic activities. The 2020/2021 GEM Global Report (Global Entrepreneurship Monitor, 2021) has pointed out that entrepreneurial intention is urgently needed for younger entrepreneurs. However, the digital featured new entrepreneurial activities are also more likely to encourage young entrepreneurs (Radović-Marković et al., 2009). The studies usually span at least 3 years, in both government official release and academic paper published. But the global situation requires more timely entrepreneurial studies to release the key to global economic recovery, just as vaccination is the key to global health recovery. The sampling in this study has covered students who have received entrepreneurship education within 1 year after graduation, as it has tried to present entrepreneurial details among those being actively impacted by entrepreneurship education. Such effect will decay over time after graduation, and then the 1-year window was chosen in the cross-sectional study design.

LITERATURE REVIEW

Independent Entrepreneurship

Shane and Venkataraman (2000) have defined entrepreneurship as a process that includes the discovery, identification, measurement, and utilization of entrepreneurial opportunities. It is the result of the joint action of individual endogenous and external supporting factors (Lim et al., 2016). Independent entrepreneurship, as independently exploits the contents of entrepreneurship (Margolis, 2014), is widely used in entrepreneurship-related research (Clark and Drinkwater, 2010; Kwon et al., 2013; Falco and Haywood, 2016). For example, Ajzen (1991) has constructed a model of the correlation between

entrepreneurial behavior and entrepreneurial willingness based on the theory of planned behavior. The model considers that the emergence of entrepreneurial behavior is influenced by the factors of individuals, such as ability and attitude, and external environment, such as social norms. In terms of internal factors, entrepreneurs identify new entrepreneurial opportunities based on their own knowledge accumulation and practical experience and then decide whether to conduct independent entrepreneurship (Zampetakis et al., 2017). For external factors, the implementation of entrepreneurial behavior is influenced by the entrepreneurial experience of family members (Giannetti and Simonov, 2009), the level of educational institutions (Hrsmann and Daghbashyan, 2014), and the overall entrepreneurial atmosphere of society (Shirokova et al., 2016). In addition, Fayolle et al. (2006) believed that entrepreneurship education would affect the behavior of independent entrepreneurship of college students. For instance, entrepreneurship education can improve entrepreneurial willingness. Students specialized in science and engineering have better entrepreneurial abilities after receiving entrepreneurship education (Liu et al., 2019). The influence of different types of entrepreneurship education on entrepreneurship behavior implementation is also different. For example, there are significant differences in the tendency of choosing independent entrepreneurship between the students receiving entrepreneurship theory education and those who receive entrepreneurship practice training (Panagiotis and Dimo, 2014).

Entrepreneurship Education

Entrepreneurship education refers to the theory that teachers pass entrepreneurial knowledge and skills to the students (Gorman et al., 1997) and practice training in the hands-on activities (Rideout and Gray, 2013). The impact of entrepreneurial education was and still is everywhere, from an entity such as enterprises (Dana et al., 2021) to an abstract concept such as economic transition (Rachwal et al., 2016). Theory-based entrepreneurship education plays a fundamental role in entrepreneurship education (Fiet, 2001; Salamzadeh et al., 2014; Gorostiaga et al., 2019), which is helpful to improve the rate of independent entrepreneurship of college students (Zhao et al., 2005; Vukmirović, 2019), entrepreneurial ability (Detienne and Chandler, 2004), and entrepreneurial willingness (Wannamakok and Liang, 2019; Botha, 2020). Entrepreneurial practice can avoid the disconnection between entrepreneurial knowledge and entrepreneurial practice (Salamzadeh et al., 2013; An and Xu, 2021). Besides, entrepreneurial practice has a significant impact on the improvement of entrepreneurial ability (Morris et al., 2013). Both types of education can be regarded as taking a class in person or online (Radović-Marković et al., 2009), while the practice training features various formalities such as street vending, entrepreneurial contest, and internship. Durations for theory-based courses and practice-based courses are not strictly stipulated, but theory-based courses last generally longer for most Chinese universities. The ultimate purpose of a successful course design for college entrepreneurship education should be at satisfying industrial expectations (Wu and Chen, 2019).

Entrepreneurial Opportunity Identification

There has been an important and long-term debate over entrepreneurial opportunities whether they should be recognized as being objective or subjective. The discovery views believed that opportunity is an objective existence that needs to be discovered (Hayek, 1937; Casson, 1982; Krueger, 2000; Shane and Venkataraman, 2000). The creation views suggested that entrepreneurial opportunity was a subjective procedure generated in the entrepreneurial interaction (Schumpeter, 1934, 1942; Alvarez and Barney, 2013). Despite the disagreement between the discovery views and creation views, a consensus has been reached to define entrepreneurial opportunities, i.e., the phrasing may vary, and entrepreneurial opportunities should be competitive situations in which goods and services can be introduced and sold at greater than their cost of production (McBride and Wuebker, 2021). Under the perspective of the creation viewpoint, every opportunity was supposed to be constructed, which was spontaneously exploitable to the entrepreneur, regardless of the identification procedure. Thus, entrepreneurial opportunity identification could only be linked to the discovery or recognition. The core of entrepreneurial opportunity identification was associated with information processing that was shaped by personally relevant factors such as knowledge acquired, growth environment, and innovation sparks (Vaghely and Julien, 2010). When opportunity got perceived, the ability of entrepreneurial opportunity identification directly affects the result of entrepreneurship (Krueger, 2000). To a certain extent, they affect the achievement of entrepreneurship goals or entrepreneurial benefits (Garud and Giuliani, 2013).

Entrepreneurial Experience

Entrepreneurial experience refers to the entrepreneurial activities carried out by entrepreneurs before the establishment of a new enterprise (Stuart and Robert, 1990). It not only helps individuals to acquire entrepreneurial knowledge and skills from past experience (Tornikoski and Newbert, 2007), as well as master valuable market and product information (Clarysse et al., 2013), but also helps entrepreneurs to identify entrepreneurial opportunities in related fields (Yu et al., 2021). Entrepreneurial experience can affect the behavior of entrepreneurs (Tihula and Huovinen, 2010), for example, it can affect the individual judgment on the feasibility of entrepreneurial opportunities (Canavati et al., 2021), give full play to the ability of entrepreneurial opportunity identification (Ucbasaran et al., 2003), and improve entrepreneurial willingness (Graevenitz et al., 2010).

RESEARCH HYPOTHESIS

For university students with entrepreneurial intentions, entrepreneurship education can provide them with the knowledge to carry out their own entrepreneurial activities (Wilson et al., 2007). It also has a positive impact on the choice of independent entrepreneurship. Entrepreneurship curricular teaching plays a positive role in developing entrepreneurial

willingness (Fayolle and Gailly, 2013) and entrepreneurial ability of students (Jones et al., 2017). Entrepreneurial practice activities help to improve the entrepreneurial ability and willingness of college students, guiding them to start their own businesses (Fiore et al., 2019). Therefore, the following hypotheses were proposed:

H1a: Entrepreneurship theory-based course is positively related to independent entrepreneurship.

H1b: Entrepreneurship practice training is positively related to independent entrepreneurship.

Entrepreneurial opportunity identification can be cultivated through entrepreneurial education (Itelvino et al., 2018). It is discovered that entrepreneurial courses and entrepreneurial practice training have positive effects on the cultivation of entrepreneurial opportunity identification ability. For example, based on a Solomon-Four-Group-Designed experiment, entrepreneurship theory-based courses have a positive effect on entrepreneurial opportunity identification (Detienne and Chandler, 2004). Entrepreneurship practice training will help students to grasp opportunities in the entrepreneurial environment full of risks and uncertainties (Neck and Greene, 2011). Therefore, the following hypotheses were proposed:

H2a: Entrepreneurship theory-based course is positively related to entrepreneurial opportunity identification.

H2b: Entrepreneurial practice training is positively related to entrepreneurial opportunity identification.

As a prerequisite for the implementation of entrepreneurial behavior, entrepreneurial opportunity identification has a positive impact on the choice of individuals to start their own business (Alvarez et al., 2013), especially for college students. Fitzsimmons and Douglas (2011) performed an analysis of 414 MBA students from Australia, China, India, and Thailand, and it was transpired that the higher the entrepreneurial opportunity identification ability can lead to stronger independent entrepreneurship tendency. Therefore, the following hypothesis was proposed.

H3: Entrepreneurial opportunity identification is positively related to independent entrepreneurship.

After receiving entrepreneurship education, the entrepreneurial opportunity identification ability of college students has been improved (Itelvino et al., 2018). This ability helps college students to identify and use entrepreneurial opportunities in the market to carry out independent entrepreneurship. Therefore, entrepreneurial opportunity identification plays a mediating role between entrepreneurship education and independent entrepreneurship (Gielnik et al., 2013). In addition, after statistical analysis of the questionnaire data of 291 college students from six universities in Palestine, it was found that entrepreneurial opportunity identification had a mediating function between entrepreneurship education and the choice of independent entrepreneurship (Nidal and Norashidah, 2017). Combined with hypotheses **H2a**, **H2b**, and **H3**, when

entrepreneurship theory-based course and entrepreneurship practice training were set as antecedents, entrepreneurial opportunity identification had a mediating effect between them and independent entrepreneurship. Therefore, the following hypotheses were proposed:

H4a: Entrepreneurial opportunity identification plays a mediating role between entrepreneurial theory-based courses and independent entrepreneurship.

H4b: Entrepreneurial opportunity identification plays a mediating role between entrepreneurial practice training and independent entrepreneurship.

Compared with those without entrepreneurial experience, entrepreneurs with entrepreneurial experience have a higher identification level of entrepreneurial opportunities and are more likely to seize valuable entrepreneurial opportunities (Ucbasaran et al., 2003). In addition, entrepreneurs with entrepreneurial experience can also identify the authenticity of entrepreneurial opportunities through their experience (Baldacchino, 2013). In view of the improvement of entrepreneurial opportunity identification level, college students with entrepreneurial experience will better understand entrepreneurship and then choose to start their own business (Graevenitz et al., 2010). Therefore, the following hypothesis was proposed:

H5: Entrepreneurial experience plays a positive moderating role between entrepreneurial opportunity identification and independent entrepreneurship.

Taking hypotheses **H4a**, **H4b**, and **H5** into consideration, it was recognized that college students holding entrepreneurial experience could have a higher level of entrepreneurial opportunity identification ability, in comparison with those who have never attached such entrepreneurial experience. Meanwhile, based on the accumulation of knowledge in the process of entrepreneurship education, college students with entrepreneurial experience could have advantages in terms of applying theoretical knowledge to practice and seizing entrepreneurial opportunities from practice, namely the implementation of independent entrepreneurship action. Therefore, the following hypotheses were proposed:

H6a: Entrepreneurial experience positively moderates the mediating effect of entrepreneurial opportunity identification on the relationship between entrepreneurial course and independent entrepreneurship.

H6b: Entrepreneurial experience positively moderates the mediating effect of entrepreneurial opportunity identification on the relationship between entrepreneurial practice training and independent entrepreneurship.

The theoretical model and calculation formula used in this study were exhibited as **Figure 1**.

$$Y = c_0 + c_{11}X_1 + c_{12}X_2 + e_1 \quad (1)$$

$$W = a_0 + a_{11}X_1 + a_{12}X_2 + e_2 \quad (2)$$

$$Y = c'_0 + c'_{11}X_1 + c'_{12}X_2 + b_1M + e_3 \quad (3)$$

$$Y = b_0 + bW + e_4 \quad (4)$$

$$Y = b_0 + c'W + b'_1M + b'_2WM + e_5 \quad (5)$$

$$Y = c''_0 + c''_{11}X_1 + c''_{12}X_2 + c'_2W + b_2M + b_3WM + e_6 \quad (6)$$

MATERIALS AND METHODS

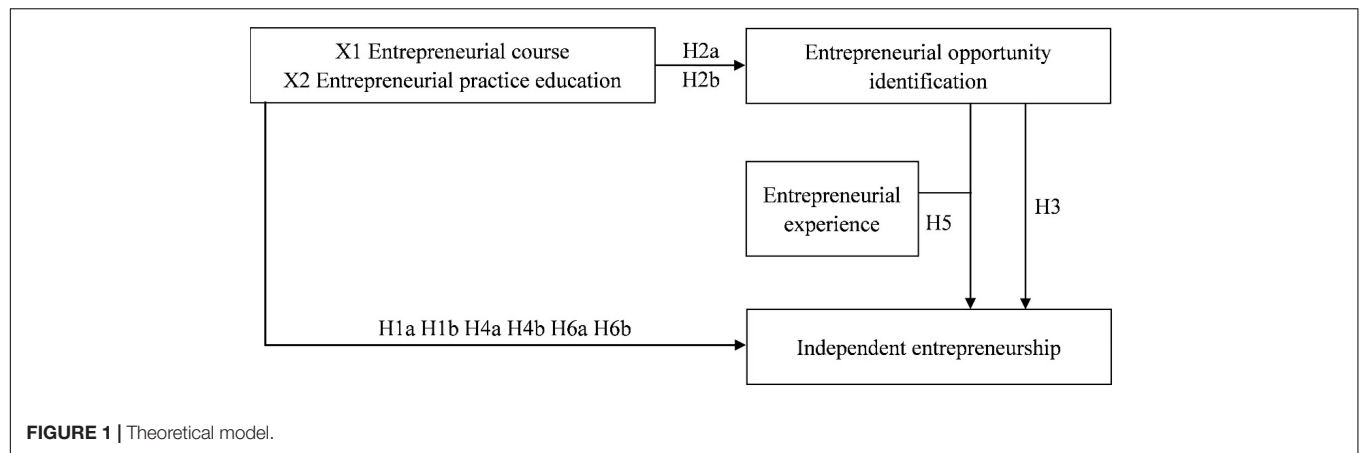
Sampling

The sample used in this study was obtained by the China Institute of Innovation and Entrepreneurship Education through online surveys and offline interviews for 6,424 graduates with a postgraduation period not more than 1 year of graduation. An online invitation with the quick response (QR) code was sent out to the 5,000 graduates provided by the collaborating universities, outlining the brief purpose of the study. Corresponding data could be accumulated directly. The offline interview has followed the same pattern and the same questionnaire, and the interviewees were recruited by the administrative staff on campus during alumni gatherings. A total of 1,424 pieces of written questionnaires were recovered. The questions were elaborately generated, combining the coverage of core variables and the convenience of understanding and answering.

The data collection was performed within 31 provinces across China between 2017 and 2018. The output was shown as follows. For gender, 45.3% were men and 54.7% were women. For entrepreneurial experience, 34.4% of the respondents had an experience of establishing a start-up during their studentship period. They recognized its positive inspiration. Notably, 16.3% of the respondents had declared their willingness to start their own business, as the most favorable postgraduation choice; 10.7% of sampled graduates were from the provincial capital cities or province-level municipalities; 24.2% of the surveyed sample confirmed that their parents or other immediate family members have experienced entrepreneurship; and 27.0% of samples specialized in engineering and 13.1% graduated from "Double First-class" top universities. Refer **Tables 1, 2**.

Measurement of Variables

On the basis of a well-established scale among existing studies, combined with the results of in-depth semi-structured interviews of scholars in the field of entrepreneurship education, the questionnaire for this study was designed after three rounds of modification and testing. The variables used in the research and analyses were derived from elements that have been recognized in the Pedagogy and widely applied. These variables were constructed based on the fundamentals in the mainstream field of interest to ensure validity, attempting to offer a panorama for the study. The content has covered entrepreneurial spirit, entrepreneurship theory-based course, and entrepreneurship

**TABLE 1 |** Distribution of majors.

Major	Quantity	Major	Quantity	Major	Quantity
Philosophy	66 (1.03%)	History	45 (0.70%)	Military	7 (0.11%)
Economics	888 (13.82%)	Science	579 (9.01%)	Management	1254 (19.52%)
Law	150 (2.33%)	Engineering	1734 (26.99%)	Art	272 (4.23%)
Pedagogy	355 (5.53%)	Agronomy	141 (2.19%)		
Literature	312 (4.86%)	Medicine	621 (9.67%)	Total	6424

TABLE 2 | Distribution of demographics.

Eastern	Quantity	Central	Quantity	Western	Quantity
Beijing	80 (1.25%)	Shanxi	125 (1.95%)	Sichuan	529 (8.23%)
Tianjin	327 (5.09%)	Inner Mongolia	9 (0.14%)	Guizhou	55 (0.86%)
Hebei	216 (3.36%)	Jilin	30 (0.47%)	Yunnan	60 (0.93%)
Liaoning	360 (5.60%)	Heilongjiang	200 (3.11%)	Tibet	2 (0.03%)
Shanghai	125 (1.95%)	Anhui	195 (3.04%)	Shaanxi	373 (5.81%)
Jiangsu	179 (2.79%)	Jiangxi	195 (3.04%)	Gansu	42 (0.65%)
Zhejiang	622 (9.68%)	Henan	667 (10.38%)	Qinghai	34 (0.53%)
Fujian	91 (1.42%)	Hubei	73 (1.14%)	Ningxia	0 (0.00%)
Shandong	1418 (22.07%)	Hunan	54 (0.84%)	Xinjiang	8 (0.12%)
Guangdong	111 (1.73%)	Guangxi	54 (0.84%)		
Hainan	86 (1.34%)	Chongqing	104 (1.62%)		
Eastern Total	3615 (56.27%)	Central Total	1706 (26.56%)	Western Total	1103 (17.17%)

practice training. Except for certain demographic characteristics and options requiring special clarification, the scales used in this study were in Likert 5-score measurement. Score 1 represented strongly disagree, while Score 5 was strongly agree. All the data were statistically processed using SPSS.

Entrepreneurship theory-based course questions were designed with reference to certain publications (Hosseini and Pouratashi, 2011; Wiley and Berry, 2015). Three measurement items were included, which were “diversified types of entrepreneurship education courses,” “closely integrated with major,” and “closely integrated era trends.”

Entrepreneurship practice training questions were designed with reference to certain publications (Greefs, 1998; Dos-Santos and Spann, 2011; Zou and Zhao, 2014). Five measurement items were included, which were “exclusive funding provided,” “integrated entrepreneurial practice services provided,” “independent entrepreneurship park provided,” “exclusive off-campus practice base provided,” and “practice projects highly integrated with professional learning.”

Entrepreneurial opportunity identification question was designed with reference to the 2017 GEM report “U: whether the respondent thinks there are good opportunities for starting a business in their local area.” Entrepreneurial opportunity identification was indicated by “good entrepreneurial opportunities in the local province.”

Virtual variables were used to measure entrepreneurial experience. For the question “among all the entrepreneurial practice activities you have participated in during school, which has helped you more,” digit 1 was marked for response “start a company outside school,” and the rest was recorded as 0.

Virtual variables were also used to measure independent entrepreneurship. For the question “the most favorable postgraduation choice,” digit 1 was marked for response “independent entrepreneurship,” and the rest was recorded as 0.

In terms of variable control, referring to the relevant research on college student independent entrepreneurship, four variables were selected, including gender, family entrepreneurship experience, major type (limited to engineering), and university type (limited to “Double First-class” top universities).

Test for Reliability and Validity

The overall results derived from the test for reliability and validity were described as $\alpha = 0.921$ and Kaiser-Meyer-Olkin (KMO) = 0.945, indicating that the overall scale has demonstrated

decent reliability and validity. The value of α was larger than 0.7, leading to the fact that the reliability test and validity test results of each factor (refer to **Table 3** for details) have all passed the internal consistency test, indicating that the reliability of each factor scale was satisfying. The KMO measure and Bartlett sphere test showed that all variables pass the test (KMO > 0.5), which met the factor analysis standard. The results of exploratory factor analysis showed that the factor load after item rotation was greater than 0.6, the combined reliability (CR) of all factors was greater than 0.7, and the average variance extracted (AVE) value of all factors was greater than 0.5. Each of the abovementioned three standards has clarified that the scale designed then utilized in the study had outstanding convergence validity.

Descriptive Statistics and Correlation Analysis

Each variable was paired to the rest of the variables for the calculation of variance dilation factor (VIF). Every VIF was less than 5, representing that multicollinearity did not happen. The results are shown in **Table 4**. Entrepreneurship theory-based course, entrepreneurship practice training, entrepreneurial opportunity identification, and entrepreneurship policy were positively correlated with independent entrepreneurship.

Considering the insufficiency of Harman’s single factor test, confirmatory factor analysis was performed to exclude the homology bias. The results are shown in **Table 5**. Among them, the single factor latent variable model with each item had a poor fitting, which indicated that common variance deviation was not detected among the variables used in this study. By comparing the fitting degree of the five-factor model and the four-factor model, it was found that the five-factor model used in this study was better than the four-factor model. In addition, the common method variance (CMV) was tested by setting nonmeasurable potential method factors. The output was found that the fitting statistics of the model did not appear obvious optimization, which further showed that the homologous method problem of the data used in this study was controlled, and the fitting degree of the model was satisfying.

EMPIRICAL ANALYSIS

Considering that the dependent variable selection of independent entrepreneurship was a binary variable, which could not be tested

TABLE 3 | The reliability and validity of each factor.

Factor	Item	Factor load	r^2	KMO	α	CR	AVE
Entrepreneurial course	Diversified types	0.811	83.59%	0.738	0.902	0.904	0.759
	Integration with major	0.893					
	Integration with era trends	0.907					
Entrepreneurial practice training	Exclusive entrepreneurship park	0.860	82.89%	0.910	0.948	0.949	0.787
	Exclusive off-campus practice base	0.900					
	Integration with professional knowledge	0.905					
	Exclusive funding	0.854					
	Entrepreneurial practice services provided	0.915					

TABLE 4 | Statistical parameters for each variable.

Variables	A	B	C	D	E	F	G	H	I
A	1								
B	−0.133**	1							
C	0.124**	−0.034**	1						
D	−0.045**	−0.316**	−0.078**	1					
E	−0.095**	−0.101**	−0.069**	0.235**	1				
F	0.089**	−0.042**	0.108**	−0.007	−0.056**	1			
G	0.071**	−0.021	0.082**	0.024	−0.002	0.818**	1		
H	0.120**	−0.022	0.145**	−0.060**	−0.104**	0.471**	0.433**	1	
I	0.060**	−0.114**	0.062**	0.009	−0.005	0.054**	0.047**	0.053**	1
Mean	0.160	1.550	0.240	0.270	0.130	3.555	3.688	3.180	0.340
Std Dev	0.370	0.498	0.428	0.444	0.337	0.925	0.906	0.994	0.475

** $p < 0.01$.

A, Independent entrepreneurship. B, Gender. C, Family entrepreneurship experience. D, Major type (Engineering). E, University type (Double First-class). F, Entrepreneurship theory-based course. G, Entrepreneurship practice training. H, Entrepreneurial opportunity identification. I, Entrepreneurial experience.

TABLE 5 | Validation factor analysis.

Model	χ^2/DF	CFI	GFI	AGFI	RMSEA	IFI	NFI
Single-factor	80.416	0.934	0.896	0.844	0.111	0.934	0.934
Four-factor	84.314	0.936	0.898	0.836	0.114	0.936	0.935
Five-factor	21.837	0.986	0.977	0.959	0.057	0.986	0.985
CMV	23.887	0.986	0.978	0.955	0.060	0.986	0.986

by structural equation model and the plug-in called process, this study conducted multiple hierarchical regression analysis on the sampled data to verify the hypotheses. Among them, Models 1–6 were logistic regression with independent entrepreneurship as a dependent variable, and Models 7 and 8 were linear regression with entrepreneurial opportunity identification as a dependent variable.

Main Effect Test

The regression coefficient of *X1 Entrepreneurship theory-based course* and *Y Independent entrepreneurship* was significantly positive ($\beta = 0.141$, $p < 0.05$). The effect of *X2 Entrepreneurship practice training* on *Y Independent entrepreneurship* was not significant ($\beta = 0.053$, $p > 0.05$). Derived from such results, hypothesis **H1a** was corroborated, and **H1b** was not supported. Refer **Table 6**.

Mediating Effect Test

By substituting each index into formula (1), formula (2), and formula (3), the analysis results of Model 2, Model 3, and Model 7 were obtained. The direct effect of *X1 Entrepreneurship theory-based course* on *Y Independent entrepreneurship* was not significant ($\beta = 0.073$, $p > 0.05$). *X1 Entrepreneurial course* had a significantly positive impact on *M Entrepreneurial opportunity identification* ($\beta = 0.323$, $p < 0.01$). *M Entrepreneurial opportunity identification* had a significantly mediating effect on the relationship between *X1 Entrepreneurial course* and *Y Independent entrepreneurship* ($\beta = 0.217$, $p < 0.01$). Consequently, both hypotheses **H2a** and **H4a** were corroborated. As hypothesis **H1b** was not supported, it was impossible to

test the mediating effect through the step-by-step method. However, *X2 Entrepreneurial practice training* had a significantly positive impact on *M Entrepreneurial opportunity identification* ($\beta = 0.160$, $p < 0.01$). It was revealed that hypothesis **H2b** was corroborated, while **H4b** was falsified. Refer **Table 7**.

To ensure the accuracy of the test, according to the study by Zhao et al. (2010), the product of coefficients was directly tested by bootstrap analysis with 1,000 samples (Felsenstein, 1985). The results showed that the interaction between *X1 Entrepreneurial course* and *M Entrepreneurial opportunity identification* was significant (95% CI = 0.035–0.077); thus, hypothesis **H4a** was supported.

Moderated Effect Test

By substituting each index into formula (4), the analysis results of Model 4 showed that *M Entrepreneurial opportunity identification* had a significantly positive impact on *Y Independent entrepreneurship* ($\beta = 0.259$, $p < 0.01$). Thus, hypothesis **H3** was supported. By substituting each index into formula (5), the results of Model 5 demonstrated that the interaction between *M Entrepreneurial opportunity identification* and *W Entrepreneurial experience* had a significantly positive regression ($\beta = 0.250$, $p < 0.05$). The hypothesis **H5** was corroborated. Refer **Table 8**.

Moderated Mediating Effect Test

According to the analysis results of Models 2 and 8, each index was substituted into formula (6) to get the analysis results of Model 5. Under the moderation of *W Entrepreneurial experience*, the direct effect of the *X1 Entrepreneurial course* on *Y Independent entrepreneurship* was not significant ($\beta = 0.070$,

TABLE 6 | Parameters for main effect test.

Independent variable	Dependent variable	β	Result
X1 Entrepreneurship theory-based course	Y Independent entrepreneurship	0.141	H1a corroborated
X2 Entrepreneurship practice training	Y Independent entrepreneurship	0.053	H1b falsified

TABLE 7 | Parameters for mediating effect test.

Independent variable	Dependent variable	β	Result
X1 Entrepreneurship theory-based course	Y Independent entrepreneurship	0.073	H2a H4a corroborated
X1 Entrepreneurship theory-based course	M Entrepreneurial opportunity identification	0.323	
M Entrepreneurial opportunity identification	X1 Entrepreneurship theory-based course Y Independent entrepreneurship	0.217	H2b corroborated H4b falsified
X2 Entrepreneurial practice training	M Entrepreneurial opportunity identification	0.160	

TABLE 8 | Parameters for moderated effect test.

Independent variable	Dependent variable	β	Result
M Entrepreneurial opportunity identification	Y Independent entrepreneurship	0.259	H3 corroborated
M Entrepreneurial opportunity identification	W Entrepreneurial experience	0.250	H5 corroborated

$p > 0.05$). *M Entrepreneurial opportunity identification* had a significantly mediating effect on the relationship between *X1 Entrepreneurial course* and *Y Independent entrepreneurship* ($\beta = 0.151$, $p < 0.01$). The interaction between *M Entrepreneurial opportunity identification* and *W Entrepreneurial experience* had significantly positive regression ($\beta = 0.247$, $p < 0.05$). Through the stepwise test, there was a moderating mediating effect emerged, and it showed positive regulation, namely, hypothesis **H6a** was supported. Hypothesis **H1b**, which should be a prerequisite for testing the moderating mediating effect using the stepwise method, was falsified. It is naturally transpired that **H6b** was also falsified.

To ensure the accuracy of the test, a 1,000-sample bootstrap analysis was conducted on the coefficient product of each variable with moderated mediating effect. It was found that the interaction items of *X1 Entrepreneurship theory-based course*, *M Entrepreneurship opportunity identification*, and *W Entrepreneurship experience* were significant (95% CI = 0.030–0.096). Hypothesis **H6a** was firmly corroborated. Refer **Table 9**.

DISCUSSION

The analysis results are shown in **Table 10**. According to the analysis of hypothesis **H1a**, entrepreneurship theory-based course had a significantly positive effect on independent entrepreneurship. After years of development, the content and form of entrepreneurship education in China are currently mature and perfect along with the socioeconomic rapid

alteration. It has been derived from the lectures, case analyses, and other classic teaching approaches to the modern teaching modules including entrepreneurship plan design, case analysis contest, entrepreneurship project consultation, and workshops closely following the frontier of social focus (Charney and Libecap, 2000). Rich teaching content and diversified teaching forms have helped students to acquire more entrepreneurial knowledge. In terms of teaching forms, 50.08% of the respondents scored 3–5 points for “diversified types of courses.” The diversity of teaching methods has been recognized. Notably, 69.35% of the respondents had received case teaching and thought it was effective, 18.47% had attended exclusive lectures, 45.47% had participated in group discussion, 73.29% had carried out simulation practice, and 7.95% had studied online courses. In terms of teaching content, 53.50% of them scored 3–5 points for “entrepreneurship theory-based course content is closely combined with era trends.” Therefore, due to the increasingly diversified teaching methods and contents, different groups of students could find suitable learning methods and contents catering to their own interests and research directions, so as to obtain the knowledge and skills needed for independent entrepreneurship.

Entrepreneurship practice training had no significantly positive effect on independent entrepreneurship, which falsified hypothesis **H1b**. It is a highly counter-intuitive result as it has been widely believed that practice puts forward entrepreneurial activities. In this survey, 78.80% of the respondents scored 1–3 on “You think you have got enough knowledge, skills, and experience to start a business,” which, to a certain extent, reflected

TABLE 9 | Parameters for moderated mediating effect test.

Independent variable	Dependent variable	β	Result
X1 Entrepreneurial course	Y Independent entrepreneurship	0.070	H6a corroborated
M Entrepreneurial opportunity identification	X1 Entrepreneurial course Y Independent entrepreneurship	0.151	H6b falsified
M Entrepreneurial opportunity identification	W Entrepreneurial experience	0.247	

TABLE 10 | Multilevel regression analysis.

Variable	Y Independent entrepreneurship						M Entrepreneurship opportunity identification	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Gender	−0.873** (0.073)	−0.875** (0.073)	−0.847** (0.073)	−0.852** (0.073)	−0.870** (0.074)	−0.827** (0.074)	−0.079** (0.026)	−0.048* (0.023)
Family entrepreneurship experience	0.620** (0.074)	0.576** (0.074)	0.537** (0.075)	0.545** (0.075)	0.533** (0.075)	0.526** (0.075)	0.312** (0.029)	0.203** (0.025)
Major (Engineering)	−0.418** (0.087)	−0.419** (0.087)	−0.404** (0.087)	−0.402** (0.087)	−0.401** (0.087)	−0.403** (0.087)	−0.091** (0.030)	−0.102** (0.026)
University Type (Double First-class)	−0.964** (0.141)	−0.964** (0.141)	−0.899** (0.141)	−0.902** (0.141)	−0.901** (0.141)	−0.899** (0.142)	−0.263** (0.037)	−0.210** (0.033)
X1 Entrepreneurial Course		0.141* (0.063)	0.073 (0.065)			0.070 (0.065)		0.323** (0.019)
X2 Entrepreneurship Practice training		0.053 (0.063)	0.014 (0.064)			0.013 (0.064)		0.160** (0.019)
M Entrepreneurship Opportunity Identification			0.217** (0.041)	0.259** (0.036)	0.190** (0.047)	0.151** (0.050)		
W Entrepreneurial experience					−0.334 (0.258)	−0.332 (0.257)		
M × W					0.250* (0.120)	0.247* (0.120)		
Hosmer-Lemeshow test	0.346	0.813	0.385	0.650	0.110	0.690		
R ²							0.032	0.246
F							53.137	349.269

* $p < 0.05$, ** $p < 0.01$.

that those students, which have received entrepreneurial practice training realized their existing knowledge accumulation and ability training, were insufficient to tackle the risks and difficulties in the entrepreneurial process, leading to more cautious considerations in choosing independent entrepreneurship. Such a result intimated that college students may not choose to be independent entrepreneurship after participating in entrepreneurial practice. It revealed an unprecedented finding that happened after graduation.

According to the analysis of hypothesis **H2a**, entrepreneurship theory-based course had a significantly positive impact on the cultivation of entrepreneurial opportunity identification. In this survey, 20.00% of the respondents thought that the entrepreneurship theory-based course received on campus was the most helpful to improve their entrepreneurial ability, which showed the importance of entrepreneurship theory-based course to cultivate their entrepreneurial ability to a certain extent. Notably, 47.56% of the respondents scored 3–5 points in “entrepreneurship curriculum content is closely combined with major,” indicating that students recognized the rationality of teaching content within the curriculum. Entrepreneurship education content based on professional knowledge can be handier to assist students by essentially combining professional knowledge and entrepreneurship knowledge and then further cultivating the ability to identify entrepreneurial opportunities.

According to the analysis of hypothesis **H2b**, entrepreneurial practice training had a significantly positive impact on entrepreneurial opportunity identification ability. The university provided students with entrepreneurship contests (43.24% participation), practice in the campus entrepreneurship park (57.22% participation), entrepreneurship simulation training camp (34.34% participation), and enterprise management internship (44.75% participation). In addition, 53.50% of the respondents confirmed that entrepreneurship practice during studentship was most helpful to improve their entrepreneurial opportunity identification ability.

According to the analysis results of hypotheses **H1a**, **H2a**, and **H4a**, the total effect of entrepreneurship theory-based course on independent entrepreneurship was significant, the mediating effect of entrepreneurial opportunity identification was also significant, and the 95% CI of the interaction between entrepreneurship theory-based course and entrepreneurial opportunity identification did not contain 0. The mediating effect test and bootstrap analysis confirmed that entrepreneurial opportunity identification played a mediating role between entrepreneurial course and independent entrepreneurship. In addition, as the direct effect of entrepreneurship theory-based course on independent entrepreneurship was not significant, the mediating effect was exhibited as a full mediating effect. It represented that those entrepreneurial opportunities would be completely identified by entrepreneurship theory-based course, which indirectly affected the choice of independent entrepreneurship. This provided practical support for the current academic view that entrepreneurship education indirectly promoted students to start their own businesses by cultivating their entrepreneurial ability (Fayolle et al., 2006). According to the analysis results of hypotheses **H1b**, **H2b**,

and **H4b**, the total effect of entrepreneurial practice training on independent entrepreneurship was not significant, and the mediating role of entrepreneurial opportunity identification between entrepreneurial practice training and independent entrepreneurship could not be verified through the mediating effect test. Therefore, entrepreneurial opportunity identification could not play a mediating role between entrepreneurial practice training and independent entrepreneurship.

According to the analysis results of hypothesis **H3**, entrepreneurial opportunity identification had a positive impact on guiding college students to start their own businesses. In addition, according to the analysis results of hypothesis **H5**, the interaction between entrepreneurial opportunity identification and entrepreneurial experience had a significantly positive effect on independent entrepreneurship. Entrepreneurial experience played a positive moderating role between entrepreneurial opportunity identification and the choice of independent entrepreneurship. Specifically, college students with entrepreneurial experience have accumulated entrepreneurial experience, and their entrepreneurial opportunity identification ability could be improved significantly after learning entrepreneurial knowledge and skills. They were more inclined to carry out independent entrepreneurship.

According to the analysis results of hypotheses **H1a**, **H2a**, and **H6a**, the mediating effect of entrepreneurial opportunity identification was still significant after adding entrepreneurial experience as a moderating variable. The 95% CI of the interaction among entrepreneurial course, entrepreneurial opportunity identification, and entrepreneurial experience did not contain 0, which meant that the mediating effect test and bootstrap analysis confirmed a moderated mediating effect model with the entrepreneurial course as the antecedent variable, entrepreneurial opportunity identification as the mediating variable, entrepreneurial experience as the moderating variable, and independent entrepreneurship as the dependent variable. In addition, as the direct effect of entrepreneurship theory-based course on independent entrepreneurship was not significant, the mediating effect was demonstrated as the full mediating effect between the entrepreneurship theory-based course and the choice of independent entrepreneurship.

CONCLUSION AND IMPLICATIONS

This study sampled fresh graduates who have received entrepreneurship education, through the construction of a moderated mediating model with entrepreneurship education as the antecedent variable. The role of entrepreneurship education in promoting college students to carry out independent entrepreneurship was analyzed, and the impact mechanism of entrepreneurial experience between entrepreneurial opportunity identification and independent entrepreneurship was verified. This study has raised and then tested several hypotheses. Hypotheses **H1a**, **H2a**, **H2b**, **H3**, **H4a**, **H5a**, **H5b**, and **H6a** were supported, while hypotheses **H1b**, **H4b**, and **H6b** were rejected. The result summary of hypothesis testing is shown in **Table 11**.

TABLE 11 | Summary of study hypothesis test results.

Hypothesis	Content	Conclusion
H1a	Entrepreneurship theory-based course positively related to independent entrepreneurship	Corroborated
H1b	Entrepreneurship practice training positively related to independent entrepreneurship	Falsified
H2a	Entrepreneurship theory-based course positively related to entrepreneurial opportunities identification	Corroborated
H2b	Entrepreneurship practice training positively related to entrepreneurial opportunities identification	Corroborated
H3	Entrepreneurship opportunity identification positively related to independent entrepreneurship	Corroborated
H4a	Entrepreneurial opportunity identification plays a mediating role between entrepreneurial course and independent entrepreneurship	Corroborated
H4b	Entrepreneurial opportunity identification plays a mediating role between entrepreneurial practice training and independent entrepreneurship	Falsified
H5	Entrepreneurial experience plays a positive moderating role between entrepreneurial opportunity identification and independent entrepreneurship	Corroborated
H6a	Entrepreneurial experience positively moderates the mediating effect of entrepreneurial opportunity identification on the relationship between entrepreneurial course and independent entrepreneurship	Corroborated
H6b	Entrepreneurial experience positively moderates the mediating effect of entrepreneurial opportunity identification on the relationship between entrepreneurial practice training and independent entrepreneurship	Falsified

Theoretical Implications

This study devoted three theoretical contributions to the mechanism of entrepreneurship education on college student independent entrepreneurship.

This research expanded new ideas of entrepreneurship education research. Previous studies on entrepreneurship education had shown that both entrepreneurship theory-based course and entrepreneurship practice training had exposed a positive role in promoting independent entrepreneurship. However, based on the data analysis of the questionnaire survey, this study confirmed that entrepreneurship theory-based course and entrepreneurship practice training had different impact directions. Entrepreneurship theory-based course had a significantly positive impact on independent entrepreneurship, while entrepreneurship practice training had not. But both entrepreneurship theory-based course and entrepreneurship practice training could generate a positive impact on the entrepreneurial opportunity identification. Therefore, this new research discovery expanded new ideas for the research of entrepreneurship education.

This research demonstrates that entrepreneurship education played an important role in entrepreneurial opportunity identification and indirectly promoted independent entrepreneurship. Previous studies on entrepreneurship education had majorly focused on the direct promotion of entrepreneurship education for college students (Fayolle et al., 2006). However, based on the data analysis of sampled graduates, this study finds that entrepreneurial opportunity identification played a complete mediating role between entrepreneurship curriculum education and independent entrepreneurship. Entrepreneurship theory-based course indirectly affects independent entrepreneurship through entrepreneurial opportunity identification, rather than directly promoting college students to choose independent entrepreneurship.

This research enriches the horizon on the process mechanism of entrepreneurship education affecting independent entrepreneurship. Previous studies on the mechanism of entrepreneurship education on independent entrepreneurship

were mostly based on the mediating role of opportunity identification (Nidal and Norashidah, 2017) or the moderating role of entrepreneurial experience (Shirokova et al., 2015), but studies in the field of mediating mechanism were severely inadequate (Wei et al., 2019). Through investigation and exploration, this study analyzes the correlation between entrepreneurship education, entrepreneurial opportunity identification, entrepreneurial experience, and independent entrepreneurship in different dimensions and demonstrated the existence of moderated mediating effect model with entrepreneurship theory-based course as the antecedent variable, entrepreneurial opportunity identification as the intermediary variable, entrepreneurial experience as the moderating variable, and independent entrepreneurship as the dependent variable, which enriched the affecting mechanism of entrepreneurship education on independent entrepreneurship.

Practical Implications

This study puts forward three practical implications for the mechanism of entrepreneurship education on independent entrepreneurship.

The teaching approaches of entrepreneurship theory-based course can be improved. By deepening the existing diversified entrepreneurship theory-based courses such as case analysis, exclusive lecture, group discussion, and simulation practice, online teaching of entrepreneurship theory-based course should be appropriately promoted to help different types of students find their own teaching content and obtain the relevant knowledge needed for entrepreneurship, so as to help them carry out independent entrepreneurship.

The form of entrepreneurship practice training should be expanded. On the basis of improving the existing entrepreneurial contest, on-campus entrepreneurial park practice, entrepreneurial simulation training camp, and other practice activities within the campus, off-campus practice activities should be appropriately developed, enterprise

management internship, for instance. Enriched forms of practical education provided conditions for college students to carry out practical activities and help them test whether it could be plausible for entrepreneurship at the minimum cost.

The support system for college students to start their own businesses should be improved. Cooperation between the university and local government/enterprise should be further strengthened to build a set of support systems, in terms of venues, funds, personnel, and policies, capable for the student to establish off-campus start-ups, as a method of willingness promotion.

Limitations and Prospects

Due to limitations such as funds, time, and other factors, the proportion of samples collected in this study was not satisfactorily abundant. Since this is a cross-sectional design study, the sampled data represented only the situation of college students who have received entrepreneurship education within 1 year after graduation instead of a more common period of 3–5 years. Although the variables used in the research and analyses were dedicated generated within the field of Pedagogy, they could not completely avoid the deviation caused by individual subjective opinions. Besides, there were no controlled variables, which possibly led to the deviation even when three rounds of test modification had been carried out.

In the future, this study can further discover the relationship between variables at different time points or periods. Top priority should be given to the in-depth comparative analysis in the follow-up studies. The collected data can be further compared with general university graduates in China to conduct a comparative analysis of data grouping and subspecialty. Moreover, diverse datasets to reexamine and multiexamine the relationship of the factors on the various background graduates can further be utilized to justify the entrepreneurial opportunity results. It is also practicable to explore the impact of other personal characteristics or situational factors as moderators on independent entrepreneurship, in order to find more moderators that can affect the relationship between entrepreneurship education, entrepreneurial opportunity identification, and independent entrepreneurship. It is worthy of considering

absorbing other entrepreneurial capabilities that are not involved in this study and then exploring whether entrepreneurial self-efficacy, entrepreneurial awareness, and other mediating variables are applicable in the model constructed.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to this work, and approved it for publication.

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A Bibliometric Analysis of the Landscape of Problem-Based Learning Research (1981–2021)

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Background: Problem-Based Learning (PBL) is an instructional method of hands-on, active learning centered on investigating and resolving messy, real-world problems. This study aims to systematically analyze the current status and hotspots of PBL research and provide insights for research in the field.

Methods: Problem-based learning-related publications were retrieved from the Web of Science Core Collection using “Problem-Based Learning”. Annual publications, countries, institutions, authors, journals, references, and keywords in the field were visually analyzed using the R, VOSviewer, and Microsoft Excel 2019 software.

Results: A total of 2,790 articles and reviews were analyzed, with a steady increase in publications in the field of PBL. Overall, the United States was the major contributor to the study of PBL. Van Der Vleuten CPM was the key researcher in this field. Moreover, most of the publications were published in *Medical Education*. Keyword analysis showed that current research hotspots focus on the extensions of PBL teaching mode, application of PBL teaching method, and reform of PBL.

Conclusion: Research on PBL is flourishing. Cooperation and exchange between countries and institutions should be strengthened in the future. These findings will provide a better understanding of the state of PBL research and inform future research ideas.

Keywords: problem-based learning, bibliometric analysis, education, citation, research

INTRODUCTION

Problem-based learning (PBL) is a pedagogy that has received widespread attention in recent years (Albanese and Mitchell, 1993). It emphasizes setting learning into complex problem situations, allowing learners to solve authenticity problems collaboratively, understand the scientific knowledge implicit behind the problems (Wood, 2003; Dolmans et al., 2005). In addition to course content, PBL can promote the development of critical thinking skills, problem-solving abilities, and communication skills (van der Vleuten and Schuwirth, 2019). It can also allow working in groups, finding and evaluating research materials, and life-long learning (Compton et al., 2020).

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As a broad approach, PBL first originated in medical education in the 1960s at the medical school at McMaster University in Canada (Jones, 2006) and has since been promoted and modified in more than 60 medical schools (Servant-Miklos et al., 2019). PBL was most used in the first 2 years of medical courses, replacing traditional teaching methods in anatomy, pharmacology, and physiology (Devine et al., 2020). Today, PBL has been widely used in business, dentistry, health sciences, law, engineering, education (Huth et al., 2021; Kühner et al., 2021; Michalsky and Cohen, 2021).

Bibliometrics analysis refers to the qualitative and quantitative evaluation of specific research areas using mathematical and statistical methods to understand the knowledge structure and explore development trends (Bornmann and Leydesdorff, 2014). In recent years, bibliometric types of research have received extensive attention to provide a comprehensive overview of the published literature and identify research frontiers and future research trends (Liu et al., 2021; Shawahna, 2021; Yu et al., 2021).

Previously published bibliometric studies on PBL have been limited to highly cited articles (Azer, 2017). In order to understand the research trends of PBL teaching, the aim of the study, therefore, is to analyze international scientific publications using both quantitative and qualitative bibliometric analysis on PBL teaching. This work will provide new perspectives and references for future PBL research.

MATERIALS AND METHODS

Data Sources

Publications about PBL were retrieved from the Web of Science Core Collection database. The database covers over 21,000 peer-reviewed, high-quality academic journals, including open access journals published in over 250 medical, social science and humanities disciplines worldwide, and is widely used for bibliometric analysis.

Moreover, the database provides access to the authors (country), affiliation, keywords, and references cited for each publication, which is necessary for this study.

Search Strategy

The searched strategy was TS = “Problem-Based Learning” from inception to 27 October 2021. No language restrictions. A total of 3,339 publications was retrieved, and after excluding meeting abstracts, editors, letters, and corrections, 2,790 publications were included, of which 156 were reviews, and 2,634 were articles.

Data Analysis

All downloaded documents were imported to the R (version 4.1.1), VOSviewer (version 1.6.15), and Microsoft Excel 2019.

Bibliometrix R package is an open-source tool for quantitative research in scientometrics and bibliometrics (Aria, 2017). VOSviewer is a software tool for constructing and visualizing bibliometric networks, including countries, journals, and authors based on citation, co-citation, or co-authorship relations. VOSviewer also offers text mining functionality that can be used to construct and visualize co-occurrence networks of important

terms extracted from a body of scientific literature (van Eck and Waltman, 2010). Scientific knowledge mapping can intuitively understand the research hotspots and development process of each field in the knowledge system and predict the development trend of each field (Chen, 2004).

RESULTS

Trends in Global Publication

Based on the number of annual publications, this period was preliminarily divided into three phases (**Figure 1**): the first phase is the initial period (1981–1990), with an average of two publications per year; the second phase, from 1991 to 2009, was considered as the development period, with an average of annual publications of 70; and the third phase, from 2010 to present, was known as the stable period when the annual number in this period was at a relatively stable state, and 120 publications were published annually.

Distribution of Countries/Regions

A world map based on the number of publications published in each country is shown in **Figure 2A**. A total of 87 countries/regions have been published in the field. The United States contributed the most publications (801, 28.71% of all publications), followed by the United Kingdom (267, 9.57%), Canada (249, 8.92%), Australia (201, 7.20%), and the Netherlands (159, 5.70%) (**Figure 2B**). Publications from the United States (21,139 citations) were the most cited, with the United Kingdom (6,402 citations), the Netherlands (6,002 citations), Canada (5,263 citations), and Australia (3,580 citations) ranking second through fifth, respectively (**Figure 2C**).

The co-authorship analysis found a total of 56 countries/regions with at least five publications published in this field. The five countries with the highest total link strength were the United States (total link strength = 150), the United Kingdom (total link strength = 132), the Netherlands (total link strength = 93), Canada (total link strength = 79) and Australia (total link strength = 65). The network of cooperative relationships between countries is shown in **Figure 2A**.

Distribution of Institutions

A total of 1,973 institutions have published papers in this field. Among them, the Maastricht University contributed the most (95 records), followed by McMaster University (66 records), Harvard University (47 records), University of Pennsylvania (43 records), and University of Manchester (42 records) (**Figure 3A**).

We analyzed co-authorship relationships between 187 institutions with at least five publications. Excluding the 24 unconnected items, **Figure 3B** shows the collaborations of 163 institutions. The five institutions with the highest connection total link strength were Maastricht University (total link strength = 34), Erasmus University Rotterdam (total link strength = 25), Harvard University (total link strength = 25), the University of Sydney (total link strength = 18), and Johns Hopkins University (total link strength = 14).

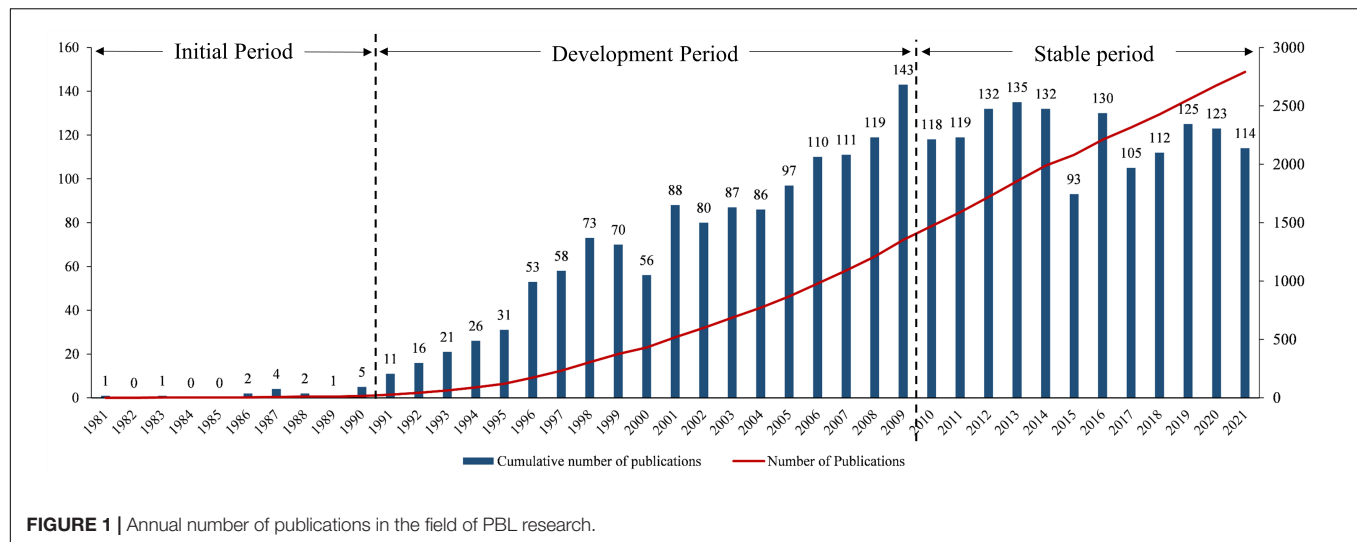


FIGURE 1 | Annual number of publications in the field of PBL research.

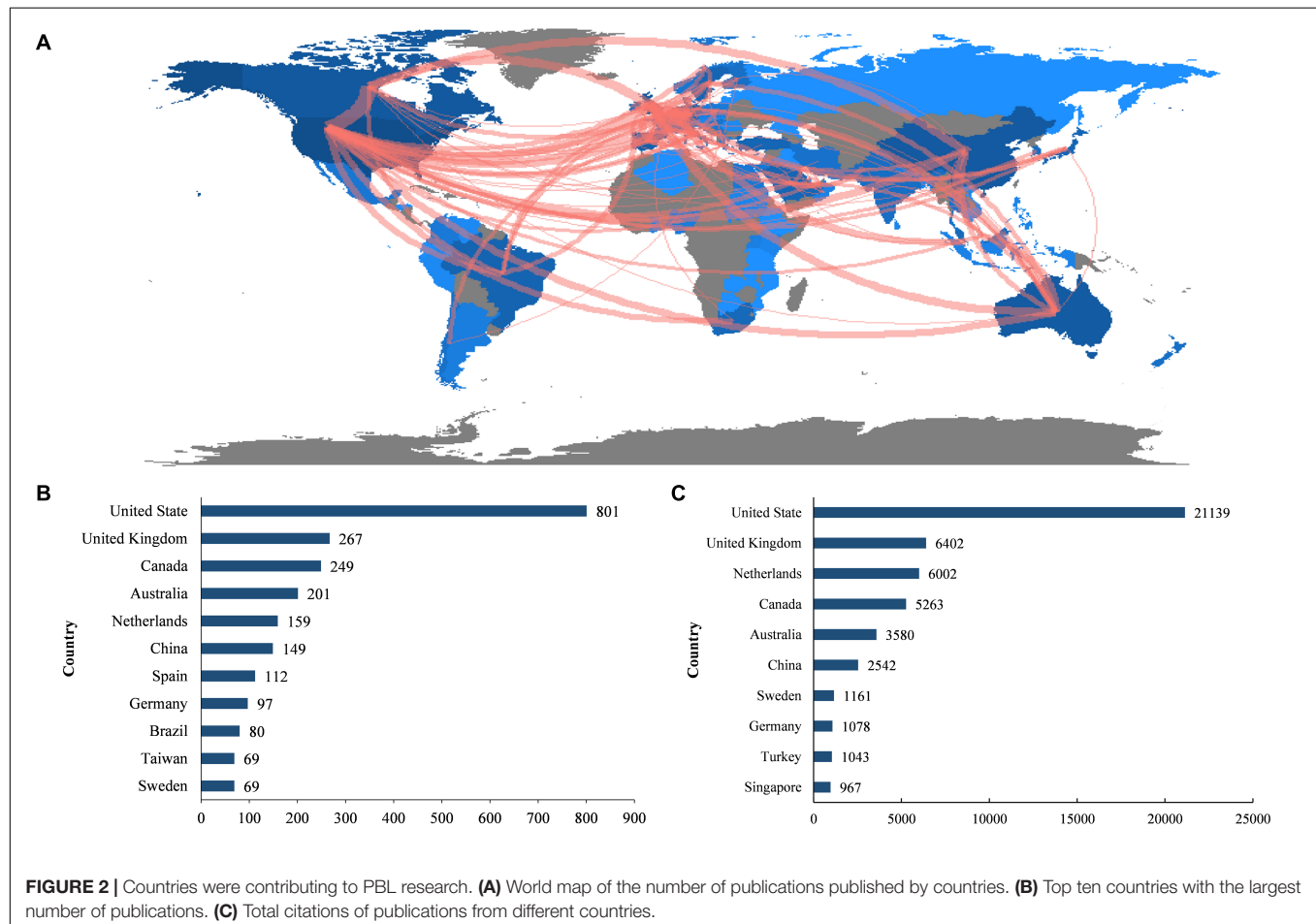


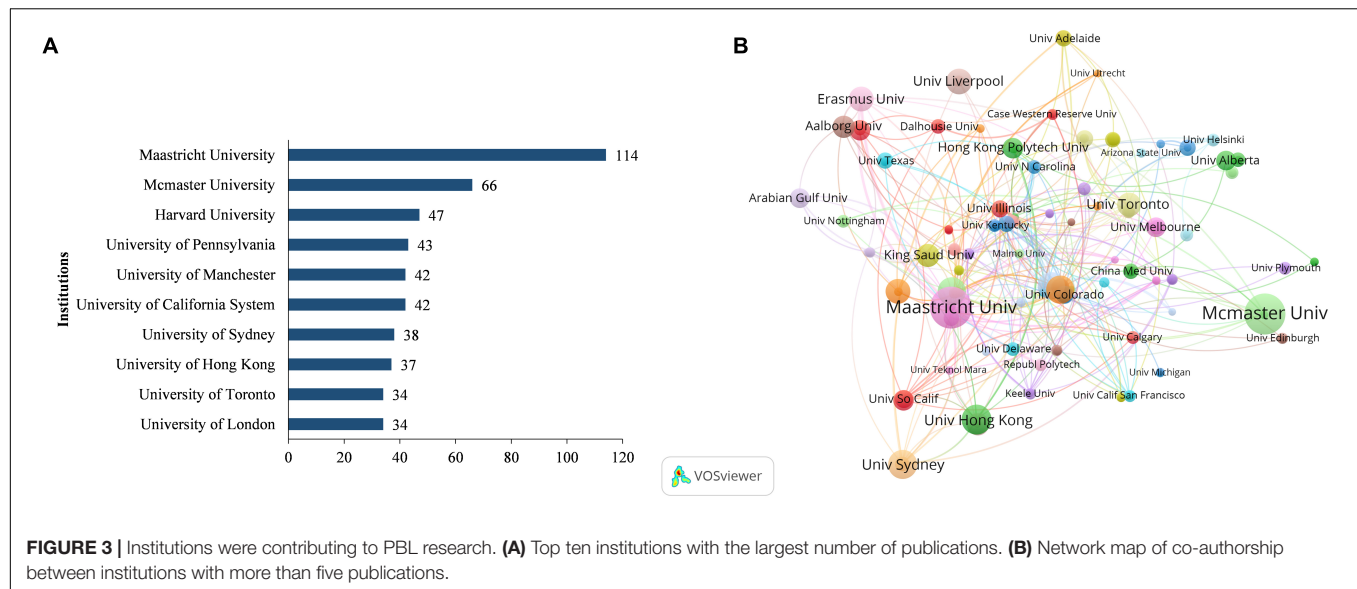
FIGURE 2 | Countries were contributing to PBL research. (A) World map of the number of publications published by countries. (B) Top ten countries with the largest number of publications. (C) Total citations of publications from different countries.

Analysis of Journals and Research Areas

There are 2,890 papers published in 608 journals. Table 1 lists the top ten most popular journals for publishing papers on PBL. *Medical Education* published 235 articles, by far the most, followed by *Medical Teacher* ($n = 194$), *International Journal of*

Engineering Education ($n = 127$), *Advances in Health Sciences Education* ($n = 111$), *Academic Medicine* ($n = 100$).

We analyzed a total of 141 journals that were co-cited at least 50 publications (Figure 4). Table 1 lists the top ten journals. Of these, *Medical Education* has the most citations (4,757 citations),



followed by *Academic Medicine* (4,482 citations), *Medical Teacher* (2,252 citations), *Journal of Dental Education* (894 citations), and *Advances in Health Sciences Education* (817 citations).

TABLE 1 | The top ten popular journals and cited journals.

Rank	Journals	Records (n)	2020 IF	Cited journals	Records (n)	2020 IF
1	Medical Education	235	6.251	Medical Education	4,757	6.251
2	Medical Teacher	194	3.650	Academic Medicine	4,482	6.893
3	International Journal of Engineering Education	127	0.969	Medical Teacher	2,252	3.650
4	Advances in Health Sciences Education	111	3.853	Journal of Dental Education	894	2.264
5	Academic Medicine	100	6.893	Advances in Health Sciences Education	817	3.853
6	BMC Medical Education	86	2.463	Nurse Education Today	773	3.442
7	Nurse Education Today	72	3.442	Problem Based Learning	732	–
8	Biochemistry and Molecular Biology Education	69	1.160	Teaching and Learning in Medicine	647	2.414
9	American Journal of Pharmaceutical Education	66	2.047	American Journal of Pharmaceutical Education	624	2.047
10	Journal of Dental Education	62	2.264	Journal of Chemical Education	589	2.979

The included publications were categorized into 108 research areas. The most representative research areas were Educational Research (1,573 records), HealthCare Sciences (774 records), Engineering (359 records), General Internal Medicine (230 records), Nursing (212 records) (Table 2).

Analysis of Authors

In terms of the number of publications, Van Der Vleuten CPM was the most prolific author ($n = 43$), followed by Dolmans DHJM ($n = 40$), Schmidt HG ($n = 32$), Azer SA ($n = 24$), Scherpbier AJJA ($n = 21$) (Figure 5A). From the author's influence, Schmidt HG has the largest number of citations in this field (1,074), followed by Dolmans DHJM (561), Van Der Vleuten CPM (540), Norman GR (445), Mitchell S (423) (Figure 5B). Publications from Van Der Vleuten CPM had the highest h -index (27), followed by Schmidt HG (22), Dolmans DHJM (22), Scherpbier AJJA (16), Wolfhagen IHAP (13) (Figure 5C).

We further analyzed a total of 212 authors that were co-authorship in more than three publications. After removing non-connected authors from each other, the network shows the collaboration of 29 authors (Figure 5D). The five authors with the highest total link strength were Van Der Vleuten CPM (total link strength = 66 times), Dolmans DHJM (52), Wolfhagen IHAP (40), Scherpbier AJJA (33), and Schmidt HG (32).

Citation and Co-citation Analysis

The citation analysis showed that 243 documents had at least 50 citations (Figure 6A). Table 3 lists the top ten documents with the highest citations. In addition, we analyzed the 32 references that were co-cited in more than 50 citations (Figure 6B). Table 4 lists the top ten references with the highest citations.

Co-occurrence Analysis of Keywords

We analyzed a total of 86 keywords that were identified as having occurred more than five times (Figure 7A). The colors in the

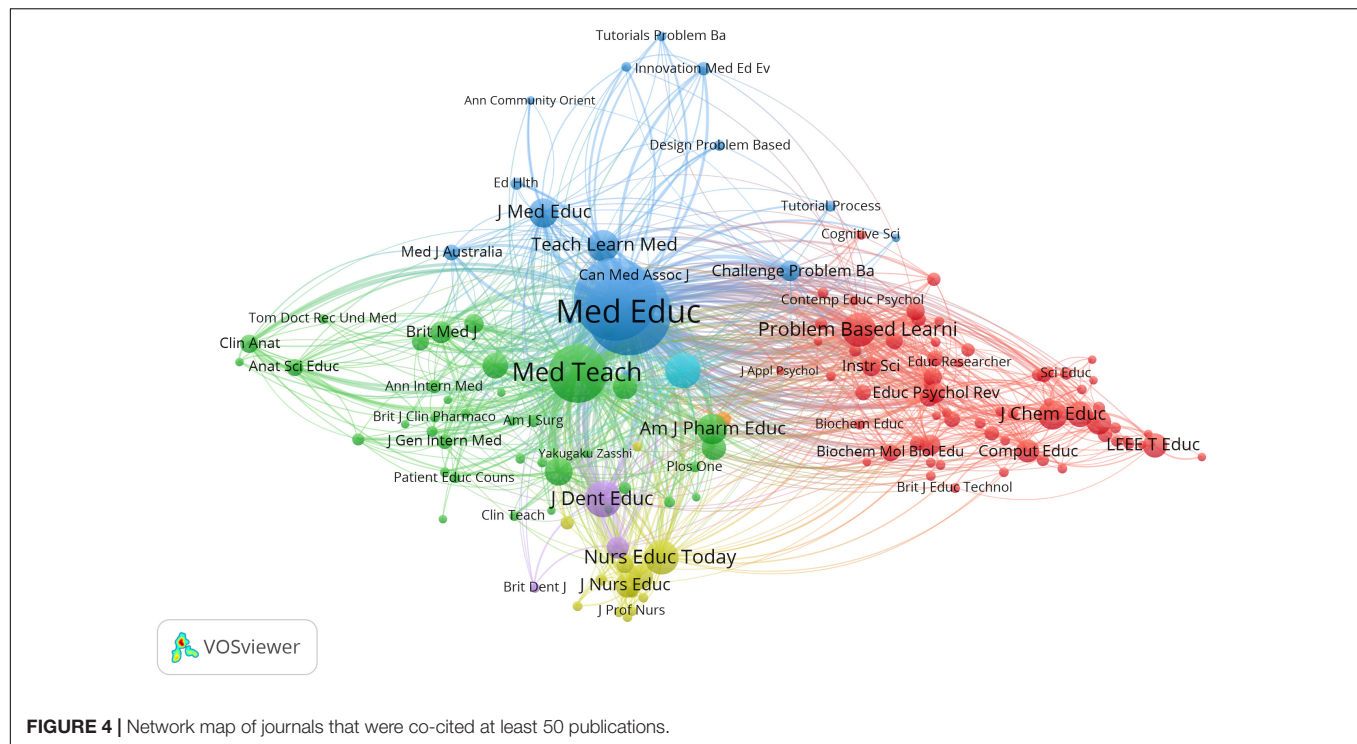


FIGURE 4 | Network map of journals that were co-cited at least 50 publications.

overlay visualization shown in **Figure 7B** indicate the average publication year of the identified keywords. Most keywords were published after 2012, with greener or yellower colors. The density visualization showed the exact identified keywords mapped by frequency of appearance (**Figure 7C**).

DISCUSSION

This study analyzed the bibliometric properties of 2,790 publications included in a citation index of PBL studies conducted over the past 40 years. The trend of annual publications demonstrated that the studies during this period were stable growth. The bibliometric results provide researchers, policymakers, and teaching staff with valuable insights and enable them to get meaningful references based on objective data.

A quantitative and visual analysis of the distribution of countries/regions and institutions shows that the United States and the United Kingdom are the leading countries where PBL research is being conducted. As shown in **Figure 3A**, there is a greater density and breadth of collaboration between the various countries. Research teams in the United States mainly collaborated with the United Kingdom, Canada, China, Australia, and Europe. In addition, although each institution has its collaborative network, the breadth and intensity of the collaboration are not ideal. The cooperation center mainly revolves around Maastricht University, McMaster University, and Harvard University, the three institutions with the largest publications. The intricacies of the mapping illustrate two things: first, the close cooperation among institutions that have contributed to the results of PBL research, and second, the continuous development of PBL in the teaching of different disciplines.

Problem-based learning is a problem-oriented teaching method (Savery and Duffy, 1997). It is a teaching model in which students collect information independently around problems, find out and solve problems, and develop independent learning and innovation abilities (Domingo-Osle et al., 2021). Most studies of PBL were published in influential education-related journals such as *Medical Education* and *Medical Teacher*. Regarding co-cited journals, we can see that most studies were from high-impact journals. These journals are equally focused on education and influence the direction of research in the field. As shown in **Table 2**, in addition to educational research, PBL teaching has now been extended to clinical medicine, engineering, computer science. This result is similar to the findings of another study, in which Azer found that highly cited

TABLE 2 | The top ten representative research areas.

Rank	Research areas	Records (n)	% (of 2,790)
1	Educational research	1,573	56.38%
2	Healthcare sciences	774	27.74%
3	Engineering	359	12.87%
4	General internal medicine	230	8.24%
5	Nursing	212	7.60%
6	Pharmacology pharmacy	153	5.48%
7	Computer science	148	5.30%
8	Dentistry oral surgery medicine	113	4.05%
9	Biochemistry molecular biology	88	3.15%
10	Physiology	61	2.19%

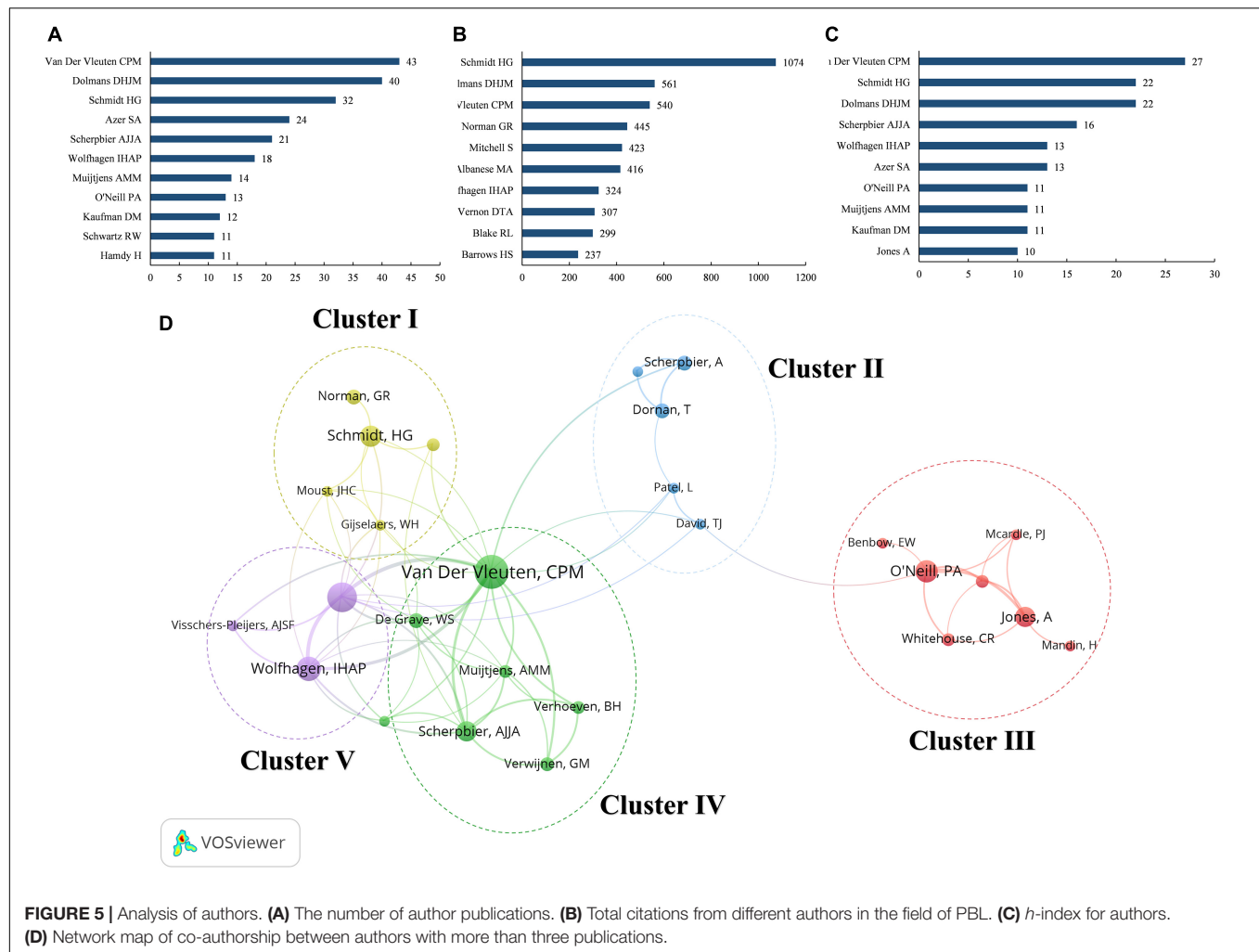


FIGURE 5 | Analysis of authors. **(A)** The number of author publications. **(B)** Total citations from different authors in the field of PBL. **(C)** *h*-index for authors. **(D)** Network map of co-authorship between authors with more than three publications.

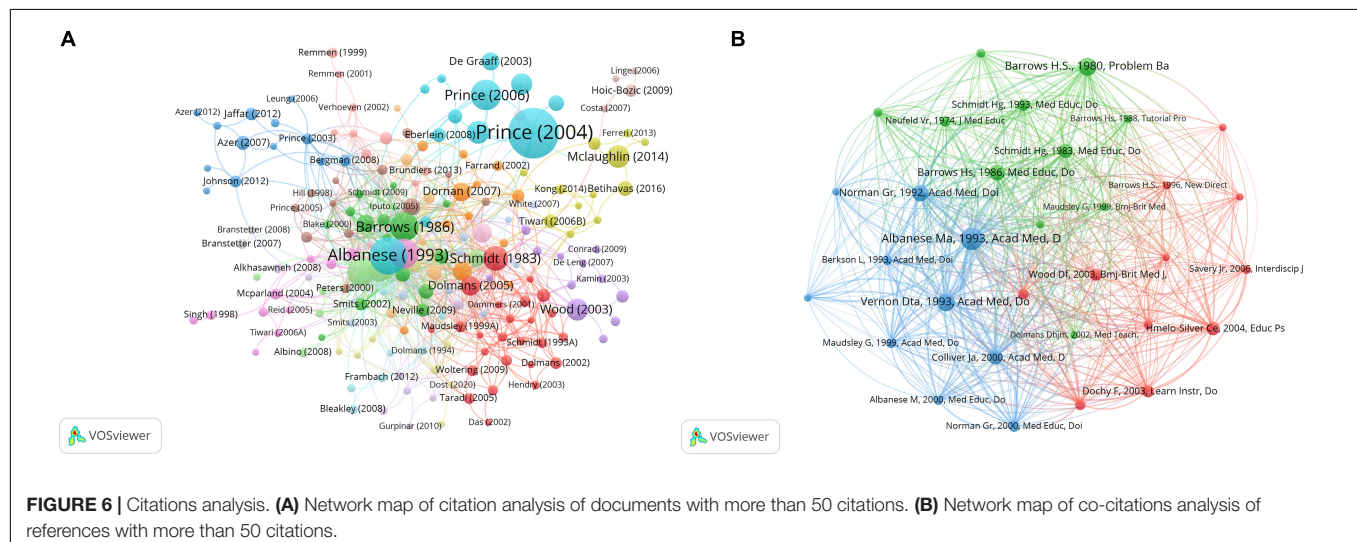


FIGURE 6 | Citations analysis. **(A)** Network map of citation analysis of documents with more than 50 citations. **(B)** Network map of co-citations analysis of references with more than 50 citations.

articles in the field of PBL were distributed among journals in dental and medical education, general medicine, and teaching psychology (Azer, 2017).

In the past decade, the focus of teaching and learning, including medical education, has gradually shifted to developing students' problem-solving, critical thinking, and self-directed

TABLE 3 | Top ten citations analysis of publications on this field.

Rank	Title	First Author	Source	Publication Year	Citations (n)
1	Problem-based learning: a review of literature on its outcomes and implementation issues (Albanese and Mitchell, 1993)	Albanese MA	Academic Medicine (IF: 6.893)	1993	413
2	Does problem-based learning work? A meta-analysis of evaluative research (Vernon and Blake, 1993)	Vernon DTA	Academic Medicine (IF: 6.893)	1993	266
3	The psychological basis of problem-based learning: a review of the evidence (Norman and Schmidt, 1992)	Norman GR	Academic Medicine (IF: 6.893)	1992	234
4	A taxonomy of problem-based learning methods (Barrows, 1986)	Barrows HS	Medical Education (IF: 6.251)	1986	198
5	Effectiveness of problem-based learning curricula: research and theory (Colliver, 2000)	Colliver JA	Academic Medicine (IF: 6.893)	2000	177
6	Problem-based learning: rationale and description (Schmidt, 1983)	Schmidt HG	Medical Education (IF: 6.251)	1983	171
7	Problem based learning (Wood, 2008)	Wood DF	BMJ (IF: 39.890)	2003	123
8	Foundations of problem-based learning: some explanatory notes (Schmidt, 1993)	Schmidt HG	Medical Education (IF: 6.251)	1993	115
9	Effectiveness of problem-based learning curricula: theory, practice and paper darts (Norman and Schmidt, 2000)	Norman GR	Medical Education (IF: 6.251)	2000	102
10	Problem-based learning: future challenges for educational practice and research (Dolmans et al., 2005)	Dolmans DHJM	Medical Education (IF: 6.251)	2005	94

TABLE 4 | Top ten co-citation analyses of cited references on this field.

Rank	Title	First author	Source	Publication year	Citations (n)
1	Problem-based learning: a review of literature on its outcomes and implementation issues (Albanese and Mitchell, 1993)	Albanese MA	Academic Medicine (IF: 6.893)	1993	413
2	Problem-Based Learning: An Approach to Medical Education (Barrows and Tamblyn, 1980)	Barrows HS	New York: Springer	1980	270
3	Does problem-based learning work? A meta-analysis of evaluative research (Vernon and Blake, 1993)	Vernon DTA	Academic Medicine (IF: 6.893)	1993	266
4	The psychological basis of problem-based learning: a review of the evidence (Norman and Schmidt, 1992)	Norman GR	Academic Medicine (IF: 6.893)	1992	234
5	A taxonomy of problem-based learning methods (Barrows, 1986)	Barrows HS	Medical Education (IF: 6.251)	1986	198
6	Effectiveness of problem-based learning curricula: research and theory (Colliver, 2000)	Colliver JA	Academic Medicine (IF: 6.893)	2000	177
7	Problem-based learning: rationale and description (Schmidt, 1983)	Schmidt HG	Medical Education (IF: 6.251)	1983	171
8	Problem-based learning: What and how do students learn? (Hmelo-Silver, 2004)	Hmelo-Silver CE	Education Psychology Review (IF: 5.167)	2004	157
9	Problem based learning (Wood, 2003)	Wood DF	BMJ (IF: 30.223)	2003	123
10	Effects of problem-based learning: A meta-analysis (Dochy et al., 2003)	Dochy F	Learn and Instruction (IF: 3.323)	2003	116

learning skills (Merisier et al., 2018). PBL is being adopted and valued by an increasing number of universities and hospitals as a teaching model that fits well with constructivist learning theory and medical teaching principles (Al-Azri and Ratnapalan, 2014). This phenomenon is corroborated by the results of PBL posting journals and citations presented in **Tables 1–4**. Dentistry stands out in medical education as one of the most widely implemented disciplines for PBL teaching. Various branches of dentistry such as prosthodontics and orthodontics are convenient subjects and have close cross-fertilization with many fields such as material science, clinical medicine, pathology,

physiology (Ferro et al., 2019). Therefore, dentistry teaching requires students to be proficient in dentistry-related courses and, more importantly, to apply and integrate them. As Azer said, the bibliometric analysis of PBL has implications for dental teaching and research (Azer, 2017).

The most prolific authors in PBL studies and the global citations to their work differed. The most prolific and influential author is Van Der Vleuten CPM, while the most cited author was Schmidt HG. In terms of the number of citations, “PBL: a review of literature on its outcomes and implementation issues” (Albanese and Mitchell, 1993) published by Albanese MA was

search term for the study topic to “PBL,” some relevant articles may be missed, such as “PBL.”

CONCLUSION

The current study provides an overview of research findings and valuable insights into PBL worldwide. Research on PBL has continued to increase over the past few decades. The most productive country is the United States, participating in nearly 30% of publications, and the leading institution is the Maastricht University. The most attractive journal in terms of PBL is *Medical Education*. In addition, collaborative research initiatives need to be established between institutions in developing countries and those in developed countries.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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AUTHOR CONTRIBUTIONS

FZ: conceptualization. FZ and HW: methodology and writing-original draft preparation. FZ and YB: software and data curation. HCZ: writing-review and editing. All authors have read and agreed to the published version of the manuscript.

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University Students' Successive Development From Entrepreneurial Intention to Behavior: The Mediating Role of Commitment and Moderating Role of Family Support

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University students having high entrepreneurial intention while not transferring into actual entrepreneurial behavior is a contradictory issue in need of in-depth research. To explore the successive development mechanism of the entrepreneurial process, this study constructed a moderated mediation model to examine whether entrepreneurial commitment from three dimensions (affective, behavioral, and continuance) mediated the relationship between entrepreneurial intention and behavior, and whether this mediating process was moderated by family support. A survey was conducted among university students from six major universities in south China using the snowball sampling approach. A total of 469 valid responses were obtained (44.6% male and 55.4% female participants). Structural equation modeling was adopted for data analysis. According to the results of the confirmatory factor analysis, it was found that entrepreneurial intention had both direct and indirect positive effects on entrepreneurial behavior, while entrepreneurial commitment worked as the mediator, and family support moderated the relationship between entrepreneurial intention and behavior. Results indicated that entrepreneurial commitment bridged the path from entrepreneurial intention to behavior, and family support created the boundary effect. This finding highlights the importance of guiding students through entrepreneurial commitment toward entrepreneurial behavior, and pays special attention to the crucial role of family support under the national strategy.

Keywords: successive development, entrepreneurial intention, entrepreneurial commitment, family support, entrepreneurial behavior

INTRODUCTION

Entrepreneurship plays a key strategic role in global economy (Chandra, 2018; Dhahri and Omri, 2018), job creation (Kim et al., 2018), business opportunities (Global Entrepreneurship Monitor [GEM], 2022), social impact, and particularly during global crisis such as the COVID-19 pandemic (Sieger et al., 2021). In recent years, the GUESSS project (i.e., global university enterprise spirit students' survey) has attracted wide attention, and reflected great importance on university students' entrepreneurship research. Many countries and governments have successively

enacted a series of policies on finance, taxation, and education (Liao et al., 2017) for fostering entrepreneurship among university students. However, there is still a big gap between students' entrepreneurial intention and their entrepreneurial behavior. According to relevant Chinese survey results, up to 70–80% of university students have reported entrepreneurial intention, while only 0.3–2% of them have actually engaged in entrepreneurship (Zhu et al., 2017). The Sieger et al. (2021) showed that the current transformation of global university students' entrepreneurial intention into behavior was not optimistic, with 50.1% of all students ($N = 75,838$) intended to be an entrepreneur, but only 28.4% of all students actually started up their business. The individual behavior in entrepreneurship is usually the purpose and destination of research. However, due to the complexity and difficulty of measuring behavior, after Bird (1988) creatively proposed that entrepreneurial intention was a prerequisite for the entrepreneurial behaviors, researchers began to study entrepreneurial intention as the starting point of entrepreneurial process to represent behaviors (Bird, 1988; Douglas and Fitzsimmons, 2013). In essence, entrepreneurial intention is the entrepreneurial idea aiming at planned behaviors (Ajzen, 1991; Krueger et al., 2000). Only the talents with entrepreneurial intention can start their entrepreneurial behaviors (Thompson, 2009). China and some emerging countries have conducted a large number of studies on entrepreneurial intention and its transformation to entrepreneurial behavior (Cui et al., 2017; Bogatyreva et al., 2019). However, later on, scholars started to realize the drawbacks of using entrepreneurial intention to predict behaviors. A meta-analysis showed that intention can only explain 28% of the variation of behavior (Sheeran, 2002), so the “jump” prediction of behavior by entrepreneurial intention is not reasonable (Shirokova et al., 2016; Ma, 2017). Shirokova et al. (2016) suggested that although many studies confirmed the high correlation between intention and behavior, however, the transformation from intention to behaviors is indirect and with uncertainty. The uncertainty and complexity of the entrepreneurship process has caused the deviation of entrepreneurial behavior from intention and a cognitive bias in entrepreneurship cognition. These deviations leads to the ultimate failures in transforming entrepreneurial intention into real behavior (Adam and Fayolle, 2015). Bird et al. (2012) made a pertinent comment on entrepreneurial behavior research and claimed that entrepreneurs' behavior is affected by cognition and emotion. What we see is only the appearance of behavior. In fact, the invisible cognitive causes of behavior are prone to be more interesting. In order to solve this “gap,” Gollwitzer (1999) suggested that entrepreneurial commitment is a psychological variable that is more observable than entrepreneurial intention, but has not yet been performed as behavior. Entrepreneurial commitment plays an intermediary role in the relationship between entrepreneurial intention and entrepreneurial behavior (Fayolle et al., 2011). If the entrepreneurs are willing to invest a high degree of time, energy, money, intelligence, and endurance in entrepreneurship, rather than just intention, they are more likely to implement entrepreneurial behavior (Fayolle and Liñán, 2014; Esfandiari et al., 2019). Accordingly, we propose a basic

entrepreneurial cognition model of “intention–commitment–behavior.” The above views provide a new perspective for linking between entrepreneurial intention and entrepreneurial behavior.

The present study constructed a model from entrepreneurial intention to behavior to fill the gap, and tried to answer the following research question: How does university students' entrepreneurial intention affect their entrepreneurial behaviors in the Chinese context? In terms of the internal factors, entrepreneurial commitment is proposed as a psychological variable closer to entrepreneurial behavior (Fayolle et al., 2011; Vamvaka et al., 2020). This study explores the transformation from intention to behavior through commitment by testing its mediating effect.

Besides, our aim was to determine the most important external factors influencing students when making decisions in the Chinese context. Thus, we conducted an investigation among university students on “*The person who has most influenced you in your decision-making process.*” Among the 124 questionnaires, 88 respondents (71%) reported that parents or siblings had the greatest impact on their major decisions. Results indicated that family support is the most important factor, which we analyzed in this study considering its crucial role in decision-making for inexperienced Chinese university students. In fact, lots of research confirmed that family background affected students' entrepreneurial intention (Herman, 2019; Huang, 2021). Family support plays a positive regulatory role in Chinese farmers' entrepreneurship (Dong and Zhao, 2019; Yang et al., 2019) and university students' entrepreneurship (Tian and Chen, 2019). Its moderating effect has been tested to investigate the boundary conditions of intention, commitment, and behavior. This study aspired to make two main contributions. First, an entrepreneurial cognitive model, based on “intention–commitment–behavior,” is proposed in this paper. It provides a new perspective for understanding the entrepreneurial psychological process of university students and deepens the research on “entrepreneurial commitment” to a certain extent. Due to the important role of “family support” in decision-making, the moderating effect of “family support” on “entrepreneurial intention to behavior” partly reflects the characteristics of university students' entrepreneurship in the Chinese context. Second, this study focuses on the bridging role of “entrepreneurial commitment” and highlights the important role of family support in entrepreneurship in China. It also provides guidance for cultivating entrepreneurial talents and improving the diversification of entrepreneurship education in practice.

THEORY AND HYPOTHESES

Entrepreneurial Intention and Entrepreneurial Behavior

Entrepreneurial intention is a psychological state of entrepreneurs when they start a new venture or create new values in an extant enterprise (Bird, 1988). It is effectively predictable for such a rare, unobservable and time-lagged activity as entrepreneurship (Krueger et al., 2000). Entrepreneurial

behavior involves specific activities of individuals inspired by the idea of starting a business (Penrose, 1959), and it has both a narrow and a broad sense. Narrow entrepreneurial behavior emphasizes the entrepreneurial opportunity identification and resources integration throughout the entrepreneurial process, while the broad sense includes a series of behaviors from survival to development after starting a business. We explore the entrepreneurial behavior from a narrow sense in the following sections.

Despite entrepreneurial behavior being the final goal of entrepreneurial intention (Gieure et al., 2020), due to the inherent difficulty of entrepreneurial behavior research, scholars did not focus on the antecedent variables of entrepreneurial behavior until Bird (1988) creatively proposed entrepreneurial intention as the precondition for starting and developing a new business in the late 1980s. Most of them noticed entrepreneurial intention as the starting point of the entrepreneurial process (Newman et al., 2019). Thereafter, the application of Planned Behavior Theory in entrepreneurship research has further stated the role of entrepreneurs' attitudes (Barrios et al., 2021), namely, entrepreneurial intention, on their actual behavior (Ajzen, 1991; Mei et al., 2016). Essentially, entrepreneurship is intentional in view of entrepreneurial intentions as the entrepreneurial ideas aiming at planned behavior (Krueger et al., 2000). Thus, entrepreneurial intention is the only best predictor of entrepreneurial behavior (Krueger, 2017).

Individuals with high entrepreneurial intention are more concerned and sensitive to entrepreneurial information (Farrukh et al., 2017). They always have a stronger desire to achieve their entrepreneurial goals than those with low intentions (Bird, 1988). Specifically, they are inclined to respond sensitively to the related information (Kickul et al., 2010), in order to identify entrepreneurial opportunities quickly (Fearon et al., 2019) and skillfully integrate external entrepreneurial factors, such as materials, technology, and information (Meyer and Meyer, 2020). Meanwhile, their desire for entrepreneurial goals will be internalized as the motivation to inspire themselves to work hard toward achieving the presupposed goals (Sheeran, 2002). Only intrinsic motivation can have a positive influence on individuals (Ryan and Deci, 2020; Zhan et al., 2021a). If the antecedents of entrepreneurship are met, they would implement entrepreneurial behavior and advance on the right track (Barrios et al., 2021). Accordingly, this paper suggests that entrepreneurial intention has a positive effect on the development of entrepreneurial behavior. Thus, based on the arguments presented above we hypothesize:

H1: Entrepreneurial intention will be positively related to entrepreneurial behavior.

Entrepreneurial Intention, Commitment, and Behavior

Multiple studies have argued that entrepreneurial intention does not transform directly into entrepreneurial behavior (Sheeran, 2002; Zhu et al., 2017), and the entrepreneurial cognitive bias has aroused some scholars to seek the bridge between them. Hereby, drawing upon the concept of organizational

commitment with three components affective, normative and continuance (Meyer and Herscovitch, 2001), entrepreneurial commitment has been proposed and considered a closer psychological variable to entrepreneurial behavior. If individuals intend to be self-employed and are willing to devote a huge amount of time (Wood et al., 2019), energy (Naz et al., 2020), money (Bice, 2020), intelligence (Ristianti et al., 2020), and endurance (Barba and Atienza, 2017) to entrepreneurial activities, they would have high entrepreneurial commitment and are more likely to start up rather than only staying with intentions. Therefore, entrepreneurial commitment plays a role as bridge between "intention" and "behavior." In addition, entrepreneurial commitment could be divided into three key dimensions: affective, behavioral, and continuance commitment (Tang, 2008).

Actually, individuals with higher intentions would be more sensitive and concerned about information related to entrepreneurship, such as that from entrepreneurial books, contests, study classes (Hassan et al., 2020), experience sharing meetings (Giones et al., 2016), business incubators (Al-edenat and Hawamdeh, 2020), policies (Bahl et al., 2020), and so forth. With unconscious influence, they will be determined to pursue their entrepreneurial intention with more motivation and willingness to promote entrepreneurial ideas, and naturally form the desire to start businesses, which is also known as entrepreneurial commitment. It is an individual's internal commitment to undertake entrepreneurial activities in the future. Those with high entrepreneurial commitments spend more time studying entrepreneurial knowledge (Saptono et al., 2020), which means they are more likely to choose to start businesses in the future. Though they might fail, they would keep going until they succeed. There is no doubt that entrepreneurial commitment binds an individual to their goals (Fayolle and Liñán, 2014; Dahmardeh and Nastiezaie, 2019). Therefore, it is considered as a bridge between entrepreneurial intention and behavior (Wallmeroth et al., 2018), playing its transitional role between them. The above explains the "intermediary role" of "entrepreneurial commitment" to a certain extent. In conclusion, we thus propose:

H2: Entrepreneurial intention will be positively related to entrepreneurial commitment.

H3: Entrepreneurial commitment will be positively related to entrepreneurial behavior.

H4: Entrepreneurial commitment will mediate the relationship between entrepreneurial intention and behavior.

To understand the specific role of entrepreneurial commitment, we test the mediating effect of entrepreneurial commitment from its three dimensions. We adopt a pattern most accepted by scholars to divide its dimensions into affective commitment, behavioral commitment, and continuance commitment (Tang, 2008; Indrawati et al., 2015). Specifically, affective commitment notes the willingness, excitement, and persistence of individuals in entrepreneurship (Jena, 2020), which also shows individuals' psychological attachment to

the employment through fondness, pleasure, or preference (Zhang et al., 2019). As for those who regard entrepreneurship as the enactment of a non-pecuniary goal (Dahmardeh and Nastiezaie, 2019), a high level of commitment will facilitate the continuance of their venture to realize their own goals. Meanwhile, people with high levels of behavior commitment focus more on accomplishment of their entrepreneurial “task”; hence, they are willing to devote whatever they have to the activity (Tang, 2008), such as time, money, effort, and passion. Continuance commitment is closely related to the costs of giving up their present position (Meyer and Allen, 1991). Based on some studies of commitment (Tremblay, 2021), it is twofold: first, people with a high level of continuance commitment resist stopping halfway considering the huge costs and sacrifices; second, they will not recognize other options as an alternative in their career. This study adopted the three-component model of commitment accepted by Tang (2008) and Indrawati et al. (2015) to test the mediating effect of three underlying dimensions of entrepreneurial commitment. Hence, hypothesis H4 also includes the three following sub-hypotheses:

H4a: Affection commitment will have a mediating effect on the relationship between entrepreneurial intention and behavior.

H4b: Behavior commitment will have a mediating effect on the relationship between entrepreneurial intention and behavior.

H4c: Continuance commitment will have a mediating effect on the relationship between entrepreneurial intention and behavior.

The Moderating Effect of Family Support

Family plays an essential role in shaping an individual's propensity for aspects of emotion (Edelman et al., 2016), spirit (Abraham, 2020), and mentality (Saptono et al., 2020). It is the primary and most powerful emotional system for an individual (Xu et al., 2020), and parents provide the most support for the young in making occupational decisions. We argue that the decisive role of parents dominates personal decisions in the Chinese context according to our survey of 124 university students, of whom 81 (65.3%) responded parents and 7 (5.6%) chose brothers or sisters in answer to the question: “The person who has most influenced you in your decision-making process.” Due to the complexity of self-employment, which is one of the most important career choices for contemporary university students, their families have certain expectations and make requests. Family support of emotions or resources can help students to enhance their abilities and confidence in dealing with difficulties, construct their mental safeguards (Zhong et al., 2016), meet uncertainty and emergency issues (Zhan et al., 2021b,c), and make strategic decisions in a calmed state under low pressure (Zhang et al., 2019). Specifically, family members would take an approach to offer entrepreneur resources with lower prices, because of their close relationship and inherent consciousnesses (Banerji and Reimer, 2018). Besides, young entrepreneurs who are resource-poor always ask those whom they have strong ties with for help throughout the emergence phase (Klyver et al., 2018; Abraham, 2020). Not only that, when entrepreneurs want

to share some ideas, their parents are the best listeners. Similarly, the suggestions of parents are vital for those entrepreneurs who need to make an important decision (Annisa et al., 2021). Consequently, throughout the entrepreneurial process, family support mainly indicates the support that parents offer to entrepreneurs, such as entrepreneurial funds, information, connections, and emotion (Edelman et al., 2016; Jena, 2020).

This study suggests that entrepreneurs with high family support can receive more understanding and respect from parents for their engagement in entrepreneurship and the special occupational decision they have made undertaking more risk and responsibility (Verver and Koning, 2017). The parents might support them in terms of venture capital, interpersonal networks (Bohlmann et al., 2017), work experience (Estrada-Robles et al., 2020), and care to ease their stress when making strategic decisions in a complicated and changeable social environment (Zhang et al., 2019). That is, family support would help to transform entrepreneurial intention into behavior (Jaskiewicz et al., 2015; Hernández-Linares and López-Fernández, 2018). In addition, the increase in their entrepreneurial commitment after overcoming the main obstacles in entrepreneurship also speed up the translation of entrepreneurial behavior (Failla et al., 2017). Furthermore, those with high entrepreneurial intention and family supports might have a strong sense of moral obligation and proceed to entrepreneurial plans and behaviors in return for family support (Edelman et al., 2016). On the contrary, parents of those with low family supports lack understanding of their work and even hinder them, so that their sense of frustration would increase tremendously while their possibility of success would decrease. Based on this, the following hypotheses were proposed:

H5: Family support will have a positive moderating effect on the relationship between entrepreneurial intention and behavior.

H6: Family support will have a positive moderating effect on the relationship between entrepreneurial intention and commitment.

H7: Family support will have a positive moderating effect on the relationship between entrepreneurial commitment and behavior.

The conceptual model of the action mechanism of entrepreneurial intention to engage in entrepreneurial behavior in this study is shown in **Figure 1**.

MATERIALS AND METHODS

Participants

In this study, snowball sampling approach was utilized to recruit university students from six major universities in South China and encourage them to pass the survey on to other students. The snowball sampling approach is often used for the survey of rare groups, such as university students. First find an individual (i.e., the “source,” also referred to as the “seed”) who has the desired characteristics and uses the person's social networks

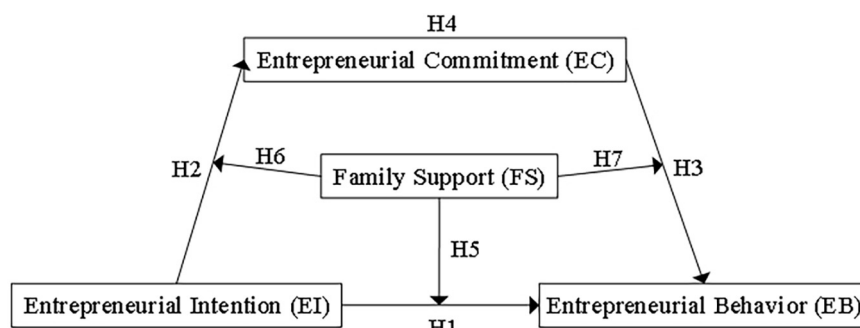


FIGURE 1 | Conceptual model.

to recruit similar participants (Sadler et al., 2010). A total of 521 questionnaires were distributed and 495 respondents were obtained, including 469 valid respondents, the recall rate was 95%. Missing values were specified for the questionnaires with fewer missing values, and holographic maximum likelihood estimation was used. The overall effective rate was 94.75%. The respondents of the questionnaire survey consisted of 55.4% females; 7.5% were aged 18 years old or below, 90.8% aged between 19 and 22 years old, and 1.7% aged 23 years old or above; 20.9% were freshmen, 27.3% were sophomores, 29.4% were juniors, and 22.4% were seniors. Regarding the occupation of the respondents' fathers, privately- or individually-owned business accounted for 28.6%, followed by farmers (16.0%) and workers (14.9%). Regarding the occupation of the respondents' mothers, most mothers were from other occupations, accounting for 23.8%, followed by privately- or individually-owned business (21.4%) and farming (16.2%). Additionally, the highest ratio (23.1%) of family per capital monthly income was located in the range of 3,500–6,000 RMB.

Measures

The chosen constructs are mostly based on established measurement scales. In line with relevant research (Edelman et al., 2016; Liu T. et al., 2019), we conceptualized and measured the family support with 12 items, such as “My parents respect my idea of starting a business.” Apart from the measurement of family support compiled by the research team, other variables were mainly based on the mature scale in China and other countries. Gordon approach was adopted to determine the number of entries and the representation of the Family Support Scale. The contents are as follows:

Entrepreneurial intention was operationalized as construct with four formative dimensions (Mei et al., 2016, 2017; Hoang et al., 2020), capturing different configurations that might promote the innovation behavior, that is, uncertain timetable, unlimited timetable, limited timetable, and clear timetable.

Entrepreneurial commitment was assessed with a measurement scale based on Iffan (2018), with 10 items, comprising affection commitment (items 1–4), behavior commitment (items 5–9), and continuance commitment (items 9–10).

Entrepreneurial behavior was assessed with 15 items extracted from Edelman et al. (2016) and Vamvaka et al. (2020), referring to behavior about ‘knowledge preparation,’ ‘ability to cultivate,’ ‘team preparation,’ ‘information preparation,’ ‘fund preparation,’ and ‘relationship preparation.’

Family support was assessed with a validated scale with 12 items developed by Edelman et al. (2016) and Liu T. et al. (2019), which reflected the degree of parental support for the respondents' entrepreneurship.

We controlled family location, parent's occupation, family income, and entrepreneurial experience of family member and friends as potential control variables.

Unless otherwise stated, the participants indicated their agreement on a 5-point Likert scale (from 1 = strongly disagree to 5 = strongly agree). The final list of items for each construct is shown in **Table 1**. The specific contents of constructs and their reliability and validity are shown in **Table 2**.

Data Collection and Analysis

SPSS 20.0 was used to run exploratory factor analysis (EFA) with half of the collected data. The KMO value was 0.821, and the Bartlett test was significant ($p < 0.001$). Six items for entrepreneurial behavior and three for family support were removed, as the results implied a low-level reliability load (less than the threshold of 0.5).

In the other half of the sample, the structural equation modeling was used for confirmatory factor analysis. The results showed that the model was well fitted with the data, and the specific results are demonstrated in **Table 1**, indicating that the factor load of each measurement index was higher over 0.5. **Table 2** illustrates that the range of Cronbach's alpha of each variable is 0.752–0.884, reaching more than the threshold of 0.7,

TABLE 1 | Summary of fit indices.

Variable	χ^2	df	χ^2/df	CFI	TFI	RMSEA
Entrepreneurial intention	6.734	2	3.367	0.988	0.965	0.071
Entrepreneurial commitment	85.691	32	2.678	0.973	0.963	0.060
Entrepreneurial behavior	103.669	27	3.840	0.955	0.940	0.078
Family support	102.211	27	3.786	0.950	0.933	0.077

TABLE 2 | Reliability and validity.

Variable	Measure indexes	Loading
Entrepreneurial intention CR = 0.752	E1 I think I will start a business in the future	0.618
	E2 If I have the chance to make the decision by myself, I will choose my own business	0.612
	E3 Considering all sorts of restrictions (such as lack of funds, family opposition, etc.), I would still prefer to start business	0.675
	E4 It is likely that I will start my own business in the next 5 years	0.718
Entrepreneurial commitment CR = 0.930	EC1 I prefer to start my own business compared to other career options	0.799
	EC2 Starting a business will help me achieve other important goals in my life	0.775
	EC3 I will put my heart and soul into the process of entrepreneurship	0.871
	EC4 I think entrepreneurship is promising I am willing to go on	0.834
	EC5 I will try my best to starting my business	0.759
	EC6 I would like to choose to start business, even if I have to do many things like customer visits or propaganda every day	0.819
	EC7 I'd be happy to work more than fifteen hours a day for my goals	0.660
	EC8 I will actively build up my own social relationship and try to get support from all sides	0.655
	EC9 If this business idea turns out to be fail, I will choose to get employment	0.687
	EC10 As the business has put a lot of effort into it, I won't consider abandon	0.660
Entrepreneurial behavior CR = 0.887	EB1 I've had a lot about entrepreneurial courses	0.614
	EB2 I often attend lectures on business administration or entrepreneurship	0.628
	EB3 I've been participated in many entrepreneurship competition	0.643
	EB4 I have establish bantam store and enterprise	0.619
	EB5 I've got some appropriate business partners	0.716
	EB6 To gain in-depth information about the market, I've done a lot of research	0.739
	EB7 I have taken my initiative to understand the process of entrepreneurship	0.725
	EB8 I have successfully raised the funds for starting a business	0.735
	EB9 I have set up a social network for business need	0.722
Family support CR = 0.873	FS1 My parents respect my idea of starting a business	0.699
	FS2 My parents believe that I can succeed in entrepreneurship	0.683
	FS3 My parents are concerned about my preparation for Entrepreneurship	0.661
	FS4 My parents are willing to provide me with start-up funds	0.687
	FS5 My parents will advise me on entrepreneurship	0.672
	FS6 My parents will help me make my entrepreneurial decision	0.631
	FS7 My parents will look for solutions to the problems I have encountered in the process of entrepreneurship	0.633
	FS8 My parents will use their personal connections to help me find opportunities for Entrepreneurship	0.611
	FS9 My parents think that entrepreneurship can test my ability	0.647

TABLE 3 | Correlation analysis.

Variable	Mean	S.D.	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
Entrepreneurial interest	3.19	0.812												
Family location	3.07	1.385	0.091											
Father's occupation	4.82	1.973	0.024	0.216**										
Mother's occupation	5.35	2.047	-0.016	0.087	0.514**									
Father's education	2.09	1.529	-0.082	-0.259**	-0.278**	-0.178**								
Mother's education	1.88	1.520	-0.117*	-0.212**	-0.225**	0.024	0.697**							
Family monthly income per capita	2.91	1.568	-0.015	-0.336**	-0.189**	-0.016	0.187**	0.210**						
Family's entrepreneurial experience	1.53	0.499	-0.128*	0.140**	-0.025	-0.082	0.037	0.086	-0.225**					
Friends' entrepreneurial experience	1.39	0.488	-0.134*	-0.002	-0.032	-0.117*	0.046	0.031	-0.016	0.274**				
Entrepreneurial intention	2.56	0.774	0.394**	0.077	-0.106*	-0.015	-0.071	0.012	-0.026	-0.120*	-0.143**			
Entrepreneurial commitment	2.92	0.682	0.306**	0.076	-0.095*	-0.128**	-0.086	-0.010	0.022	-0.042	-0.040	0.453**		
Family support	2.09	0.794	0.100*	-0.005	-0.147**	-0.134**	0.025	0.067	0.108*	-0.032	-0.061	0.416**	0.456**	
Entrepreneurial behavior	2.79	0.812	0.193**	-0.092	-0.034	0.394**	0.076	0.041	0.117*	-0.143**	-0.122*	0.315**	0.174**	0.286**

* $p < 0.05$, V1, entrepreneurial interest; V2, family location; V3, father's occupation; V4, mother's occupation; V5, father's education; V6, mother's education; V7, family monthly income per capita; V8, family's entrepreneurial experience; V9, friend's entrepreneurial experience; V10, entrepreneurial intention; V11, entrepreneurial commitment; V12, family support; V13, entrepreneurial behavior.

and the combination reliability (CR) of each factor was greater than 0.7, indicating that the measurement has good reliability.

The descriptive statistical results of the variables are shown in **Table 3**, and the correlation analysis shows that there is a significant positive correlation between entrepreneurial behavior and entrepreneurial intention, entrepreneurial commitment, and family support ($p < 0.001$). It can be seen that the correlation between the variables is basically consistent. The variance expansion factor (VIF) of each variable is far less than 10, which indicates that there is no serious multi-collinearity between variables. The square roots of each factor average variance extracted are greater than the other related line values of its row and column, and the discriminant validity of the scale is good.

RESULTS

Common Method Bias

This study performed the Harman's one-factor test (Podsakoff and Organ, 1986) to examine the common method bias. The results reveals that, no single factor emerged from this analysis, nor was there a general factor that was greater than 40% of variance in these variables. The first factor explained only 26.055% of the total variance. Thus, this indicates that common method bias is not an issue in this study.

Testing of the Mediating Effect

We performed structural equation modeling using Mplus 7.4 to test the hypotheses. Firstly, we tested the effect of the predictor variable on the outcome variable. Results showed that entrepreneurial intention had a significantly positive effect on entrepreneurial behavior ($\gamma = 0.519, p < 0.001$). The mediating model (M_e) fit indices ($\chi^2/df = 2.169, \chi^2 = 676.834, df = 312, RMSEA = 0.052, SRMR = 0.071, CFI = 0.918, TLI = 0.909$) all met the requirements of the study, indicating good fit to the sample data. Then, we tested the significance of the two mediating path coefficients. Results indicated that entrepreneurial intention had a positive effect on entrepreneurial commitment ($\alpha_{me} = 0.625, p < 0.001$). Entrepreneurial commitment also had a significant, positive relationship with entrepreneurial behavior ($\beta_{me} = 0.450, p < 0.001$). Therefore, it was concluded that the mediating effect of entrepreneurial commitment reached a significant level. Lastly, after introducing entrepreneurial commitment as a mediating variable, the direct effect of entrepreneurial intention as a predictor on entrepreneurial behavior as an outcome variable was still significant ($\gamma_{me} = 0.256, p < 0.001$). Thus, the results provide support for H1, H2, and H3, demonstrating that entrepreneurial commitment plays a partial mediating role between entrepreneurial intention and entrepreneurial behavior, which supports H4.

Further, we examined the effects of three sub dimensions of the mediator variable using the same tests as above. The mediating models of affection (M_{e1}), behavior (M_{e2}), and continuance (M_{e3}) revealed the following good fit to the data: $\chi^2/df = 2.621, 2.140, 2.249$ ($\chi^2 = 471.851, 385.178, 321.666, df = 180, 180, 143$); $RMSEA = 0.061, 0.051, 0.053$; $SRMR = 0.076, 0.067, 0.062$; $CFI = 0.916, 0.929, 0.925$; $TLI = 0.905, 0.920,$

0.913. It was found that entrepreneurial intention had a positive significant impact on affection, behavioral, and continuance commitment, respectively ($\alpha_{e1} = 0.530, p < 0.001; \alpha_{e2} = 0.333, p < 0.001; \alpha_{e3} = 0.424, p < 0.001$), and these three dimensions of commitment also positively influenced entrepreneurial behavior ($\beta_{e1} = 0.197, p < 0.01; \beta_{e2} = 0.314, p < 0.001; \beta_{e3} = 0.161, p < 0.05$). Therefore, we determined that the mediating effects of affective, continuance, and behavioral commitment reached a significant level. Lastly, after introducing these three mediator variables in the model, the result still revealed the significant effect of entrepreneurial intention as a predictor on the outcome variable entrepreneurial behavior ($\gamma_{e1} = 0.427, p < 0.001; \gamma_{e2} = 0.430, p < 0.001; \gamma_{e3} = 0.452, p < 0.001$). Affective, behavioral, and continuance commitment played a partial mediating role in the relationship between entrepreneurial intention and entrepreneurial behavior. Thus, H4a, H4b, and H4c were all supported.

The detailed test results of the hypothetical path in the above model are depicted in **Table 4**.

Testing of the Moderated Mediating Effect

The results of the moderated mediating model test illustrated a good fit, with $\chi^2/df = 2.671$ ($\chi^2 = 1536.016, df = 575$), $RMSEA = 0.062, CFI = 0.904, \text{ and } TLI = 0.896$. We followed the testing procedure that was proposed by Wen and Ye (2014) to assess the moderated mediation. The moderated mediating model indicated that the entrepreneurial intention (i.e., independent variable) influences the entrepreneurial behavior (i.e., dependent variable) through the entrepreneurial commitment (i.e., mediating variable), and the mediating process is moderated by the family support (i.e., moderating variable). First, we establish a simple moderating model of the relationship between entrepreneurial intention and entrepreneurial behavior to test whether the direct effect is moderated by family support. Next, we establish a moderated mediation model to test whether the mediating effect of entrepreneurial intention on entrepreneurial behavior through entrepreneurial commitment is moderated by family support. Before the test, entrepreneurial intention and family supporting variables were mean-centered to minimize multi-collinearity. We first tested the simple moderating model to investigate whether family support moderates the relationship between entrepreneurial behavior and intention. Entrepreneurial intention significantly predicted entrepreneurial behavior ($\lambda = 0.472, p < 0.001$), and the interaction effect of entrepreneurial intention and family support was significantly positive ($\lambda_{if} = 0.240, p < 0.001$).

To further test the role of family support as moderator in the mediating mechanism from entrepreneurial intention to behavior through entrepreneurial commitment, we developed the moderated mediating model with only the indirect effect moderated and conducted path analysis in turn. Results suggest that entrepreneurial intention positively predicted entrepreneurial commitment ($\alpha_{oe} = 0.529, p < 0.001$). The interaction effect of entrepreneurial intention and family support was also significantly positive ($\lambda_{ifc} = 0.136,$

TABLE 4 | The result of the path analysis.

Relationship of the hypothetical path	Coefficient of the standardized path	SE	t-Value	p-Value
Entrepreneurial intention → Entrepreneurial commitments (α_{me})	0.625	0.055	11.328	0.000
Entrepreneurial commitments → Entrepreneurial behavior (β_{me})	0.450	0.076	5.896	0.000
Entrepreneurial intention → Entrepreneurial behavior (γ_{me})	0.256	0.077	3.329	0.001
Entrepreneurial intention → Emotional commitments (α_{e1})	0.530	0.046	11.429	0.000
Emotional commitments → Entrepreneurial behavior (β_{e1})	0.197	0.058	3.378	0.001
Entrepreneurial intention → Entrepreneurial behavior (γ_{e1})	0.427	0.061	7.007	0.000
Entrepreneurial intention → Behavior commitments (α_{e2})	0.333	0.055	6.023	0.000
Behavior commitments → Entrepreneurial behavior (β_{e2})	0.314	0.049	6.464	0.000
Entrepreneurial intention → Entrepreneurial behavior (γ_{e2})	0.430	0.050	8.527	0.000
Entrepreneurial intention → Continual commitments (α_{e3})	0.424	0.061	6.935	0.000
Continual commitments → Entrepreneurial behavior (β_{e3})	0.161	0.064	2.494	0.013
Entrepreneurial intention → Entrepreneurial behavior (γ_{e3})	0.452	0.059	7.659	0.000

$p < 0.05$). Entrepreneurial commitment positively predicted entrepreneurial behavior ($\beta_{oe} = 0.366$, $p < 0.001$), while the interaction effect between entrepreneurial commitment and family support was not statistically significant ($\lambda_{cfb} = 0.103$, $p = 0.115$). Entrepreneurial intention positively predicted entrepreneurial behavior ($\gamma_{oe} = 0.204$, $p < 0.01$), and the interaction effect of entrepreneurial intention and family support was significantly positive ($\lambda_{ifb} = 0.195$, $p < 0.001$). The detailed results are depicted in **Table 5**.

Table 5 shows that family support moderates the mediating effect of entrepreneurial commitment on the link between entrepreneurial intention and behavior. Therefore, H5 and H6 were supported but H7 was not.

To further understand the moderating effect of family support between entrepreneurial intention and behavior, as well as entrepreneurial intention and commitment, we conducted simple slope analyses (Aiken and West, 1991) and plotted the moderating effect of family support in **Figure 2**. **Figure 2A** shows the effects of entrepreneurial intention on commitment for two levels of family support: low (regression coefficient was 0.084, $R^2 = 0.007$, $t = 0.710$, $p = 0.480$) and high (regression coefficient was 0.644, $R^2 = 0.414$, $t = 6.181$, $p < 0.001$). It reveals that the relationship between entrepreneurial intention and commitment is stronger at high levels than at low levels of family support, indicating that the positive relationship between entrepreneurial intention and commitment is strengthened by high family support. **Figure 2B** shows the effects of entrepreneurial intention on behavior for the two levels of family support: low (regression coefficient was 0.236, $R^2 = 0.056$, $t = 1.986$, $p = 0.051$) and high (regression coefficient was 0.578, $R^2 = 0.335$, $t = 5.354$, $p < 0.001$). It reveals that the relationship between entrepreneurial intention and behavior is stronger at high levels than at low levels of family support, indicating that the positive correlation between entrepreneurial intention and behavior is strengthened by high family support. In addition, **Figure 2** shows the apparent crossing of two lines in each group. The slope of the solid lines (high family support) is greater than that of the dashed ones (low family support), thus suggesting that entrepreneurial commitment, as well as entrepreneurial behavior, is more strongly associated with entrepreneurial intention when the level of family support is high.

DISCUSSION

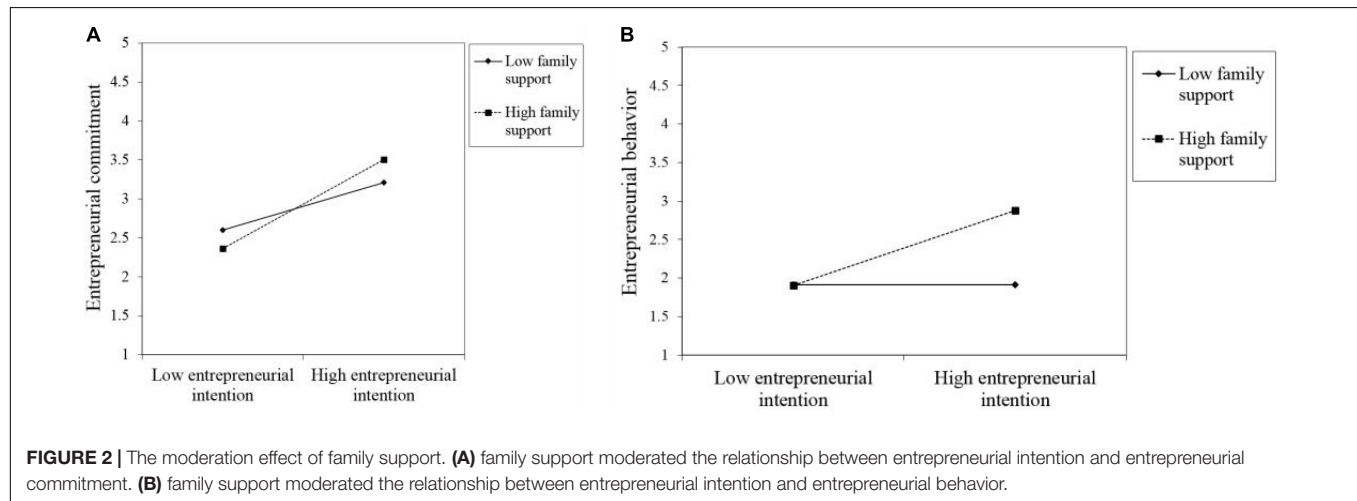
On the one hand, this paper highlighted entrepreneurial commitment and tested the mediating role of its three dimensions including affective, continuance, and behavioral commitment on relationship between entrepreneurial intention and behavior. Some scholars argued that there exists a gap between high entrepreneurial intention and low behavior. Although some studies proposed that entrepreneurial commitment could explain the gap (Wallmeroth et al., 2018), there is currently limited in-depth empirical research on the mechanism. Thus, this study has extended the entrepreneurial cognition theory from intention to behavior. On the other hand, the paper revealed the moderating role of family support on the relationship between entrepreneurial intention, commitment, and behavior, and noted its positive material and psychological effect on entrepreneurs, which implies the potential value of family support for entrepreneurship in the Chinese context.

In the first place, the current study noted the intermediate role of entrepreneurial commitment as a breakthrough in conventional entrepreneurial cognition. It imposes a specific effect underlying the relationship between entrepreneurial intention and behavior through three dimensions of affective, behavioral, and continuance commitment. Compared with entrepreneurial intention (Liu X. et al., 2019), entrepreneurial commitment has closer ties with entrepreneurial behavior (Naz et al., 2020; Sherkat and Chenari, 2020). It was also found that there exists great uncertainty of entrepreneurial intention before it is turned into real behavior merely as an individual's intention. It mostly remains in thought, so the individual's decision in entrepreneurship also depends on the transformation and improvement through behavioral strategies. In general, it is through aspects of affection (Dahmardeh and Nastiezaie, 2019; Naz et al., 2020), behavior (Neneh, 2019; Vamvaka et al., 2020), and continuance (Vamvaka et al., 2020) that entrepreneurial commitment imposes a positive influence on the individual's entrepreneurial intention, which is moderated by family support to encourage individuals to overcome the "gap" between thought and action physically and mentally, and to engage themselves in real entrepreneurship. The commitment with specific aims and

TABLE 5 | The result of the moderating effect.

Relationship of the hypothetical path	Coefficient of the standardized path	Standard error	t-Value	p-Value
El × FS → EB (λ_{ifb})	0.195	0.048	4.533	0.000
El × FS → EC (λ_{ifc})	0.136	0.058	2.335	0.020
EC × FS → EB (λ_{cfb})	0.103	0.065	1.574	0.115

El, entrepreneurial intention; EC, entrepreneurial commitments; FS, family support; EB, entrepreneurial behavior.



plans can influence entrepreneurial behavior development more directly (Wood et al., 2019).

Next, it is worth noting the boundary effect of family support considering the Chinese context in the present study. We argue that the relationship between entrepreneurial intention and behavior is moderated by family support, rather than solely being affected by entrepreneurial commitment. Individuals' entrepreneurial intention improvement can not only hasten entrepreneurial behavior directly, but also has a positive effect on behavior by improving entrepreneurial commitment. The current study verified that the parents' cognition of an individual's entrepreneurship and their material or emotional support are the key to promoting entrepreneurship, as suggested by Zhang and Jia (2016). In addition, family support plays a more important role for individuals with much family support in the development of entrepreneurial commitment and behavior, underpinned by the fact that their entrepreneurial intentions have higher correlations with commitment and behavior. We can infer that in entrepreneurship, which is unpredictable and hard to observe with time lags, support from parents in terms of time, energy, or money, namely, the intervention of family support as the strongest factor in individual decision-making in the Chinese context, can raise potential entrepreneurs' confidence and sustainability and hence encourage ultimate engagement in entrepreneurship. Although much effort has been devoted to public entrepreneurship, the effect of practice is far from perfect. Given the large variance of individuals' entrepreneurial abilities and levels, schools or relative social institutions should carry out targeted-entrepreneurial education for individuals suitable for entrepreneurship, further facilitating their behaviors from intentions. On the other hand, for those who

are not suitable, their education should focus on entrepreneurial spirit and innovation development, which is essential and indispensable in all fields.

CONCLUSION

In this study, we constructed a moderated mediation model to examine whether entrepreneurial commitment from three dimensions (affective, behavioral, and continuance) mediated the relationship between entrepreneurial intention and behavior, and whether this mediating process was moderated by family support. The results of this study verify the decisive role of entrepreneurial commitment underlying the relationship between entrepreneurial intention and behavior. Therefore, individuals cannot only improve entrepreneurial intention directly, but can rely on entrepreneurial commitment as the bridge mechanism to hasten entrepreneurial behavior in order to increase the rate of entrepreneurship in entrepreneurship management. Besides, affective and behavioral commitment plays a more significant role on the link from entrepreneurial intention to behavior as the corresponding mediating effects, which highlights the importance of developing individuals' affective and behavioral commitment in practice. The study offers evidence indicating that family support strengthens their internal links at both stages from entrepreneurial intention to commitment and from intention to behavior. The result also provides evidence for targeted-entrepreneurial education for individuals with different entrepreneurial intentions, rather than being a unified call for "public entrepreneurship and innovation." Traditional

entrepreneurial education applies to all students and adopts the same methods to encourage their engagement in entrepreneurship, neglecting the variance in their entrepreneurial abilities and levels. Moreover, it is essential to gain a belief of the significance of family support in entrepreneurship in the Chinese context. In order to promote the actual rate of entrepreneurship, we should not solely rely on the efforts of the governments, schools, and society, but also pay attention to the role of family support in the Chinese context, namely, the significant family effect. As a more effective factor, the support from family for entrepreneurs may exert more effects than those from the governments, schools, and the society in entrepreneurship in China.

There are some limitations to be noted in this study: Firstly, there is limited published scales for measuring family support variables currently. The scale adopted in this study was revised from the existing scale on family support. Although the preliminary scale has been tested, it has not been widely used and lacks representativeness. Since family plays an important role in individuals' major decision making, future research is recommended to further verify and improve the scale of family supports. Secondly, we mainly discussed the mediating effect of the three dimensions of "entrepreneurial commitment." Future research may consider dividing "entrepreneurial commitment" into three dimensions to analyze its relationship with "entrepreneurial intention" and "entrepreneurial behavior," which is a more detailed and in-depth study. Finally, this study adopted a cross-sectional approach, which only reflected the relationship between entrepreneurial intention and entrepreneurial behavior at a certain time spot. However, entrepreneurial intention, commitment, and behavior are actually changing over time. Thus, considering the dynamics of entrepreneurship, future research is needed on a longitudinal design in time series to examine the changing nature of the relationship among entrepreneurial intention, commitment, and behavior.

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by South China Normal University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

HM identified research ideas, designed and facilitated this research, wrote the draft, and made substantial revisions to this work. ZZ conducted experiments, wrote the draft, assisted in writing the draft, and revised the manuscript. ZM assisted with data collection, analyzed the data, wrote the draft, and provided advice on revisions. WN, HZ, JW, and YH revised the manuscript. All authors contributed to the article and approved the submitted version.

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The Impact of Scenarios on the Performance of Entrepreneurial Imaginativeness: Evidence From an Experiment

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With the advent of the era of artificial intelligence, “scenario” frequently appears in new product development and has gradually become an effective tool for analyzing user needs. However, the reasons for this phenomenon have not been explored in depth. New product development is a creative activity that requires product designers to imagine how people will live in the near future. So, we speculated that a familiar scenario that matches designers’ background (including knowledge, expertise, and experience) can spark their entrepreneurial imaginativeness by empathic simulation and conducted an experiment to research the impact of scenarios on the performance of entrepreneurial imaginativeness. Results of this study confirmed that a familiar scenario did indeed inspire entrepreneurial imaginativeness more than an unfamiliar scenario, especially for high entrepreneurial imaginativeness. This study provided a new perspective for understanding the relationship between the empathy process and entrepreneurial opportunity recognition and evaluation processes and had practical implications for entrepreneurial practice, especially those that make human life better based on new digital technologies. Finally, we gave some suggestions on enhancing individuals’ entrepreneurial imaginativeness through different familiar scenarios and improving the team performance on creative tasks.

Keywords: scenario, entrepreneurial imaginativeness, new venture ideas, creativity, imagination

INTRODUCTION

The term “scenario” was first introduced into business practice in the 1960s by the futurist Herman Kahn (Kahn and Wiener, 1967). Later, scenario analysis, as a planning method, was used by enterprises operating in unstable political and social environments (such as Royal Dutch/Shell Group, General Electric, and Lockheed) to predict possible future developments through hypothetical sequences of events (Gausemeier et al., 1998). With the advent of the era of artificial intelligence, “scenario” frequently appears at the product level (more micro than the organizational level) and is becoming an effective tool gradually for analyzing user needs. Through the lens of scenario, product developers can see possible future needs of people in some scenarios and propose different product concepts to address these needs (Passey et al., 2006). For instance, in October 2021, Meta CEO Mark Zuckerberg presented several product concepts for different scenarios in Meta’s metaverse (e.g., Horizon Home, for home spaces; Horizon Worlds, to create worlds or games; and Horizon Workrooms, for working) (López-Díez, 2021). Pillan et al. (2014)

similarly confirmed that “scenarios presented by video can visualize implicit needs and fertile cues for designers” and “video-scenarios as a tool to support imagination can orient designers’ efforts toward an optimal solution in terms of human satisfaction.” In addition, the scenario method also links product development to the visions of sustainability at the societal level by a systemic view (Gaziulusoy et al., 2013). Therefore, the scenario method plays an important role in the early parts of new product development—idea generation, product conceptualization, and concept selection (Crawford, 2008).

Why are scenarios becoming the essential condition of business ideas generation? Perhaps, related psychology research can provide inspiration for answering this question. Packard and Burnham (2021) proposed a “simulated empathy theory” that connects the empathy process to entrepreneurial opportunity recognition and evaluation processes. This theory is used to help entrepreneurs to predict consumer demand before it exists, thereby seizing entrepreneurial opportunities. It is worth noting that empathy, as a type of vicarious imagination (Coplan, 2011), is “a rational imagination process, intentional and knowledge-based”; and empathic simulation, as a vicarious mental simulation, is “the imaginative play-out of a particular scenario through the empathizer’s empathic model” (Packard and Burnham, 2021). That is, the empathizer’s vicarious imagination is activated by a particular scenario that provides a specific space–time context for empathy simulation. In addition, a particular scenario also provides a specific space–time context for the application of the transcendental schema (Kant, 1908) that can be used to interpret present sensations acquired through empathy and give solutions to address these sensations.

However, as a kind of external factor directly acting on the imaginative process, what effects do scenarios have on the exertion of entrepreneurial imaginativeness? This seems to be an interesting and new research topic that has hardly been covered in previous studies. After reviewing the relevant literature on imagination, we got some clues. There are two kinds of imaginative processes, namely, “one that is unconscious, uncontrolled, and effortless, and another that is conscious, controlled, and effortful”; the performance of any given thought experiment relies more or less on one of two kinds of imaginative processes, depending on the performer’s abilities and experience (Stuart, 2021). Similarly, Kier and McMullen (2018) argued that an individual’s domain knowledge, expertise, and experience on innovation, communication, and administration are preconditions of entrepreneurial imaginativeness exerting. Therefore, we speculated that the fit between an individual’s background (including knowledge, expertise, and experience) and scenarios affects the performance of entrepreneurial imaginativeness and proposed Hypothesis 1 as the performance of entrepreneurial imaginativeness in a familiar scenario is better than in an unfamiliar scenario. In addition, entrepreneurial imaginativeness used to generate and select new venture ideas involves creative, social, and practical imaginativeness (Kier and McMullen, 2018), which have individual differences. People with a high level of creative, social, and practical imaginativeness generate a larger set of new venture ideas, presumably due to “their ability to make novel connections between seemingly

unrelated things,” “their ability to translate the thoughts, feelings, and intentions of others into new venture ideas,” and “their ability to identify problems in need of solutions” (Kier and McMullen, 2018). So, we speculated that familiar scenarios enable high entrepreneurial imaginativeness to be more fully inspired than unfamiliar ones and proposed Hypothesis 2a to performers with a high level of entrepreneurial imaginativeness, their performance of entrepreneurial imaginativeness in a familiar scenario is better than that in an unfamiliar scenario. But entrepreneurial imaginativeness, as a cognitive skill, is relatively stable and difficult to significantly improve in a short time. Even supported by familiar scenarios, low entrepreneurial imaginativeness can hardly perform well. Therefore, we proposed Hypothesis 2b to performers with a low level of entrepreneurial imaginativeness, their performance of entrepreneurial imaginativeness in a familiar scenario is not significantly different from that in an unfamiliar scenario.

To empirically test our hypothesis, in this article, “scenario” was designed as an exogenous manipulated variable that affects the performance of entrepreneurial imaginativeness by matching with an individual’s background (including knowledge, expertise, and experience). We conducted an experiment in which 249 MBA students were randomly divided into three groups to conceive new venture ideas based on Fifth Generation Mobile Communication (5G) Technology in three scenario settings, namely, “smart city” (a scenario relatively familiar to the public), “smart factory” (a scenario relatively unfamiliar to the public), and “no-scenario” (compared with the other two scenarios). This enabled the manipulation of scenarios as familiar or unfamiliar while comparing this manipulation with the no-scenario group. Furthermore, drawing on the mature scale of Kier and McMullen (2018) to measure entrepreneurial imaginativeness, we distinguished participants with different levels of entrepreneurial imaginativeness to test the influences of three scenario settings on their performance of entrepreneurial imaginativeness.

METHODOLOGY

Participants and Design

A total of 249 Master of Business Administration (MBA) students participated in Study 1 in exchange for a nice present, which ensured participants had basic business operations knowledge and experience. Using a between-group experimental design, participants were randomly assigned to a (1) smart city (85 people), (2) smart factory (86 people), or (3) no-scenario (78 people). Finally, 219 valid samples were collected, including 75 in the smart city group, 71 in the smart factory group, and 73 in the no-scenario group.

A total of 219 participants with ages ranging from 21 to 55 years ($M_{age} = 32.89$, $SD_{age} = 4.485$) were included; 48.4% were men and 99.5% had a bachelor’s degree or above. All the participants came from 20 different industries, with 85.4% having more than 5 years of work experience ($M_{working-years} = 5.13$, $SD_{working-years} = 1.114$); 38 (17.14% of the total) had tried to start a business once in their career; 26 (11.9% of the total) tried

two times to start a business, and 5 (2.3% of the total) tried three or more times.

Materials and Measures

Scenario

A particular scenario that inspires the empathizer's vicarious imagination entails "the who, what, when, where, why, and how—the happenings within that experience, the contextual factors surrounding it, and the motivations and mechanisms that underpin it" (Packard and Burnham, 2021). In addition, Koh and Leung (2019) confirmed that a future orientation, as a means, can facilitate creativity through activating change and progress schemas to broaden thinking. Thus, both the familiar and unfamiliar scenarios chosen by us are future-orientated and equipped with the characteristics listed in **Table 1**. Based on the above criteria, we chose the smart city as the familiar scenario and the smart factory as the unfamiliar scenario and showed participants both scenarios through video. Specifically, a smart city involves almost all aspects of social life, such as government affairs, transportation, medical care, education, culture, entertainment, and environmental protection. Most of the public has an intuitive and specific understanding of these elements, processes, and existing problems. However, smart factory involves professional knowledge and industry experience, such as cognitive automation, cyber-physical system-based real-time monitoring (Stehel et al., 2021), sustainable manufacturing Internet of Things (Hawkins, 2021), and industrial big data analytics (Kovacova and Lewis, 2021). These are unfamiliar for most of the practitioners in the non-manufacturing and processing industries.

Performance of Entrepreneurial Imaginativeness

We used the quantity and originality of business ideas to measure participants' performance of entrepreneurial imaginativeness. Consistent with prior research that has utilized raters to evaluate idea originality, the four-point originality scale ranges from 1 (common, mundane, or boring business idea) to 4 (rare, unusual, ingenious, imaginative, or surprising business idea) (Douglas et al., 2006). Three expert raters independently scored the originality of business ideas generated by participants. The overall inter-rater reliability of the idea originality measure was acceptable (Intra-class correlation coefficient (ICC) = 0.673, $p < 0.001$; based on the criteria of the effect size suggested by Cohen et al. (2014), ICC = 0.50 can be considered as a large effect).

Entrepreneurial Imaginativeness

We adopted the scale developed by Kier and McMullen (2018) to measure entrepreneurial imaginativeness. Before the formal research, the pre-research was undertaken with 100 participants who met our experimental design. Then, a parsimonious survey measure was created through the confirmatory factor analysis that eliminated any problematic items. The resulting nine-item survey measure was rated on a seven-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Our final three-factor measurement model showed excellent goodness of fit: Chi-Squared/Degree of freedom (χ^2/df) = 0.826,

Goodness-of-fit index (GFI) = 0.981, Comparative fit index (CFI) = 1, Incremental fit index (IFI) = 1.003, Root mean square error of approximation (RMSEA) = 0, $p = 0.707$. The measure possessed strong reliability (0.832, 0.877, and 0.890 for creative, social, and practical imaginativeness, respectively), convergent validity, and discriminant validity.

Procedure

In the beginning, participants were randomly assigned to three groups, namely, smart city, smart factory, and no-scenario. Then, participants of the smart city group and smart factory group watched a 5-min video on the theme of smart city or smart factory. After watching a video, they were asked to generate as many business ideas as possible for 5G technology applications in a smart city or smart factory. However, participants of the no-scenario group were directly asked to generate as many business ideas as possible for 5G technology application without watching a video. Subsequently, participants were asked to choose one of the most creative ideas and write a short description of it. The instructions of the experiment and introduction of 5G technology are also given. Finally, participants were asked to fill out a questionnaire about entrepreneurial imaginativeness. All the tasks were completed online.

Results

In this experiment, we wanted the manipulation of scenarios to induce different performances of entrepreneurial imaginativeness (including the quantity and originality of business ideas). Every participant should be ensured to attend closely to the manipulation and conceive business ideas effortfully. So, based on the suggestions of Hauser et al. (2018), we did not do a manipulation check before this experiment in order for "the sequence of events to capture the participant's attention and to unfold naturally, and the measures to seem natural and appropriate in the context of the participant's experience."

Testing Hypothesis 1

We conducted an analysis of covariance (ANCOVA) to examine the differences in performances of entrepreneurial imaginativeness among three scenario setting groups. The independent variable is a *scenario*, the dependent variables are the *quantity* and *originality* of business ideas.

In addition, we used Pearson correlation coefficients to test any significant correlations between the dependent variable (i.e., *quantity* and *originality*) and potential factors (i.e., *entrepreneurial imaginativeness* and *Effort*¹ on the tasks), which determined the covariates to be included in the ANCOVA. The correlations among the variables are described in **Table 2**. *Quantity* was significantly correlated with *practical imaginativeness* ($r = 0.197$, $p = 0.003$), *Effort 1* ($r = 0.246$, $p < 0.001$), and *Effort 2* ($r = 0.437$, $p < 0.001$); *originality* was significantly correlated with *creative imaginativeness* ($r = 0.178$, $p = 0.008$), *Effort 1* ($r = 0.291$, $p < 0.001$), and *Effort 2*

¹We measured *Effort* in two different ways, that is, *Effort 1* is the time spent by a participant to complete the tasks, measured in seconds, while *Effort 2* is the amount of words written to describe ideas. *Effort 1* and *Effort 2* were calculated by a computer program.

TABLE 1 | Characteristics of a familiar/unfamiliar scenario.

A familiar scenario	An unfamiliar scenario
(1) The attributes, features, and performance of elements in this scenario are known well to most public	(1) The attributes, features, and performance of elements in this scenario are known less to most public
(2) It is not a hard work for most public to identify the similarity, differences, and relevance among the elements in this scenario accurately	(2) It is a hard work for most public to identify the similarity, differences, and relevance among the elements in this scenario accurately
(3) Most public had or are having the same or similar experience as the description in this scenario	(3) Most public don't have the same or similar experience as the description in this scenario
(4) It is easy for most public to take the perspective of others to experience others' irritations, annoyances, and frustrations with existing products or services in this scenario	(4) Most public have little opportunity to take the perspective of others to experience others' irritations, annoyances, and frustrations with existing products or services in this scenario
(5) The same or similar professional knowledge, methods, and procedures as what is needed in this scenario are possessed by most public	(5) The same or similar professional knowledge, methods, and procedures as what is needed in this scenario are not possessed by most public

TABLE 2 | Summary of correlations.

	Creative_Ima	Social_Ima	Practical_Ima	Scenario	Effort 1	Effort 2	Quantity	Originality
Creative_Ima	1	2						
Social_Ima	0.378***	1						
Practical_Ima	0.440***	0.460***	1					
Scenario	0.178**	0.083	0.187**	1				
Effort 1	0.056	0.044	0.024	0.254***	1			
Effort 2	0.266***	0.161*	0.216**	0.295***	0.562***	1		
Quantity	0.100	0.040	0.197**	0.259***	0.246***	0.437***	1	
Originality	0.178**	0.081	0.125	0.167*	0.291***	0.450***	0.258***	1

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ (two-tailed).

Creative_Ima, creative imaginativeness; Social_Ima, social imaginativeness; Practical_Ima, practical imaginativeness.

($r = 0.45$, $p < 0.001$). Although *social imaginativeness* did not have significant correlations with *quantity* and *originality*, it was significantly correlated with *creative imaginativeness* ($r = 0.378$, $p < 0.001$), *practical imaginativeness* ($r = 0.460$, $p < 0.001$), and *Effort 2* ($r = 0.161$, $p = 0.017$). Therefore, five potential factors (i.e., *creative imaginativeness*, *social imaginativeness*, *practical imaginativeness*, *Effort 1*, and *Effort 2*) were used as the covariates to exclude any preexisting differences in participants' performance of entrepreneurial imaginativeness (i.e., *quantity* and *originality*).

The ANCOVA results indicated that there were significant differences among three groups in *quantity* [$F(2, 216) = 17.488$, $p < 0.001$, $\eta_p^2 = 0.142$] and *originality* [$F(2, 216) = 7.685$, $p = 0.001$, $\eta_p^2 = 0.068$] (Table 3). The results of pairwise comparisons showed that (1) the mean *quantity* of the smart city group was significantly higher than the smart factory group ($MD = 0.974$, $p < 0.001$); and (2) the mean of *originality* of the smart city group was significantly higher than the smart factory group ($MD = 0.235$, $p = 0.002$), which suggested that the performance of entrepreneurial imaginativeness in the smart city scenario was better in the smart factory scenario (Table 4). Therefore, Hypothesis 1 was supported.

Compared with the no-scenario group, (1) the mean *quantity* of the smart city group was not significantly higher than the no-scenario group ($MD = 0.311$, $p = 0.234$), while the mean *quantity* of the smart factory group was significantly lower than the no-scenario group ($MD = -0.663$, $p = 0.001$); and (2) the mean of *originality* of the smart city group was not significantly higher than the no-scenario group ($MD = 0.05$, $p = 1.000$),

while the mean of *originality* of the smart factory group was significantly lower than the no-scenario group ($MD = -0.231$, $p = 0.004$) (Table 4). The results of comparisons with the no-scenario group showed that the familiar scenario (i.e., smart city) did not promote the exertion of entrepreneurial imaginativeness significantly, but the unfamiliar scenario (i.e., smart factory) restrained it.

Testing Hypothesis 2

We calculated medians of participants' entrepreneurial imaginativeness (including creative, social, and practical imaginativeness) scores based on the questionnaires they filled out (Table 5). Then, participants were divided into two levels by median, that is, high and low entrepreneurial imaginativeness. Specifically, there were 115 participants with high creative imaginativeness (HCI) (43 in the smart city group, 38 in the

TABLE 3 | The ANCOVA results of the impact of scenario on quantity and originality.

Dependent variable	Scenario	N	Mean	SD	F	Sig.	η_p^2
Quantity	No-scenario	73	2.110	1.087	17.488	0.000	0.142
	Smart factory	71	1.845	0.936			
	Smart city	75	2.853	1.291			
Originality	No-scenario	73	2.251	0.474	7.685	0.001	0.068
	Smart factory	71	2.188	0.481			
	Smart city	75	2.436	0.383			

TABLE 4 | Pairwise comparisons of quantity and originality between different scenarios.

Dependent variable	Scenario (I)	Scenario (J)	M.D. (I–J)	Std. error	Sig.	95% confidence interval for difference	
						Lower bound	Upper bound
Quantity	Smart city	No-scenario	0.311	0.176	0.234	–0.113	0.735
	Smart city	Smart factory	0.974*	0.167	0.000	0.057	1.377
	No-scenario	Smart factory	0.663*	0.179	0.001	0.232	1.094
Originality	Smart city	No-scenario	0.005	0.070	1.000	–0.165	0.174
	Smart city	Smart factory	0.235*	0.067	0.002	0.074	0.397
	No-scenario	Smart factory	0.231*	0.072	0.004	0.058	0.403

Based on estimated marginal means.

*The mean difference is significant at the 0.05 level.

MD, mean difference.

smart factory group, and 34 in the no-scenario group); 104 with low creative imaginativeness (LCI) (32 in the smart city group, 33 in the smart factory group, and 39 in the no-scenario group); 93 with high social imaginativeness (HSI) (38 in the smart city group, 23 in the smart factory group, and 32 in the no-scenario group); 126 with low social imaginativeness (LSI) (37 in the smart city group, 48 in the smart factory group, and 41 in the no-scenario group); 132 with high practical imaginativeness (HPI) (48 in the smart city group, 43 in the smart factory group, and 41 in the no-scenario group); 87 with low practical imaginativeness (LPI) (27 in the smart city group, 28 in the smart factory group, and 32 in the no-scenario group) (Table 6).

In addition, when conducting ANCOVA of the impact of *scenario* on the imaginativeness performance of participants with one type of entrepreneurial imaginativeness, we controlled for the other two types of entrepreneurial imaginativeness, *Effort 1* and *Effort 2*.

High Entrepreneurial Imaginativeness

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with HCI indicated significant differences in both *quantity* [$F(2, 112) = 8.846$, $p < 0.001$, $\eta_p^2 = 0.142$] and *originality* [$F(2, 112) = 4.243$, $p = 0.017$, $\eta_p^2 = 0.073$] (Table 7). The results of pairwise comparisons showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 1.021$, $p < 0.001$), but was not significantly higher than that in the no-scenario group ($MD = 0.234$, $p = 1.000$); (2) the mean of *quantity* in the smart factory group was significantly lower than that in the no-scenario group ($MD = -0.787$, $p = 0.015$); (3) the mean of *originality* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.229$, $p = 0.027$), but was not significantly higher than that in the no-scenario group ($MD = 0.010$, $p = 1.000$); and

(4) the mean of *originality* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.219$, $p = 0.066$) (Table 8).

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with HSI indicated significant differences in both *quantity* [$F(2, 90) = 9.251$, $p < 0.001$, $\eta_p^2 = 0.179$] and *originality* [$F(2, 90) = 3.929$, $p = 0.023$, $\eta_p^2 = 0.085$] (Table 7). The results of pairwise comparisons showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 1.127$, $p < 0.001$), but was not significantly higher than that in the no-scenario group ($MD = 0.289$, $p = 0.838$); (2) the mean of *quantity* in the smart factory group was significantly lower than that in the no-scenario group ($MD = -0.838$, $p = 0.014$); (3) the mean of *originality* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.255$, $p = 0.049$), but was not significantly lower than that in the no-scenario group ($MD = -0.025$, $p = 1.000$); and (4) the mean of *originality* in the smart factory group was significantly lower than that in the no-scenario group ($MD = -0.280$, $p = 0.046$) (Table 8).

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with HPI indicated significant differences in both *quantity* [$F(2, 129) = 15.540$, $p < 0.001$, $\eta_p^2 = 0.200$] and *originality* [$F(2, 129) = 4.879$, $p = 0.009$, $\eta_p^2 = 0.073$] (Table 7). The results of pairwise comparisons showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 1.136$, $p < 0.001$), but was not significantly higher than that in the no-scenario group ($MD = 0.135$, $p = 1.000$); (2) the mean of *quantity* in the smart factory group was

TABLE 5 | Descriptive statistics of entrepreneurial imaginativeness.

Imaginativeness	N	Mean	Median	SD	Minimum	Maximum
Creative_lma	219	14.685	15	3.461	4	21
Social_lma	219	15.785	16	2.922	6	21
Practical_lma	219	14.973	15	3.039	3	21

TABLE 6 | Distribution of high and low entrepreneurial imaginativeness levels of different scenario setting groups.

Group	LCI (N)	HCI (N)	LSI (N)	HSI (N)	LPI (N)	HPI (N)
Smart city	32	43	37	38	27	48
Smart factory	33	38	48	23	28	43
No-scenario	39	34	41	32	32	41
Total	104	115	126	93	87	132

TABLE 7 | The ANCOVA results of the impact of scenario on quantity/originality (high imaginativeness level).

Imaginativeness level	Imaginativeness performance	Group	N	Mean	SD	F	Sig.	η_p^2
HCI	Quantity	No-scenario	34	2.350	1.178	8.846	0.000	0.142
		Smart factory	38	1.890	1.034			
		Smart city	43	2.910	1.324			
	Originality	No-scenario	34	2.363	0.452	4.243	0.017	0.073
		Smart factory	38	2.219	0.419			
		Smart city	43	2.473	0.365			
HSI	Quantity	No-scenario	32	2.219	0.975	9.251	0.000	0.179
		Smart factory	23	1.739	0.619			
		Smart city	38	2.868	1.379			
	Originality	No-scenario	32	2.365	0.435	3.929	0.023	0.085
		Smart factory	23	2.159	0.437			
		Smart city	38	2.404	0.396			
HPI	Quantity	No-scenario	41	2.439	1.050	15.540	0.000	0.200
		Smart factory	43	1.837	0.785			
		Smart city	48	2.854	1.353			
	Originality	No-scenario	41	2.293	0.429	4.879	0.009	0.073
		Smart factory	43	2.233	0.491			
		Smart city	48	2.424	0.381			

TABLE 8 | Pairwise comparisons of quantity/originality between different groups (high imaginativeness level).

Imaginativeness level	Imaginativeness performance	Group (I)	Group (J)	MD (I–J)	Std. error	Sig. ^a	95% confidence interval for difference ^a	
							Lower bound	Upper bound
HCI	Quantity	Smart city	No-scenario	0.234	0.268	1.000	–0.418	0.886
		Smart city	Smart factory	1.021*	0.251	0.000	0.412	1.631
		No-scenario	Smart factory	0.787*	0.274	0.015	0.121	1.453
	Originality	Smart city	No-scenario	0.010	0.092	1.000	–0.214	0.235
		Smart city	Smart factory	0.229*	0.086	0.027	0.019	0.439
		No-scenario	Smart factory	0.219	0.094	0.066	–0.010	0.448
HSI	Quantity	Smart city	No-scenario	0.289	0.265	0.838	–0.359	0.937
		Smart city	Smart factory	1.127*	0.266	0.000	0.479	1.776
		No-scenario	Smart factory	0.838*	0.289	0.014	0.132	1.544
	Originality	Smart city	No-scenario	–0.025	0.104	1.000	–0.279	0.229
		Smart city	Smart factory	0.255*	0.104	0.049	0.001	0.508
		No-scenario	Smart factory	0.280*	0.113	0.046	0.004	0.556
HPI	Quantity	Smart city	No-scenario	0.135	0.227	1.000	–0.416	0.686
		Smart city	Smart factory	1.136*	0.217	0.000	0.609	1.664
		No-scenario	Smart factory	1.001*	0.234	0.000	0.432	1.570
	Originality	Smart city	No-scenario	0.018	0.089	1.000	–0.198	0.234
		Smart city	Smart factory	0.245*	0.085	0.014	0.039	0.452
		No-scenario	Smart factory	0.228*	0.092	0.044	0.005	0.451

Based on estimated marginal means.

*The mean difference is significant at the 0.05 level.

^aAdjustment for multiple comparisons: Bonferroni.

significantly lower than that in the no-scenario group ($MD = -1.001$, $p < 0.001$); (3) the mean of *originality* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.245$, $p = 0.014$), but was not significantly higher than that in the no-scenario group ($MD = 0.018$, $p = 1.000$); and (4) the mean of *originality* in the smart factory group was

significantly lower than that in the no-scenario group ($MD = -0.228$, $p = 0.044$) (Table 8).

From the above results, it can be seen that to the participants with high entrepreneurial imaginativeness (including creative, social, and practical imaginativeness), (1) the smart city group generated more business ideas than the smart factory group

and (2) the business ideas generated by the smart city group were more original than the smart factory group. That is, to the participants with high entrepreneurial imaginativeness, their performance of entrepreneurial imaginativeness in a familiar scenario is better than that in an unfamiliar scenario. Therefore, Hypothesis 2a was supported fully. In addition, compared to the no-scenario group, (1) the smart city group did not generate a greater number of more original business ideas, and (2) the smart factory group generated fewer business ideas. It is worth noting that (1) the *originality* of business ideas generated by the participants with HCI was not significantly different between the smart factory group and the no-scenario group, but (2) the *originality* of business ideas generated by the participants with high social/practical imaginativeness in the smart factory group was significantly lower than that in the no-scenario group.

Low Entrepreneurial Imaginativeness

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with LCI indicated significant differences in both *quantity* [$F(2, 101) = 9.354, p < 0.001, \eta_p^2 = 0.163$] and *originality* [$F(2, 101) = 3.299, p = 0.041, \eta_p^2 = 0.064$] (Table 9). The results of pairwise comparisons showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.959, p < 0.001$), but was not significantly higher than that in the no-scenario group ($MD = 0.451, p = 0.162$); (2) the mean of *quantity* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.508, p = 0.100$); (3) the mean of *originality* in the smart city group was not significantly higher than that in the smart factory group ($MD = 0.254, p = 0.060$) and that in the no-scenario group ($MD = 0.024, p = 1.000$); and (4) the mean of *originality* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.230, p = 0.137$) (Table 10).

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with LSI indicated significant differences in both *quantity* [$F(2, 123) = 8.020, p = 0.001, \eta_p^2 = 0.120$] and *originality* [$F(2, 123) = 5.226, p = 0.007, \eta_p^2 = 0.081$] (Table 9). The results of pairwise comparisons showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.889, p < 0.001$), but was not significantly higher than that in the no-scenario group ($MD = 0.333, p = 0.536$); (2) the mean of *quantity* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.557, p = 0.058$); (3) the mean of *originality* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.279, p = 0.006$), but was not significantly higher than that in the no-scenario group ($MD = 0.089, p = 1.000$); and (4) the mean of *originality* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.190, p = 0.127$) (Table 10).

The ANCOVA results of the impact of *scenario* on the imaginativeness performance of participants with LPI indicated significant differences in both *quantity* [$F(2, 84) = 4.289, p = 0.017, \eta_p^2 = 0.098$] and *originality* [$F(2, 84) = 3.700, p = 0.029, \eta_p^2 = 0.086$] (Table 9). The results of pairwise comparisons

showed that (1) the mean of *quantity* in the smart city group was significantly higher than that in the smart factory group ($MD = 0.763, p = 0.017$), but was not significantly higher than that in the no-scenario group ($MD = 0.584, p = 0.140$); (2) the mean of *quantity* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.179, p = 1.000$); (3) the mean of *originality* in the smart city group was not significantly higher than that in the smart factory group ($MD = 0.244, p = 0.091$), and not significantly lower than that in the no-scenario group ($MD = -0.030, p = 1.000$); and (4) the mean of *originality* in the smart factory group was not significantly lower than that in the no-scenario group ($MD = -0.273, p = 0.057$) (Table 10).

From the above results, it can be seen that the participants with low entrepreneurial imaginativeness (including creative, social, and practical imaginativeness) in the smart city group generated more business ideas than those in the smart factory group. Only the business ideas created by the participants with LSI in the smart city group were more original than those in the smart factory group. There were no significant differences in the *originality* of business ideas between the participants with low creative or practical imaginativeness in the smart city group and that in the smart factory group. Moreover, compared to the participants with low entrepreneurial imaginativeness in the no-scenario group, there were no significant differences in the *quantity* and *originality* of business ideas between them and the smart city group/the smart factory group. Therefore, Hypothesis 2b was partially supported.

GENERAL DISCUSSION

Entrepreneurial imaginativeness is the transformation of a person's inner cognitive abilities into explicit new venture ideas. It is a visualization process in one's brain that combines captured information and previous professional knowledge and experience with the latent ability of imagination (McMullen and Kier, 2017). The visualization of a new venture idea is realized through the construction of a scenario in which a specific demand is found and met. Although video scenarios have been confirmed to support imagination and favor team cooperation in the process of creating business ideas (Pillan et al., 2014), scenarios were closely related to daily life in prior studies; that is, these scenarios were familiar to participants and beneficial to the utilization of their prior knowledge, expertise, and experience. However, findings from such studies have not distinguished the impacts on the exerting of imaginativeness in familiar scenarios and unfamiliar scenarios. Nor have they confirmed that scenarios with different levels of public familiarity have the same or different effect(s) on the generation of new ideas for people with different levels of imaginativeness. An exploratory response to these two research questions is offered in this study.

First, the performance of entrepreneurial imaginativeness of the smart city group was significantly better than the smart factory group. However, compared to the no-scenario group, the smart city group did not have a significant advantage on the performance of entrepreneurial imaginativeness, and the smart

TABLE 9 | The ANCOVA results of the impact of scenario on quantity/originality (low imaginativeness level).

Imaginativeness level	Imaginativeness performance	Group	N	Mean	SD	F	Sig.	η_p^2
LCI	Quantity	No-scenario	39	1.897	0.968	9.354	0.000	0.163
		smart factory	33	1.788	0.820			
		Smart city	32	2.781	1.263			
	Originality	No-scenario	39	2.154	0.477	3.299	0.041	0.064
		smart factory	33	2.152	0.547			
		Smart city	32	2.385	0.407			
LSI	Quantity	No-scenario	41	2.024	1.172	8.020	0.001	0.120
		smart factory	48	1.896	1.057			
		Smart city	37	2.838	1.214			
	Originality	No-scenario	41	2.163	0.489	5.226	0.007	0.081
		smart factory	48	2.201	0.504			
		Smart city	37	2.468	0.372			
LPI	Quantity	No-scenario	32	1.688	0.998	4.289	0.017	0.098
		smart factory	28	1.857	1.145			
		Smart city	27	2.852	1.199			
	Originality	No-scenario	32	2.198	0.528	3.700	0.029	0.086
		smart factory	28	2.119	0.464			
		Smart city	27	2.457	0.394			

TABLE 10 | Pairwise comparisons of quantity/originality between different groups (low imaginativeness level).

Imaginativeness level	Imaginativeness performance	Group (I)	Group (J)	MD (I–J)	Std. error	Sig. ^a	95% confidence interval for difference ^a	
							Lower bound	Upper bound
LCI	Quantity	Smart city	No-scenario	0.451	0.231	0.162	–0.112	1.015
		Smart city	Smart factory	0.959*	0.222	0.000	0.419	1.499
		No-scenario	Smart factory	0.508	0.235	0.100	–0.065	1.081
	Originality	Smart city	no-scenario	0.024	0.112	1.000	–0.249	0.297
		Smart city	Smart factory	0.254	0.107	0.060	–0.007	0.516
		No-scenario	Smart factory	0.230	0.114	0.137	–0.047	0.508
LSI	Quantity	Smart city	No-scenario	0.333	0.246	0.536	–0.264	0.929
		Smart city	Smart factory	0.889*	0.226	0.000	0.340	1.438
		No-scenario	Smart factory	0.557	0.235	0.058	–0.014	1.127
	Originality	Smart city	No-scenario	0.089	0.097	1.000	–0.146	0.324
		Smart city	Smart factory	0.279*	0.089	0.006	0.063	0.495
		No-scenario	Smart factory	0.190	0.092	0.127	–0.035	0.414
LPI	Quantity	Smart city	No-scenario	0.584	0.289	0.140	–0.122	1.290
		Smart city	Smart factory	0.763*	0.267	0.017	0.109	1.417
		No-scenario	Smart factory	0.179	0.276	1.000	–0.497	0.855
	Originality	Smart city	No-scenario	–0.030	0.119	1.000	–0.321	0.262
		Smart city	Smart factory	0.244	0.110	0.091	–0.026	0.514
		No-scenario	Smart factory	0.273	0.114	0.057	–0.006	0.553

Based on estimated marginal means.

*The mean difference is significant at the 0.05 level.

^aAdjustment for multiple comparisons: Bonferroni.

factory group performed obviously worse. This result indicated that an unfamiliar scenario limited the effective utilization of participants' previous knowledge and experience, resulting in the insufficient exertion of entrepreneurial imaginativeness. In addition, we compared high-frequency words of new venture ideas between the smart city group and the no-scenario groups and found that ranking in the top three, *smart traffic* (including

vehicle-road synergy and *autopilot*) appeared 56 times in the smart city group and 28 times in the no-scenario group, *telemedicine* (including *remote surgery* and *remote consultation*) appeared 36 times in the smart city group and 29 times in the no-scenario group, and *virtual reality/augmented reality* appeared 21 times in the smart city group and 33 times in the no-scenario group. The analysis of high-frequency words showed that participants

still selected the scenarios they were familiar with to apply a new technology when no scenarios were given. This explained why the difference in entrepreneurial imaginativeness performances between the smart city group and the no-scenario group was not statistically significant.

Second, the participants with high entrepreneurial imaginativeness (including creative, social, and practical imaginativeness) in the smart city group outperformed significantly the participants with high entrepreneurial imaginativeness in the smart factory group. That is, the abilities and experience of the participants with high entrepreneurial imaginativeness were brought to full use in a familiar scenario to create new venture ideas. However, the impacts of an unfamiliar scenario on the exertion of high entrepreneurial imaginativeness were complex. Specifically, the HCI that makes novel connections to form new means-ends relationships (Eckhardt and Shane, 2003) was not completely inhibited by an unfamiliar scenario and still benefit to generate business ideas with good originality; but the high social and practical imaginativeness were negatively influenced by an unfamiliar scenario, resulting in the failure of this two imaginativeness to play out through the intentional and knowledge-based empathy.

Third, compared with the participants with low entrepreneurial imaginativeness (including creative, social, and practical imaginativeness) in the smart factory group, the participants with low entrepreneurial imaginativeness in the smart city group only had an advantage on the quantity of business ideas. That is, to the participants with low entrepreneurial imaginativeness, a familiar scenario still played a more active role in facilitating their entrepreneurial imaginativeness to create more business ideas than an unfamiliar scenario. However, the scenario is only an external factor acting on the imaginative process, which cannot fundamentally enhance the level of the idea originality. Especially for the participants with low creative and practical imaginativeness, even in a familiar scenario, they cannot create business ideas with more originality.

In summary, this study revealed that a familiar scenario did indeed inspire entrepreneurial imaginativeness more than an unfamiliar scenario, especially for high entrepreneurial imaginativeness. These results further clarified that the scenarios that provided a familiar space-time context for empathy simulations were tools to support imagination (Pillan et al., 2014), providing a new respective for understanding the relationship between empathy process and entrepreneurial opportunity recognition and evaluation processes (Packard and Burnham, 2021). Moreover, this study introduced scenarios into the external factors that inspire entrepreneurial imaginativeness, further deepening the research of entrepreneurial imaginativeness (Kier and McMullen, 2018). Meanwhile, this study had practical implications for entrepreneurial practice, especially those that make human life better based on new digital technologies.

In addition, we suggest that individuals utilize different familiar scenarios to foster their entrepreneurial imaginativeness and team leaders improve team performances

of entrepreneurial imaginativeness by selecting members who are not only familiar with the task scenarios but also in the high level of entrepreneurial imaginativeness, specifically as follows.

For Individual

It is recommended that individuals make full use of familiar scenarios to train their divergent thinking, foster their empathy and ability of perspective-taking, and establish and continuously enrich their knowledge system and methodology. For example, (1) generating alternative solutions to meet existing demands in familiar scenarios by making novel connections with old or seemingly unrelated elements; (2) broadening cognitive and knowledge boundaries of divergent thinking by repeatedly comparing the existing solutions to the same or similar demand(s) appearing in different familiar scenarios; (3) enriching feelings and experiences through the transformation of different characters in the same familiar scenario or the comparison of the same characters in different familiar scenarios so as to find out the real demands of people in these scenarios and the reasons why these demands are not been properly satisfied; and (4) summarizing practical problem-solving experience (including knowledge, methods, and know-how) by identifying and classifying the commonalities and differences in different familiar scenarios to make their knowledge system and methodology appropriate for more scenarios.

For Team

We suggest that team leaders who need to lead a team through a creative task should do two necessary preparations in advance. First of all, team leaders should select members who are familiar with the task scenario and have high entrepreneurial imaginativeness to ensure that the knowledge, expertise, and experience of the members can serve their creative tasks. Secondly, team leaders should make elaborate arrangements as follows: (1) members with HSI play different roles to understand others' wants and needs, and further effectively discover demand; (2) members with HCI conduct brainstorming to question existing solutions taken for granted and propose new ideas by creatively using or combining things; and (3) members with HPI deduce all the steps needed to realize these ideas, as well as the prerequisites and tools for each step. Such a task division based on the task scenario can strengthen perceived task interdependence to promote knowledge-sharing and enhance team creativity (Fong et al., 2018).

In the end, a limitation of this study might be that we did not design the interaction of participants with potential users. The reason is that it is difficult to effectively control the uncertainties of the interaction in an experiment. However, entrepreneurial imaginativeness, especially social imaginativeness, requires human interactions to make full use of it. In the future, case studies can be used to explore the influence mechanism of scenarios on entrepreneurial imaginativeness.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

YC and MW jointly developed this research question and designed the experiment. YC and YL conducted the experiment and completed data collection. YC completed the data analysis and wrote this manuscript. RL participated in the discussion of revising the manuscript and gave modification suggestions. YL completed the English editing and proofreading of the manuscript. MW provided financial support for this research as the leader of two funded projects.

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SUPPLEMENTARY MATERIAL

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Mediating Role of Entrepreneurial Self-Efficacy and Prosocial Tendency in the Relation Between College Students' Post-traumatic Growth and Entrepreneurial Intention in the Post-COVID-19 Era

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In this study, we explore the psychological mechanisms underlying the relation between college students' post-traumatic growth and their entrepreneurial intentions in the post-COVID-19 era. Using the post-traumatic growth, entrepreneurial self-efficacy, prosocial tendency, and entrepreneurial intention scales, we tested 690 valid samples of Chinese undergraduates (including 445 men and 245 women). The results revealed that post-traumatic growth of college students in the post-COVID-19 era will have a significant and positive effect on their entrepreneurial intentions. Additionally, the results indicated that students' entrepreneurial self-efficacy and prosocial tendencies play a partial mediation role between post-traumatic growth and entrepreneurial intentions in the post-COVID-19 era and that there is a chain mediating effect between students' entrepreneurial self-efficacy and prosocial tendencies. This study provides valuable insights into the influence of post-traumatic growth on entrepreneurial intentions among college students in the post-COVID-19 era and suggests that colleges and universities can improve students' entrepreneurial intentions by adopting measures to foster their post-traumatic growth, entrepreneurial self-efficacy, and prosocial tendencies.

Keywords: the post-COVID-19 era, post-traumatic growth, entrepreneurial intention, entrepreneurial self-efficacy, prosocial tendency

INTRODUCTION

The COVID-19 pandemic has plunged the global economy into a deep recession (Chen et al., 2020). Accordingly, several countries have prioritized economic recovery in the post-COVID-19 era (Skidelsky, 2020). Encouraging people to start their businesses can significantly increase effective supply, bring vitality to our economy, hasten the development of new industries, increase employment and residents' income, and promote economic and social development (Valliere and Peterson, 2009). However, enhancing people's entrepreneurial intentions is crucial to help them build up their businesses (Kusumawijaya, 2020). Considering that university

students are the new force for country's development, exploring means to enhance college students' entrepreneurial intentions in the post-COVID-19 era is crucial for the country's economic recovery.

Factors such as an individual's upbringing and growth experiences influence entrepreneurial intentions (Bird, 1988). An individual who experiences trauma, especially encountering health problems, has stronger entrepreneurial intentions (Williams and Shepherd, 2016). Resource theory states that people view a catastrophe as an opportunity to integrate resources when their resources have been destroyed after a disaster and engage in entrepreneurial activities following the catastrophic event (Shepherd and Patzelt, 2017). Traumatic experiences positively affect people's psychology; in other words, they achieve post-traumatic growth (Tedeschi and Calhoun, 1995). The COVID-19 pandemic can be considered a growth environment and experience. Considering the aforementioned fact, the level of college students' post-traumatic growth may affect their entrepreneurial intentions after their experience of the trauma caused by the pandemic.

The relation between post-traumatic growth and entrepreneurial intention and their underlying mechanisms have been ambiguous to date. Moreover, most researchers have considered post-traumatic growth as a dependent variable and have explored its influencing factors (An et al., 2017; Ersahin, 2020; Khursheed and Shahnawaz, 2020). A few researchers have treated post-traumatic growth as an independent variable to explore its effects on individual's behavioral intentions (Boerner et al., 2017; Zeng et al., 2021). In the present study, we consider post-traumatic growth in the post-COVID-19 era as an independent variable to explore its effects on college students' entrepreneurial intentions and its underlying mechanism of actions. By doing so, we aim to provide a reference for colleges to enhance college students' entrepreneurial intentions and encourage them to build up their businesses, thereby bringing vitality to economic recovery in the post-COVID-19 era.

LITERATURE REVIEW

Post-traumatic Growth and Entrepreneurial Intention

Entrepreneurial intention is an individual's belief to set up a new venture and consciously plan to put it into practice at a certain time in the future (Thompson, 2009). However, college students can build up their businesses only by enhancing their entrepreneurial intention (Li et al., 2021a). Factors such as personal experience, environment, cognition, and demographic factors affect entrepreneurial intentions; among these factors, researchers have exclusively focused on personal experience and external environment (Bilgiseven and Kasmolu, 2019). As an environment and experience for individuals, post-traumatic growth caused by the COVID-19 pandemic may be closely related to college students' entrepreneurial intentions.

Post-traumatic growth (PTG) refers to the positive changes in individuals' psychology experienced after struggling with a traumatic event (Tedeschi and Calhoun, 1995). A typical

traumatic event such as the COVID-19 pandemic poses a threat to physical and mental health of Chinese college students (Zeng et al., 2021); thus, students may experience varying degrees of PTG in the post-COVID-19 era. Individuals who experience PTG can more positively meet the challenges of traumatic events and come up with innovative ideas (Han et al., 2019). First, in terms of entrepreneurial traits, individuals who experience trauma, especially those who have encountered health problems, have stronger entrepreneurial intentions (Williams and Shepherd, 2016). Second, in terms of entrepreneurial resources, according to resource theory, as people's resources have been destroyed after a disaster, they view a catastrophe as an opportunity to integrate resources, and thus, they are motivated to build up their businesses following the catastrophic event (Shepherd and Patzelt, 2017). Moreover, studies on the theory and conceptual model of PTG have indicated that individuals who have achieved PTG possess the following characteristics: enhanced self-confidence, dynamic personality, improved personal relationships, optimistic mindset, and a stronger sense of responsibility (Tedeschi and Calhoun, 1996; Davis et al., 1998). These qualities are essential for entrepreneurs and positively influence the formation of entrepreneurial intentions (Prodan and Drnovsek, 2010). Therefore, we propose the following hypothesis (H1):

H1: College students' PTG significantly and positively affects entrepreneurial intentions.

Post-traumatic Growth, Entrepreneurial Self-Efficacy, and Entrepreneurial Intention

Bandura (1977) introduced the concept of self-efficacy, which has attracted widespread attention in the psychology circle, and defined self-efficacy as the individuals' confidence in their ability to use their skills to perform an activity. Empirical studies have shown that self-efficacy can influence individuals' performance, work practices, and work attitudes (Liu, 2019; Cepale et al., 2021). In the field of education, empirical studies have shown that teachers' self-efficacy (e.g., classroom management efficacy, and teaching efficacy) can predict their job burnout and job satisfaction (Aloe et al., 2014; Perera et al., 2021), whereas college students' self-efficacy (e.g., academic self-efficacy, career decision-making self-efficacy, and social self-efficacy) can predict their academic performance, career choice commitment, and psychological wellbeing (Chemers et al., 2001; Wang et al., 2006; Hong et al., 2021). By introducing self-efficacy to the field of entrepreneurship, Boyd and Vozikis (1994) developed the concept of entrepreneurial self-efficacy, namely, the level of an individual's belief that they can successfully assume various entrepreneurial roles and complete various entrepreneurial tasks. Entrepreneurial self-efficacy is an important prerequisite for potential entrepreneurs to start their business (Jakopec et al., 2013).

Numerous studies have revealed that PTG and self-efficacy are closely related and that the two affect each other. An individual with high self-efficacy can achieve PTG more quickly following a traumatic event. Thereafter, they will be mentally stronger and

demonstrate greater self-efficacy (Robles-Bello et al., 2020; Kwak et al., 2021). In addition, PTG leads to positive changes in an individual's cognition in many aspects, especially an increase in their inner strength (Mohd Shariff et al., 2021). The change enables them to feel more confident in themselves and demonstrate a high sense of self-efficacy under stressful events (Jia et al., 2017), thereby enhancing their entrepreneurial self-efficacy (Udayanan, 2019). Therefore, an individual who has experienced a trauma caused by the COVID-19 pandemic and has achieved PTG will be mentally strong and demonstrate a higher sense of entrepreneurial self-efficacy.

Self-efficacy theory states that people are motivated to make a certain move and can overcome potential difficulties only if they believe that they can accomplish it (Bandura, 1999). Numerous empirical studies have revealed that entrepreneurial self-efficacy is a crucial predictive variable of entrepreneurial intention (Wu et al., 2019; Li et al., 2020; Zhang et al., 2021). Furthermore, entrepreneurial self-efficacy significantly influences other behaviors such as entrepreneurial performance and entrepreneurial intention (Elnadi and Gheith, 2021). Therefore, entrepreneurial self-efficacy, a key explanatory variable in the formation of an individual's entrepreneurial intentions, is vital for entrepreneurs to seize opportunities, organize resources, establish a company, and achieve success (Tantawy et al., 2021). Taken together, an individual with a strong sense of entrepreneurial self-efficacy will be confident enough to cope with the difficulties encountered in the entrepreneurial process, which can finally enhance their entrepreneurial intentions.

In conclusion, in the post-COVID-19 era, college students who achieve PTG will be mentally stronger and demonstrate a stronger sense of self-efficacy, which make them believe that they can grasp entrepreneurial opportunities and address entrepreneurial risks with ease, thereby displaying will to build up their businesses. Some empirical studies have revealed that entrepreneurial self-efficacy directly affects entrepreneurial intention. Moreover, entrepreneurial self-efficacy has a mediating effect on entrepreneurial intention (Wenqing et al., 2019; Elnadi and Gheith, 2021). Therefore, we propose the following hypothesis (H2):

H2: College students' entrepreneurial self-efficacy plays a mediating role in the effects of PTG on entrepreneurial intention.

Post-traumatic Growth, Prosocial Tendency, and Entrepreneurial Intention

Prosocial tendency, based on altruism, is the willingness to involve in activities that benefit other people (Carlo et al., 2003). According to a study, the COVID-19 pandemic has encouraged people to engage in prosocial activities (Sin et al., 2021). This is because people's mindsets have changed, and they have achieved PTG following the pandemic (Singla et al., 2021). In addition, they have experienced positive changes in their attitudes toward personal relationships, worldview, and life values. Such positive changes further motivate them to be more willing to help and cooperate with others, as well

as more actively participate in public welfare activities (Vollhardt, 2009). Empirical studies have found that individuals with a history of trauma display stronger prosocial tendencies than those without any history of trauma (McGinley et al., 2009). Therefore, college students, influenced by PTG, may show greater prosocial tendencies after experiencing trauma due to the COVID-19 pandemic.

Kim et al. (2020) examined 179 Korean entrepreneurs who experienced traumatic events to explore the psychological causes that compelled them to start their businesses. The authors observed that prosocial tendency promoted entrepreneurial intention. This is because individuals who have suffered trauma have a strong desire to help others, and the desire motivates individuals to solve other people's difficulties by starting businesses (Le et al., 2020). Previous studies have documented that entrepreneurs' prosocial intentions contribute to entrepreneurial intention and opportunity identification (Al-Harasi et al., 2021). The prosocial tendency can predict entrepreneurial intentions (Yu et al., 2020). Prosocial tendencies are required for engaging in entrepreneurial activities, and individuals engaging in entrepreneurial activities have a strong prosocial inclination (Douglas and Prentice, 2019). Therefore, college students with prosocial tendencies may have firmer entrepreneurial intention.

Empirical studies have shown that the prosocial tendency can play a mediating role in empathy forecasting entrepreneurial intention (Tiwari et al., 2020), and it has also demonstrated mediation effects in other empirical studies (Zhu and Akhtar, 2014; Carlo et al., 2016). Altogether, the college students who have undergone coronavirus-induced traumatic events may develop a positive attitude toward interpersonal relationships, display greater prosocial tendencies, and thus have a strong desire to start their businesses (Le et al., 2020). Therefore, we propose the following hypothesis (H3):

H3: College students' prosocial tendencies play a mediating role in the effects of PTG on entrepreneurial intentions.

Post-traumatic Growth, Entrepreneurial Self-Efficacy, Prosocial Tendencies, and Entrepreneurial Intentions

Individuals who experience PTG demonstrate a strong entrepreneurial self-efficacy, and individuals with high self-efficacy are more likely to exhibit prosocial tendencies such as comforting, sharing with, and helping others (De Caroli and Sagone, 2013). A study by Liu and Ngai (2019) found that self-efficacy can influence individuals' prosocial tendencies. This is because individuals with a high sense of self-efficacy exhibit enough confidence in social activities. Additionally, they feel that they are capable of handling problems in their own way, consider the entire society or organization, and take more responsibility for the society or organization, thus displaying stronger prosocial tendency (Davis et al., 2021), and showing the willingness to start their businesses while fulfilling their social responsibilities (Douglas and Prentice, 2019).

Social cognitive theory suggests an interaction between environmental factors, individual factors, and individual behavior (Bandura's, 1977), implying that both environmental and individual factors influence individual behavior. According to the theory, environmental factors, as resources for individuals to enhance their self-prediction and effortful control, provide them with precise information that influences the direction and intensity of their behavior, while the process by which environmental factors influence behavior varies depending on the individual's cognitive features and levels (Schunk and DiBenedetto, 2020). Clearly, environmental and individual factors contribute equally in influencing individual behavior. Researchers have explored college students' entrepreneurial intentions according to the social cognitive theory, while considering the COVID-19 pandemic or social support as an environmental factor and entrepreneurial self-efficacy as an individual factor (Neneh, 2020; Zhang and Huang, 2021). In the present study, we considered PTG in the post-COVID-19 era as an environmental factor, entrepreneurial self-efficacy and prosocial tendency as individual factors, and entrepreneurial intention as a behavioral intention to explore the direct and indirect effects of PTG, entrepreneurial self-efficacy, and prosocial tendencies on entrepreneurial intentions in the post-COVID-19 era. To summarize, the social cognitive theory may also be used to explore college students' entrepreneurial intentions. Specifically, PTG is likely to enhance entrepreneurial self-efficacy and prosocial tendencies of college students in the post-COVID-19 era, whereas college students' entrepreneurial self-efficacy may also enhance prosocial tendencies, thus improving their entrepreneurial intentions. Therefore, we propose the following hypothesis (H4):

H4: College students' entrepreneurial self-efficacy and prosocial tendencies have a chain mediating effect on the influence of PTG on entrepreneurial intention.

RESEARCH METHOD

Research Participants

College students from a university in Hebei Province, China, were included in the study. The university is a truly representative sample because the Hebei Province is hard hit by the COVID-19 pandemic. Moreover, the university is a model school of entrepreneurship education with a good entrepreneurial atmosphere for college students. Using convenience sampling, we distributed 750 questionnaires. After eliminating 60 invalid questionnaires, 690 questionnaires were considered valid (including those of 445 males and 245 females). This research was conducted in accordance with the Declaration of Helsinki, and all participants' privacy, feelings, and intentions were fully considered. Participants voluntarily filled in the questionnaire and signed an informed consent (Goodyear et al., 2007).

Analytical Strategy

The analysis method of this study included the pilot test and formal stages. Furthermore, 138 valid questionnaires were returned in the pilot test stage. To test the reliability and validity of the

scale, we performed an exploratory factor analysis and a reliability analysis of this part of the data by using SPSS 21.0. In the formal stage, 690 valid questionnaires were received. We performed descriptive statistics and correlation analysis of this part of the data by using SPSS 21.0 and tested the measurement model and structural model by using AMOS 21.0.

Research Instruments

Owing to the large sample size of this study, χ^2 increased while performing a confirmatory factor analysis of the scale; thus, other adaptation indicators were considered (Hu and Bentler, 1998). The results revealed that all other fit indices met the standards established by Hsiao et al. (2015): RMR < 0.08, GFI > 0.8, AGFI > 0.8, PNFI > 0.5, PGFI > 0.5, NFI > 0.8, IFI > 0.8, CFI > 0.8, SRMR < 0.08, and RMSEA < 0.08, indicating a good fit of the measurement model for each scale.

Post-traumatic Growth

In this study, we defined PTG as the positive psychological changes of college students after experiencing traumatic events. According to Tedeschi and Calhoun (1996) measure of PTG, we added the word "the COVID-19 pandemic" to the beginning of each item and established a PTG scale for the post-COVID-19 era. The scale comprised 13 items that were divided into four dimensions: relating to others, new possibilities, personal strength, and spiritual change. The participants were asked to rate the level of their PTG on a 6-point Likert scale (1 = not at all and 6 = very much). The higher the score, the higher was the level of PTG. An exploratory factor analysis revealed that factor loadings ranged from 0.408 to 0.828, the explanation rate of the scale was 68.451%. A reliability analysis revealed that Cronbach's α for each dimension of the scale ranged from 0.783 to 0.857, Cronbach's α for the overall scale was 0.936. Furthermore, a confirmatory factor analysis revealed that $\chi^2 = 752.686$, $df = 59$, $\chi^2 / df = 12.757$, RMR = 0.089, GFI = 0.86, PNFI = 0.639, PGFI = 0.558, CFI = 0.855, IFI = 0.856, and SRMR = 0.074.

Entrepreneurial Self-Efficacy

In this study, entrepreneurial self-efficacy was defined as college students' confidence or belief in their ability to start their businesses by judging and assessing their own ability to achieve certain entrepreneurial behaviors. According to Barbosa et al. (2007) measure of entrepreneurial self-efficacy, we established an entrepreneurial self-efficacy scale comprising four dimensions and 15 items: tolerance ambiguity self-efficacy, opportunity-identification self-efficacy, relationship self-efficacy, and managerial self-efficacy. The participants were asked to rate the level of their entrepreneurial self-efficacy on a 5-point Likert scale (1 = not at all and 5 = fully); the higher the score, the higher was the level of entrepreneurial self-efficacy. An exploratory factor analysis revealed that factor loadings ranged from 0.421 to 0.831, the explanation rate of the scale was 73.289%. A reliability analysis revealed that Cronbach's α for each dimension of the scale ranged from 0.776 to 0.890, Cronbach's α for the overall scale was 0.935. The confirmatory factor analysis revealed that $\chi^2 = 741.188$, $df = 84$, $\chi^2 / df = 8.824$, RMR = 0.039, GFI = 0.878, AGFI = 0.826, PNFI = 0.713,

PGFI=0.615, NFI=0.891, IFI=0.902, CFI=0.902, SRMR=0.0536, and RMSEA=0.107.

Prosocial Tendencies

In this study, we defined prosocial tendencies as friendly and positive tendencies exhibited by people in social intercourse. We used the Prosocial tendency Scale revised by Kou et al. (2007), which was applied in measuring prosocial tendencies of Chinese adolescents. The scale comprised six dimensions and 26 items: public, emotional, altruism, compliant, anonymity, and dire. The participants were asked to rate the level of their prosocial tendencies on a 5-point Likert scale (1=not at all and 5=fully). The higher the score, the more pronounced was their prosocial tendencies. An exploratory factor analysis revealed that factor loadings ranged from 0.441 to 0.851, the explanation rate of the scale was 69.91%. A reliability analysis revealed that Cronbach's α for each dimension of the scale ranged from 0.809 to 0.895, Cronbach's α for the overall scale was 0.940. The confirmatory factor analysis revealed that $\chi^2 = 1931.72$, $df = 237$, $\chi^2 / df = 8.151$, RMR=0.046, GFI=0.824, PNFI=0.706, PGFI=0.651, CFI=0.902, SRMR=0.065, and RMSEA=0.102.

Entrepreneurial Intention

In this study, we defined entrepreneurial intention as a psychological state that directs an entrepreneur's attention, energy, and behaviors toward a specific goal. According to Li et al. (2021b) measure of entrepreneurial intention, we established an entrepreneurial intention scale comprising two dimensions (namely, goal intentions and implementation intentions) and 10 items. The participants were asked to rate the level of their entrepreneurial intention on a 7-point Likert scale (1=not at all and 7=fully). The higher the score, the higher was the level of entrepreneurial intention. An exploratory factor analysis revealed that factor loadings ranged from 0.490 to 0.841, the explanation rate of the scale was 76.014%. A reliability analysis revealed that Cronbach's α for each dimension of the scale ranged from 0.928 to 0.936, Cronbach's α for the overall scale was 0.959. A confirmatory factor analysis revealed that $\chi^2 = 548.252$, $df = 34$, $\chi^2 / df = 16.125$, RMR=0.09, GFI=0.864, PNFI=0.690, PGFI=0.534, NFI=0.913, IFI=0.918, CFI=0.918, and SRMR=0.042.

Model Comparison of CFA

To explore whether higher common factors exist in the measurement models, we compared three models in this study,

namely, Model 1 (single first-order factor model), Model 2 (16 first-order factors model), and Model 3 (4s-order factors model). As shown in **Table 1**, Model 2 was significantly different from Model 1 ($\Delta \chi^2 = 8492.72$, $\Delta df = 120$, $p < 0.001$), Model 3 was significantly different from Model 1 ($\Delta \chi^2 = 7706.5$, $\Delta df = 22$, $p < 0.001$), and Model 2 was significantly different from Model 3 ($\Delta \chi^2 = 786.22$, $\Delta df = 98$, $p < 0.001$). According to the fitness index, χ^2 , RMR, GFI, CFI, and PNFI in Model 2 were superior to those in the other models, indicating that Model 2 was the excellent model among the three models in terms of fitness and that no higher common factors were present in the measurement models.

STUDY RESULTS

Descriptive Statistics and Correlation Analysis

Table 2 presents the correlation between descriptive statistics data and Pearson correlation coefficients for all observable variables. The results revealed a significant positive correlation ($p < 0.01$) between two of each observable variable. Correlation coefficients ranged from 0.278 to 0.809, indicating no serious collinearity problem and satisfying the requirements of the structural equation model hypothesis testing.

Common Method Variance

In this study, Harman's single-factor analysis was used to detect common method variance (CMV). The results revealed that the single-factor's maximum explained amount of variation was 39.18%, indicating no serious CMV problem. For the rigor of the study, we further compared the single-factor model CFA with the multi-factor model CFA for adaptation. The results indicated that the multi-factor model χ^2 was much lower than the single-factor model ($p < 0.05$), indicating that the adaptation of the multi-factor model was significantly better than that of the single-factor model, and the CMV problem in this study was not serious (see **Table 3**).

Structural Model

The model (see **Figure 1**) examined the relation among PTG, entrepreneurial self-efficacy, prosocial tendencies, and entrepreneurial intention. The result revealed that $\chi^2 = 836.758$, $df = 98$, and $\chi^2 / df = 8.538$. Other adaptation indicators

TABLE 1 | Model comparison of CFA.

Model	χ^2	df	RMR	GFI	CFI	PNFI	$\Delta \chi^2$	Δdf	p
Model 1	21394.05	1829	0.09	0.46	0.49	0.45	—	—	—
Model 2	12901.33	1709	0.06	0.66	0.71	0.63	—	—	—
Model 3	13687.55	1807	0.07	0.64	0.69	0.61	—	—	—
M2–M1	—	—	—	—	—	—	8492.72	120	0.000
M3–M1	—	—	—	—	—	—	7706.5	22	0.000
M2–M3	—	—	—	—	—	—	786.22	98	0.000

Model 1, Single first-order factor model; Model 2, 16 first-order factors model, and Model 3, 4 second-order factors model.

TABLE 2 | Descriptive statistics and correlation analysis between the observable variables.

Variables	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	3.61	0.99	1															
2	3.84	0.94	0.564***	1														
3	4.13	0.82	0.524***	0.655***	1													
4	4.27	0.93	0.396***	0.648***	0.642***	1												
5	3.54	0.69	0.416***	0.614***	0.585***	0.464***	1											
6	3.35	0.75	0.494***	0.621***	0.577***	0.524***	0.687***	1										
7	3.64	0.68	0.457***	0.512***	0.541***	0.485***	0.672***	0.646***	1									
8	3.08	0.80	0.398***	0.505***	0.446***	0.392***	0.605***	0.649***	0.676***	1								
9	3.48	0.73	0.374***	0.343***	0.456***	0.397***	0.429***	0.430***	0.477***	0.470***	1							
10	3.76	0.78	0.382***	0.476***	0.500***	0.440***	0.432***	0.422***	0.395***	0.470***	0.299***	1						
11	4.00	0.75	0.415***	0.479***	0.516***	0.440***	0.514***	0.510***	0.529***	0.392***	0.306***	0.666***	1					
12	3.67	0.61	0.427***	0.483***	0.438***	0.437***	0.459***	0.475***	0.569***	0.441***	0.466***	0.470***	0.549***	1				
13	3.67	0.74	0.443***	0.482***	0.442***	0.435***	0.564***	0.474***	0.458***	0.486***	0.477***	0.422***	0.584***	0.576***	1			
14	3.91	0.67	0.412***	0.505***	0.375***	0.395***	0.507***	0.462***	0.453***	0.336***	0.421***	0.530***	0.578***	0.548***	0.587***	1		
15	4.61	1.33	0.530***	0.608***	0.643***	0.528***	0.578***	0.647***	0.590***	0.646***	0.481***	0.517***	0.557***	0.519***	0.607***	0.500***	1	
16	4.30	1.14	0.504***	0.538***	0.631***	0.487***	0.549***	0.633***	0.562***	0.628***	0.468***	0.461***	0.493***	0.522***	0.607***	0.394***	0.809***	1

1, relating to others; 2, new possibilities; 3, personal strength; 4, spiritual change; 5, tolerance ambiguity self-efficacy; 6, opportunity-identification self-efficacy; 7, relationship self-efficacy; 8, managerial self-efficacy; 9, public; 10, anonymous; 11, altruism; 12=compliant; 13, emotional; 14, dire; 15, goal intention; and 16, implementation intention. *** $p < 0.001$.

TABLE 3 | Comparison between single-factor model and multi-factor model.

Model	χ^2	df	$\Delta\chi^2$	Δdf	p
Single-factor model	21394.047	1829			
Multi-factor model	12901.334	1709	8492.713	120	0.001

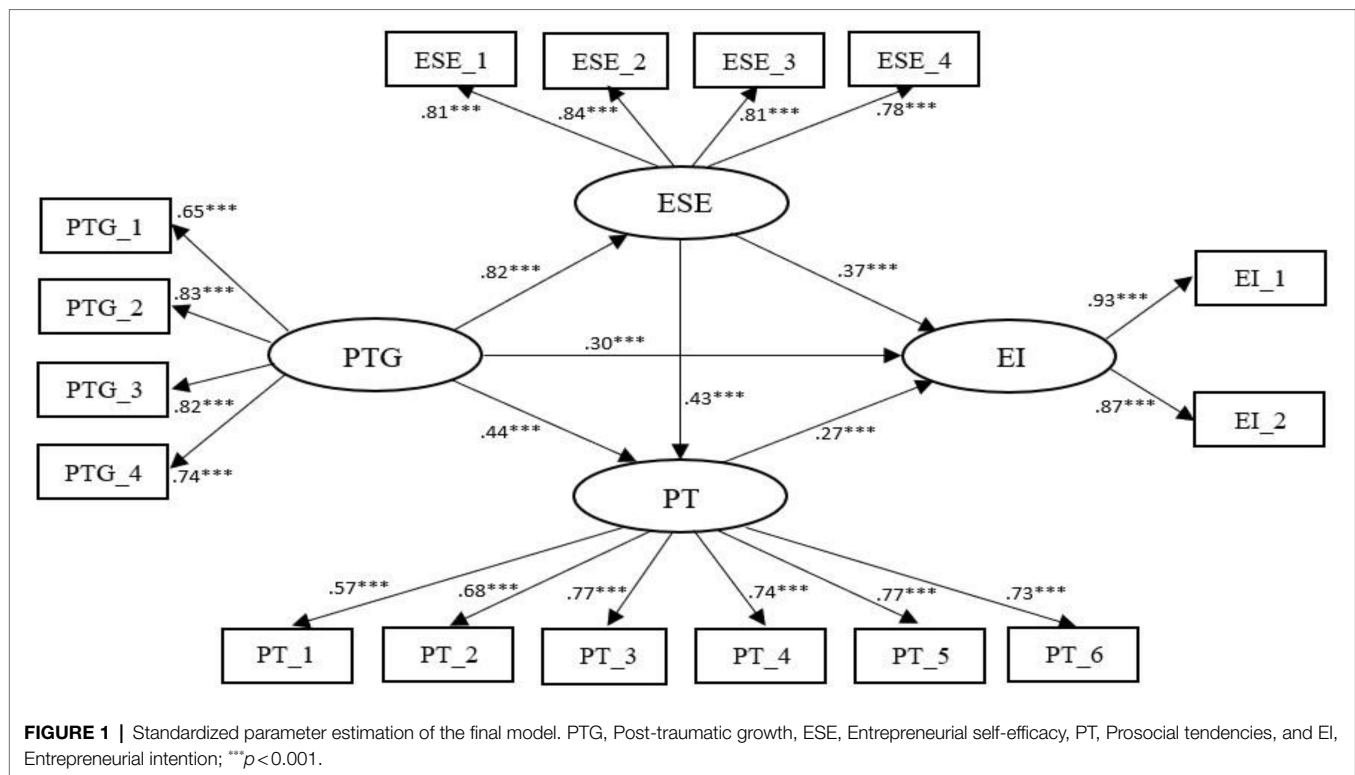
were to be considered because the large sample size of this study increased χ^2/df ratio (Hu and Bentler, 1998). Furthermore, RMR=0.032, GFI=0.874, PGFI=0.630, CFI=0.9, IFI=0.901, SRMR=0.048, and RMSEA=0.105, indicating that all fit indices reached acceptable levels (Hsiao et al., 2015). As a precautionary measure, this study further used the nonparametric percentile Bootstrap method to test mediation path effects. The results indicated that the 95% confidence intervals for the direct, indirect, and total effects of the bias-corrected nonparametric percentile did not contain 0 (see Table 4). Specifically, these results validated H1: the effect of PTG on entrepreneurial intention ($\beta=0.298$, $p<0.01$); H2: entrepreneurial self-efficacy partially mediates the effect of PTG on entrepreneurial intention ($\beta=0.302$, $p<0.01$); H3: the prosocial tendency partially mediates the effect of PTG on entrepreneurial intention ($\beta=0.117$, $p<0.01$); and H4: entrepreneurial self-efficacy and prosocial tendencies have a chain mediating effect in the relation between PTG and entrepreneurial intention ($\beta=0.095$, $p<0.01$).

Model Comparison of SEM

To illustrate that the final constructed chain mediation model outperforms other models in terms of fitness, we used SEM to construct four models (see Table 5) in this study, namely, model 1 (PTG→EI), model 2 (PTG→ESE→EI), model 3 (PTG→PT→EI), and model 4 (PTG→ESE→PT→EI). We compared the fitness of model 4 with that of other models, and the results are shown in Table 5. Model 4 was significantly different from model 1 ($\Delta\chi^2 = 768.32$, $\Delta df = 90$, $p<0.001$), Model 4 was significantly different from model 2 ($\Delta\chi^2 = 595.03$, $\Delta df = 66$, $p<0.001$), and Model 4 was significantly different from model 3 ($\Delta\chi^2 = 400.82$, $\Delta df = 47$, $p<0.001$), indicating that the chain mediation model constructed finally in this research showed a significant difference with the fit measure of other models. In Model 4, the three variables, namely PTG, entrepreneurial self-efficacy, and prosocial tendencies, together explained 76% of the entrepreneurial intention (SMC=0.76), and the interpretation ratios in Model 1, Model 2, and Model 3 were 66% (SMC=0.66), 74% (SMC=0.74), and 72% (SMC=0.72), respectively, indicating that the final chain mediation model constructed in this study had the highest explanatory power for entrepreneurial intentions.

DISCUSSION

The study results indicated that PTG significantly and positively affects entrepreneurial intention of Chinese college students who have experienced the trauma due to COVID-19 pandemic. The result is consistent with the findings of Williams and

**TABLE 4 |** Summary table of path effects.

Path	Effect	95% LLCI	95% ULCI
Direct effect	0.298**	0.160	0.430
Indirect effect1	0.302**	0.198	0.422
Indirect effect2	0.117**	0.063	0.191
Indirect effect3	0.095**	0.052	0.148
Total effect	0.515**	0.403	0.635

Bootstrapping random sampling 5,000 times; direct effect = PTG → entrepreneurial intention; indirect effect 1 = PTG → entrepreneurial self-efficacy → entrepreneurial intention; indirect effect 2 = PTG → prosocial tendencies → entrepreneurial intention; and indirect effect 3 = PTG → entrepreneurial self-efficacy → prosocial tendencies → entrepreneurial intention. ** $p < 0.010$.

Shepherd (2016) indicating that the entrepreneurial intention of college students grows higher with an increase in the levels of their PTG. The reason is that the COVID-19 pandemic has affected college students' physical and mental health to varying degrees, and college students undergo positive changes in their spiritual journey after coping with the traumatic event (Tedeschi and Calhoun, 1995). The changes enable college students to face the traumatic event and rise to life challenges with more positive emotions, eventually encouraging them to come up with creative ideas and enhancing their entrepreneurial intention. In addition, according to the theory of "altruism from suffering," the positive growth after trauma encourages college students to help others in practical ways. College students who have experienced trauma are motivated to seize the opportunity of entrepreneurship to solve problems when they see other people traumatized by social problems.

The study results indicated that college students' entrepreneurial self-efficacy partially mediates the relation between PTG and entrepreneurial intention, which is consistent with the previous findings that as the level of PTG increases, entrepreneurial self-efficacy increases; high levels of entrepreneurial self-efficacy are associated with increased entrepreneurial intention (Jia et al., 2017; Zhang and Huang, 2021). The reason is that after college students experience the trauma caused by the COVID-19 pandemic, their psychological quality becomes stronger, and they exhibit greater tolerance to stress and become confident and optimistic, which enhance their entrepreneurial self-efficacy. Individuals with a strong sense of entrepreneurial self-efficacy hold a stronger belief that they can successfully start their own businesses in an uncertain environment, thus displaying stronger entrepreneurial intention. College students hold a specific belief about their active ability and acquire the power of positive thinking after a traumatic event; thus, based on judgments of their abilities, knowledge, and experience, they plan to start their businesses. Entrepreneurial self-efficacy is the beginning of entrepreneurial intention and the key to stimulating entrepreneurial intention. Therefore, once college students aim to start their businesses, they should consciously cultivate their entrepreneurial self-efficacy and aim to achieve entrepreneurial goals with strong entrepreneurial intentions.

The findings confirmed that prosocial tendencies partially mediate the relation between PTG and entrepreneurial intention, further validating the findings of a previous study that with an increase in the level of an individual's PTG, prosocial tendencies, and entrepreneurial intention of the individual increase (Al-Harasi et al., 2021; Sin et al., 2021). The reason is that after college students experience the trauma caused by the COVID-19 pandemic,

TABLE 5 | Model comparison of SEM.

Model	χ^2	df	RMR	GFI	CFI	PNFI	$\Delta\chi^2$	Δdf	p
Model 1	68.436	8	0.03	0.97	0.98	0.52	–	–	–
Model 2	241.727	32	0.03	0.94	0.96	0.68	–	–	–
Model 3	435.939	51	0.03	0.91	0.92	0.71	–	–	–
Model 4	836.758	98	0.03	0.87	0.90	0.73	–	–	–
M4-M1	–	–	–	–	–	–	768.32	90	0.000
M4-M2	–	–	–	–	–	–	595.03	66	0.000
M4-M3	–	–	–	–	–	–	400.82	47	0.000

PTG, Post-traumatic growth, ESE, Entrepreneurial self-efficacy, PT, Prosocial tendencies, and EI, Entrepreneurial intention. Model 1 = PTG → EI, Model 2 = PTG → ESE → EI, Model 3 = PTG → PT → EI, and Model 4 = PTG → ESE → PT → EI.

they experience positive changes in their spiritual journey and recover from the trauma. Thus, they exhibit more prosocial tendencies, such as being obliging and caring for others, and display altruistic behaviors by helping others overcome the trauma. Thus, college students try to help traumatized people through prosocial tendencies, and this behavior prompts such students to transform into social entrepreneurs. On the one hand, the COVID-19 pandemic may inflict bodily and emotional injury to college students directly, for instance, being quarantined or seeing a friend or relative be diagnosed cast a shadow over them. On the other hand, they may not be traumatized, but they will be stimulated to provide help to others and society when they witness others' injury or death caused by the infection. In doing so, they change their original perception of life and living, encouraging them to value life and time more. Therefore, they will be determined to challenge themselves to do something they wanted to do before but did not have the courage, such as starting a business.

This study determined that entrepreneurial self-efficacy and prosocial tendencies have a chain mediating effect on the relation between PTG and entrepreneurial intention, validating previous study findings. PTG affects entrepreneurial self-efficacy, and individuals with high entrepreneurial self-efficacy exhibit more prosocial tendencies, thereby promoting entrepreneurship. The reason is that after coping with trauma caused by the COVID-19 pandemic, college students' psychological quality becomes stronger. They become highly confident of their ability to deal with problems and meet challenges, thereby exhibiting increased entrepreneurial self-efficacy. With an increase in the entrepreneurial self-efficacy, college students display more prosocial tendencies such as donating and volunteering. When helping other traumatized people, they realize that life is valuable and time is important, thus cherishing life and time more and realizing their life value by engaging in challenging activities such as starting businesses.

THEORETICAL CONTRIBUTIONS

The present research results make theoretical contributions to the literature on college students' entrepreneurial intentions to some degree. The study has three major findings. First, PTG significantly and positively influences college students' entrepreneurial intentions in the post-COVID-19 era. Second,

both entrepreneurial self-efficacy and prosocial tendencies partially mediate the relationship between PTG and entrepreneurial intentions. Third, entrepreneurial self-efficacy and prosocial tendencies have a chain mediating effect between PTG and entrepreneurial intentions. Some studies have shown that individuals' traumatic experiences can influence their entrepreneurial intentions (Williams and Shepherd, 2016; Shepherd and Patzelt, 2017); however, the impact of the COVID-19 pandemic on entrepreneurial intentions and its underlying mechanisms of action remain unclear. Furthermore, although previous studies have explored entrepreneurial intentions based on the social cognitive theory (Sweida and Reichard, 2013; Zhang and Huang, 2021), only a few of these studies perceived PTG as an environmental factor to explore entrepreneurial intentions in the post-COVID-19 era. Therefore, the influence of college students' PTG on entrepreneurial intention and its underlying mechanisms of action should be further explored. The contributions of this study is the findings that college students' PTG positively influences entrepreneurial intention in the post-COVID-19 era and that entrepreneurial self-efficacy and prosocial tendencies can play a mediating role between PTG and entrepreneurial intentions in the post-COVID-19 era. The results shed light on the relationship between PTG and entrepreneurial intentions in the post-COVID-19 era and may promote the application of the social cognitive theory to the studies on entrepreneurial intentions.

PRACTICAL CONTRIBUTIONS

The findings of this study provide some constructive and practical suggestions. First, since college students' PTG significantly and positively affects entrepreneurial intentions in the post-COVID-19 era, colleges and universities should pay attention to their PTG, provide regular psychological counseling to the students who have experienced trauma, and provide them with interpersonal support and enable them to enjoy teachers and classmates' company by conducting group activities. These measures can effectively increase the college students' PTG levels.

Second, given that entrepreneurial self-efficacy partially mediates the relation between PTG and entrepreneurial intentions, universities should adopt measures to improve students' entrepreneurial self-efficacy while providing them entrepreneurship

education. These measures include focusing on entrepreneurship guidance and entrepreneurship practice when teaching courses on the entrepreneurship theory; holding up some entrepreneurs as models to bolster their entrepreneurial confidence; and improving supporting policies and measures for them to start their businesses.

Third, given that the prosocial tendency partially mediates the relation between PTG and entrepreneurial intentions, colleges should praise and encourage the students who derive pleasure from helping others by holding up them as models. Teachers should inculcate empathy and habit of thinking from others' perspective in students through classroom activities. In addition, colleges and universities should cultivate college students' group cooperation spirit by adopting measures such as group competitions, thereby enhancing their prosocial tendencies.

Finally, the results of this study reveal that entrepreneurial self-efficacy and prosocial tendencies have a significant chain mediating effect on the relationship between PTG and entrepreneurial intentions. Therefore, universities should intensify their efforts to enhance students' entrepreneurial self-efficacy and prosocial tendencies to improve their level of PTG and entrepreneurial intentions. Entrepreneurial self-efficacy can in turn positively influence prosocial tendencies and thus enhance entrepreneurial intentions. Thus, the chain mediation model established in this study has a certain degree of practical contributions.

LIMITATIONS AND FUTURE DIRECTIONS

This study also has some limitations. First, we surveyed college students from only a single university in Hebei, China. Thus, future studies should aim to expand the scope of the investigation to further vindicate the findings of this study. Second, this study

considered only entrepreneurial self-efficacy and prosocial tendencies as mediating variables between PTG and entrepreneurial intention. Studies are required to explore whether there are more mediating variables in the process or whether the mediating variables are moderated by other variables. Finally, this study used cross-sectional data; thus, the relationship between the variables could be confirmed at a specific time point. We aim to adopt lagged data in future studies to better understand the dynamic process of the change in the relationship between the variables.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hengshui University. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

LW designed the study, analyzed the data, and drafted the manuscript. JH assisted in analyzing and interpreting the data and participated in the revision of the manuscript. All authors contributed to the study and approved the submitted version.

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The Influence of Psychological Safety on Students' Creativity in Project-Based Learning: The Mediating Role of Psychological Empowerment

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Creative-oriented new educational model will shape the direction and appearance of world development. This study focuses on the role of psychological safety and psychological empowerment in improving students' creativity in the context of project-based learning from the perspective of student empowerment. Based on self-determination theory, we propose that psychological safety positively affects students' creativity through psychological empowerment, and fault-tolerant culture plays a positive role in it. In this study, 238 students who participated in project-based learning were randomly selected to conduct a questionnaire survey. The results show that there is a positive correlation between psychological safety and creativity, and psychological empowerment plays an intermediary role in the relationship between them. The fault-tolerant culture enhances the direct influence of psychological safety on psychological empowerment and the indirect influence of psychological safety on creativity. Theoretical and practical implications were also discussed.

Keywords: project-based learning, psychological safety, fault-tolerance culture, psychological empowerment, creativity

INTRODUCTION

Creativity-centered education will shape the future world (Brazdauskas and Žirnelė, 2018). Entering the intelligent era full of dynamic and hyper-competition, creativity has become the main force to promote the sustainable development of the world, and it is also one of the most valued competencies of employers in the 21st century (Allina, 2018). Society is calling for innovative talents for higher levels of competence to address and solve environmental, social, cultural, and developmental problems (Brazdauskas and Žirnelė, 2018), and more attention is being paid to the cultivation and education of creative students than ever before. Compare with traditional education which improves learning creativity inefficiently (Hardika et al., 2018), project-based learning, as a systematic learning and research activity based on technology empowerment and teacher-student co-construction, can stimulate students' independent inquiry and collaborative communication by creating real problem situations, and more effectively develop students' higher-level abilities such as creativity, critical thinking ability, and entrepreneurial spirit (Anazifa and Djukri, 2017).

Although the project-based learning model has become more commoner in Chinese higher education and has an important influence on students' psychological state and behavior, researchers have not paid enough attention to it at present. Specifically, firstly, the existing research mainly focuses on the influencing factors and internal mechanisms that affect students' creativity in the traditional educational situation. For new-type education such as project-based learning, only experimental simulation, and popular science introduction are used to study (Solomon, 2003; Ergül and Kargin, 2014; Iwamoto et al., 2016; Anazifa and Djukri, 2017), and there is little empirical research on whether and why the project-based learning model is more conducive to enhance students' creativity from the individual psychological and cognitive aspects. In fact, the driving factors of creativity can be divided into situational factors and individual factors (Kim and Kim, 2017). Compared with the temporary and limited influence of situational factors, individual factors can consistently and continuously influence creativity (Ahmad et al., 2022). Therefore, this paper aims to investigate the influence of individual factors of students' creativity, so as to explore the stability and long-term antecedents of creativity promotion under the project-based learning mode. Because there are a lot of non-standardized learning contents in the course of the project, students must be liberated from the standardized and programmed indoctrination learning, and actively and efficiently carry out learning behaviors such as problem discussion, information sharing, feedback seeking, error reporting and new ideas putting forward with a relatively independent learning state. At this time, psychological safety is especially important to students. Psychological safety, as a group analysis of working environment and team as a whole (Dar et al., 2022), is the belief of individuals that it is safe to take interpersonal risks of the team (Ahmad et al., 2022). Under the uncertainty and fuzziness, the higher the psychological safety, the more likely the team members are to express different opinions and share their own knowledge, so as to enhance their creativity in freely speaking information exchange (McClintock et al., 2022; Xu et al., 2022). Therefore, this paper predicts that psychological safety can help students to make full use of the right of speaking and decision-making in project-based learning by minimizing interpersonal risks, thus enhancing creativity.

Secondly, the existing literature on empowerment under the educational background pays more attention to teachers' empowerment, that is, empowering teachers with responsibility, choice and autonomy has a positive impact on commitment, satisfaction and trust (Kusumaningrum et al., 2019; Tindowen, 2019; Tenório et al., 2020), and lacks the analysis of students' psychological empowerment under the new educational model. Considering that the power of teachers and students has changed greatly in project-based learning, students are empowered to lead the project, and teachers are only supervisors and guides (Iwamoto et al., 2016; Belwal et al., 2020), it is particularly important and urgent to explore the mechanism of psychological empowerment in project-based learning from the perspective of students. According to self-determination theory, satisfying people's three basic psychological needs, namely, autonomy, competence and relatedness, is the main way to motivate

people's behavior (Good et al., 2022). Once these needs are met, it will enhance people's autonomous motivation, promote the internalization of control motivation, and enhance their recognition of work significance and confidence in the success of the project (Dong and Wang, 2020; Luo et al., 2020). Therefore, in project-based learning, once students perceive psychological safety, they will greatly enhance their psychological needs to promote the learning process independently (autonomy needs), strengthen their confidence to solve real problems and achieve the project goals (competence needs), and gain recognition and dependence from classmates and teachers by completing a series of challenging learning activities (relatedness needs), thus enhancing students' "active orientation and control sense" of project implementation, and enabling them to generate a higher level of psychological empowerment. With the improvement of students' psychological empowerment level, they will have a stronger sense of responsibility and higher intrinsic motivation (Bin Saeed et al., 2019), and they are more willing to actively put forward new ideas, accept challenging learning tasks, promote the realization of innovative schemes, thereby enhancing their own creativity. Therefore, this paper predicts that psychological safety will enhance the psychological empowerment of students in project-based learning, and further promote their creativity.

In addition, all kinds of mistakes will inevitably occur in the process of innovation (Frese and Keith, 2015). To mitigate the impact of mistakes on students' autonomy and promote students to learn from mistakes, it is necessary to cultivate a fault-tolerant culture, which can not only reduce the negative emotional impact of mistakes and the occurrence of similar mistakes in the future, but also enhance the intrinsic motivation of students' autonomous participation, thus enhancing their creativity. Under the fault-tolerance culture, the team can face up to mistakes and provide situational support such as collaborative handling of mistakes, thus reducing the insecurity and interpersonal risks in the team. Therefore, under the culture of fault tolerance, students with high psychological safety will shift from negative emotions to error compensation and error cause analysis more quickly (Keith et al., 2021), so as to re-understand the significance of the project, improve their ability to solve problems and enhance their psychological empowerment. On the contrary, in the organizational culture where mistakes are not tolerated, people have a low sense of psychological safety, tend to hide their own problems, protect themselves too much when interacting, take defensive actions instead of speaking freely under the influence of learning anxiety, and ultimately reduce their psychological empowerment. Therefore, this paper predicts that the fault-tolerant culture can moderate the relationship between psychological safety and psychological empowerment. Overall, this study aims to answer the following research questions:

- Q1.** What is the relationship between psychological safety and students' creativity in project-based learning?
- Q2.** Does psychological empowerment play a mediating role between psychological safety and students' creativity?

Q3. Does fault-tolerant culture play a moderating role between psychological safety and psychological empowerment?

THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

Project-Based Learning and Self-Determination Theory

Project-based learning is a systematic teaching method, which requires students to explore and implement real and complex problems in a group cooperation way, and the final results need to be presented publicly (Barak and Yuan, 2021). In the process of participation, students cooperate, construct knowledge networks independently, and enhance creativity. Compare with the traditional teaching model, project-based learning covers multi-disciplinary knowledge, is student-centered, and gives students more responsibilities and powers. In the process of self-exploration, self-design, and self-execution, students can reconstruct knowledge and solve practical problems by using multi-disciplinary knowledge, instead of simply obtaining knowledge from teachers (Iwamoto et al., 2016). The teacher is only a supervisor and guide role, not too involved in the implementation of students (Belwal et al., 2020). In addition, the evaluation of project-based learning is diversified. The evaluation subject includes self-evaluation and other evaluations, and the evaluation method includes formative evaluation and summative evaluation (Anazifa and Djukri, 2017). Through the organic combination of various evaluation methods, project-based learning enables students to transfer, apply and transform into new situations based on mastering core knowledge, produce new knowledge, put it into practice, and ultimately enhance the creativity of students.

Since students in project-based learning have a considerable right and motivation to speak and make decisions through cooperation, this paper chooses the self-determination theory as the theoretical basis, research on the inner mechanism of improving students' creativity in project-based learning. Self-determination theory is the motivation process theory of human self-determination behavior put forward by Deci and Ryan (2000), which is mainly used to explain the motivation sources behind certain behaviors of individuals. Self-determination theory holds that people's behavior is based on different types of work motivation (autonomous motivation or control motivation). Autonomous motivation is a strong motivation tendency for people to implement behaviors based on their full recognition of the value of an activity or behavior, while controlled motivation is the motivation tendency toward the work that people are engaged in based on the external stimulation that they can bring to work (Guo and Cheng, 2021). Obviously, autonomous motivation is self-controllable and optional, and the degree of self-determination is high. However, the controlling motivation is uncontrollable and non-selectable, and the degree of self-determination is low (Chiu, 2021). According to self-determination theory, people's behavior

is the result of the combination of autonomous motivation and controlling motivation. To achieve self-determination and optimal motivation, the social environment must meet three basic psychological needs: autonomy (the ability to perceive that actions and thoughts can be freely chosen and decided, resulting in a sense of self-determination), competence (the sense of control and competence experienced by individuals when they interact effectively with the social environment), and relatedness (individuals need to keep in touch and close relationship with important others and experience a sense of belonging) (Good et al., 2022). Based on meeting these three needs, people internalize and integrate external rules and happenstance, and transform them into intrinsic motivation and self-determination, this fosters adaptability and creativity to change. Therefore, based on self-determination theory, this paper discusses whether and how psychological safety is related to creativity from the psychological and cognitive aspects of students.

Psychological Safety and Creativity

Psychological safety is the belief that one can show and employ oneself without fear of negative consequences to one's self-image, status, or career (Edmondson, 2018). Psychological safety describes an individual's perception of the degree of interpersonal threat in the work environment. Specifically, individuals perform an implicit calculus at the micro behavioral decision point to assess interpersonal risks associated with behaviors such as asking questions, seeking feedback, reporting errors, or coming up with new ideas, because they may be regarded by others as ignorant, disruptive, and even incompetent (Jiang et al., 2019). A high level of psychological safety allows people to relax and think that the workplace is safe for interpersonal risk-taking and is willing to participate openly in knowledge sharing and problem-solving as the basis for innovation (Frazier et al., 2017; Jiang et al., 2019). Considering that this paper pays attention to the formation mechanism of creativity in project-based learning, which is mainly in the form of student collaboration, from the cognitive level, it is more suitable for the research background and research focus of this paper to emphasize the psychological safety of voluntary contribution and active participation within the team through minimizing interpersonal risk.

The existing researches on the influence mechanism of psychological safety mainly discuss the relationship between psychological safety and the results of innovation, creativity, communication, knowledge sharing, employee voicing behavior, and team learning in the context of enterprises (Chen et al., 2014; Newman et al., 2017), but seldom analyze the influence mechanism of psychological safety in the context of education. As creativity in project-based learning is cultivated and developed by students when they solve real-world problems independently (Hanif et al., 2019), how to reduce the inherent interpersonal threats, and promote information sharing and task coordination have become the primary problem to be solved in project promotion. Therefore, this paper hypothesizes that psychological safety may promote creativity in project-based learning for the following reasons.

First of all, in terms of information efficiency, psychological safety enables team members to voluntarily provide and make

maximum use of each member's unique information and different views (McClintock et al., 2022), and at the same time, keep their openness and active listening, to better understand the complexity of the problem and realize the reconstruction of the knowledge system (Engelsberger et al., 2021), and ultimately enhance individual creativity. Secondly, in terms of social relations, psychological safety, as an individual's positive expectation of interpersonal consequences, can promote the accumulation of relationship-oriented social capital (Mikalef et al., 2019), optimize the effect of students' collaboration and interaction by developing trust and reducing interpersonal risks, and stimulate the full potential of individual creativity in dynamic cooperation (Marlow et al., 2018). Finally, in terms of behavioral motivation, psychological safety helps people overcome defensive or learning anxiety (Kolbe et al., 2020), freely concentrate on productive discussion and collective goal realization, and change from self-protection inhibition motivation to intrinsic learning motivation (Chen et al., 2019), thus affecting the leap of individual creativity. Therefore, this paper puts forward the hypothesis:

H1: There is a positive correlation between psychological safety and individual creativity.

Psychological Safety and Psychological Empowerment

Psychological empowerment is "an intrinsic motivation, which reflects the active orientation and sense of control over work, which is embodied in four kinds of cognition: meaning, competence, self-determination, and effect" (Prabowo et al., 2022). Among them, meaning represents the degree of fit between personal ideals, values, behaviors, and job requirements (Javed et al., 2019). Competence, which is closer to the concept of self-efficacy, reflects an individual's belief in his ability to perform his duties or actions (Ioannidou et al., 2016). Self-determination reflects the control and autonomy of the start, adjustment, and continuous work behavior and process (Chiu, 2021). Effect reflects the degree of personal influence on the strategy, administration, operation and organizational output of work tasks (Prabowo et al., 2022). Together, these four perceptions reflect an individual's active rather than passive orientation to a particular job role, which coincides with the fact that students are motivated and empowered to be members of a particular project team in project-based learning and need to engage in learning and problem solving on their own. At the same time, based on self-determination theory, considering that psychological safety is the view of broader interpersonal relationships and working environment, which can help individuals get more resources and support (Dar et al., 2022), this paper speculates that psychological safety may promote the promotion of psychological empowerment in project-based learning for the following reasons.

According to self-determination theory, the main way to promote work motivation is whether the external situational factors meet the three basic psychological needs of people's autonomy, competence and relatedness (Shi et al., 2018; Luo et al., 2020). For the students who are engaged in project-based

learning, they need to face and solve the practical problems of non-standard scholarship. They must break through the indoctrination and textbook-based learning process, and actively participate in the interaction with classmates and teachers with high autonomy, so as to meet the innovative goal of project-based learning. This requires students to have sufficient autonomy or control motivation in the implementation of the project, so as to encourage them to make full use of their abilities or experiences to independently complete learning and innovation (Newman et al., 2017).

In project-based learning, as an important factor for individuals to perceive external situations, psychological safety, once perceived by students, will enhance students' intrinsic learning motivation by meeting their three basic needs, thus promoting a higher level of psychological empowerment (Good et al., 2022). Firstly, in terms of enhancing meaning, by helping individuals speak out openly and provide feedback, psychological safety promotes the good interaction between students and students, as well as between students and teachers (Liang et al., 2012), meets their relatedness needs, and helps the new value of the project be discovered and developed (Edmondson, 2018), thus improving the matching degree between individual beliefs and organizational requirements. Secondly, in terms of enhancing competence, psychological safety enhances the individual's willingness and ability to challenge the status quo by reducing interpersonal risks (Kolbe et al., 2020), and make students believe that they can complete realistic challenging project tasks, so as to meet their competence needs, and then improves their self-efficacy. Thirdly, in terms of enhancing self-determination, psychological safety encourages people to put forward their own ideas, hold the decision-making power in their own hands, and enable students to initiate, adjust or discuss problem solutions more independently, meet their autonomy needs, so as to improve their self-determination awareness (Singh and Sarkar, 2018). Finally, in terms of enhancing effect, psychological safety helps individuals to disperse their thinking and adventurous spirit, and stimulate their exploratory learning behaviors (Lee et al., 2018), so that autonomous learning behaviors can be standardized in the organization (Newman et al., 2017), so as to meet their autonomy needs, and then the influence of individuals on the project process can be improved. Therefore, this paper puts forward the hypothesis:

H2: Psychological safety is positively correlated with psychological empowerment.

Psychological Empowerment and Creativity

According to self-determination theory, the satisfaction of people's autonomy, competence and relatedness needs in the organizational environment, will enhance people's autonomous motivation and promote the internalization process of controlled motivation. When people have the sense of autonomy to control their behavior at work, they will have a stronger sense of responsibility and higher internal motivation (Rhee et al., 2017), and strengthen their willingness to independently implement certain activities or behaviors (Luo et al., 2020). Therefore,

students with high psychological empowerment, who have such strong motivation to participate in learning, will improve their creativity at all stages from generation to realization.

First of all, in the stage of generating ideas, individuals with high psychological empowerment have more freedom to generate unique ideas, and they are more confident that their ideas will be valued in the organization (Javed et al., 2019), so it is easier to generate and display innovative ideas or solutions to tasks and problems (Abukhait et al., 2019). Secondly, in the stage of seeking support, individuals with high psychological empowerment have the opportunity to choose and take risks without fear of punishment (Khan et al., 2020), and high self-confidence and self-efficacy make the team willing to accept the inherent risks of challenging the status quo, so it is easier to get resource support based on mutual trust and cooperation (Aldabbas et al., 2021). Finally, in the stage of innovation implementation, individuals with high psychological empowerment have considerable intrinsic motivation to exert greater influence on the project implementation (Malik et al., 2021), and at the same time enjoy greater autonomy to carry out innovative behaviors in a proactive manner. Therefore, this paper puts forward the hypothesis:

H3: Psychological empowerment is positively correlated with individual creativity.

The Mediating Role of Psychological Empowerment

From the perspective of self-determination theory, the high autonomy model of project-based learning can meet the three basic needs of autonomy, competence, and relatedness, enhance students' autonomous learning motivation and behavior (Good et al., 2022), and then improve students' creativity. Specifically, in terms of emotional support, psychological safety gives students a sense of belonging and freedom, encourages them to take on interpersonal risks and bravely express new ideas and different opinions, promotes individual members' awareness of psychological empowerment on the basis of meeting their autonomy needs and relatedness needs, and stimulates individuals to rethink the meaning of the project and their belief in their ability to complete the project (Fernandez and Moldogaziev, 2013), thus developing their creativity. In terms of information support, psychological safety creates a free and cooperative environment of speaking freely and interacting efficiently, which stimulates students to explore and learn information and knowledge from different sources, forms the necessary conditions to enhance individual members' psychological empowerment based on meeting the needs of competence and relatedness, and makes students feel their autonomy and influence on the construction of knowledge system and project realization (Dust et al., 2018), and then develops their creativity. Therefore, this paper puts forward the hypothesis:

H4: Psychological safety positively affects individual creativity through psychological empowerment, and

psychological empowerment plays a mediating role between psychological safety and creativity.

The Moderating Role of Fault-Tolerant Culture

Creativity can't be without mistakes which can't be completely avoided in personal development and human development (Frese and Keith, 2015). The wrong negative emotions and behaviors will seriously affect the individual's self-efficacy (Wang et al., 2020). Given the cultural guidance behavior (Ravindra et al., 2019), this paper holds that the fault-tolerant culture will serve as an active and open organizational culture, maintain and improve students' psychological empowerment, and ultimately guide and promote students' creativity.

Fault-tolerant culture is a common norm, procedure, belief, and core value about facing up to the inevitability of mistakes, recognizing the input of mistakes, exchanging information and knowledge related to mistakes, and dealing with mistakes cooperatively (van Dyck et al., 2005). This organizational culture can give full play to the diversity of project-based learning evaluation to reduce negative error consequences, enhance positive results, and ultimately foster and develop students' psychological empowerment. Specifically, on the one hand, the fault-tolerant culture can reduce the insecurity and interpersonal risks in the team, so that students with high psychological safety can quickly transfer their limited cognitive resources from negative emotions to error compensation and error cause analysis (Keith et al., 2021), thus re-understanding the significance of the project, and finally enhancing their psychological empowerment. On the other hand, the fault-tolerant culture can promote individuals to learn from failures, explore and reflect on the causes of failures, and optimize the positive effects of errors more effectively in the cognition of individuals with high psychological safety, for example, promoting more adaptive practices (Svensson de Jong, 2021), thus enhancing the autonomy and influence of individuals. On the contrary, in an environment where mistakes are not tolerated, low psychological safety will make it less likely for members to express their reflections and share their new ideas again by learning from failures, which will lead to lower self-confidence and psychological empowerment, and even a vicious circle of mistakes-low self-efficacy-repeated mistakes (Hirak et al., 2012). Therefore, this paper puts forward the hypothesis:

H5: Fault-tolerant culture positively moderates the relationship between psychological safety on psychological empowerment.

Moreover, in some schools, people regard mistakes as indicators of poor performance, negligence, or even lack of intelligence (Svensson de Jong, 2021), which seriously hindered the development of individual creativity. This paper holds that fault-tolerant culture will be an inclusive and open organizational culture to guide and develop students' creative thinking and behavior. Based on the above analysis, fault-tolerant culture moderates the influence of psychological safety on psychological empowerment, while psychological empowerment plays a

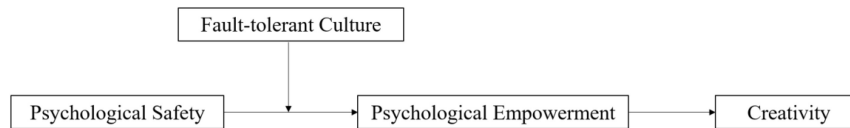


FIGURE 1 | Theoretical framework. Source: Authors build this model based on relevant data.

mediating role between psychological safety and creativity. According to this, it can be further inferred that the fault-tolerant culture may also have a moderating effect on the mediating effect of psychological empowerment between psychological safety and creativity, that is, there may be a moderated-mediation effect. Therefore, this paper puts forward the hypothesis:

H6: Fault-tolerant culture positively moderates the mediating role of psychological empowerment between psychological safety and creativity.

According to the above hypothesis, the conceptual model of this paper is shown in **Figure 1**.

RESEARCH METHODOLOGY

Sample

In this study, the online questionnaire survey system¹ was used to distribute online questionnaires to students by random sampling and collect relevant data. To reduce common method bias, respondents were told that the conditions for participation in this survey were voluntary and anonymous. Therefore, respondents do not have to guess what investigators expect, and can answer questions based on their actual situation. This study uses three filtering questions to ensure that the respondents are participants in project-based learning in higher education, that is, “What grade are you in now?” “Have you ever experienced project-based learning in higher education?” If the answer is “yes,” the respondents are required to provide a brief description of their project-based learning experience, including the opportunity, process, and results of the experience. This method eliminates those who may accidentally join the project-based learning but are uninterested and indifferent to the project-based learning course, enhances the memory of the respondents, and improves the accuracy of the follow-up answers.

Finally, a total of 318 questionnaires were issued in the 20-day period from November 5th to November 25th, 2021. Excluding those who did not pass the filter questions, ignored the reverse questions, gave incomplete answers, and submitted the questionnaire too quickly, 238 valid questionnaires were collected, the response rate is 74.8%. Among them, 118 were males and 120 were females. Most of the respondents are undergraduate students (84.0%). The monthly living expenses mainly include less than 1,500 yuan (33.6%), 1,501–3,000 yuan (29.2%) and more than 3,000 yuan (22.6%). There are 91 students (38.2%) in soft subjects and 147 students (67.8%) in hard subjects. The demographic profile of the sample are shown in **Table 1**.

¹<https://www.wjx.cn/>

TABLE 1 | Sample profile (*N* = 238).

	Value	Numbers	Percentage (%)
Gender	Male	118	49.58
	Female	120	50.42
Monthly living expenses (¥)	≤1500	178	74.79
	1501–3000	54	22.69
	≥3001	6	2.52
Education	Undergraduate students	200	84.03
	Postgraduate students	33	13.87
	Doctoral students	5	2.10
Subject category	Soft science ^a	91	38.24
	Hard science ^b	147	61.76
Site of the university	First-tier city ^c	25	10.50
	Second-tier city ^d	47	19.75
	Others	166	69.75
Site of hometown	First/second-tier cities	32	13.45
	Others	206	86.55

^aSoft science includes philosophy, economics, law, education, literature, history, and art.

^bHard science includes science, engineering, agriculture, medicine, military science, and management.

^cThe first-line cities represent Beijing, Shanghai, Guangzhou, and Shenzhen.

^dSecond-tier cities represent provincial and sub-provincial cities.

From the perspective of the proportion of sample disciplines, it is roughly the same as that of Chinese higher education students. Judging from the other characteristics of samples, it also accords with the general characteristics of Chinese students today. Therefore, the sample is representative.

Measures

This paper's questionnaire is divided into three parts: First, filtering questions. Second, the main part, which measures variables such as psychological safety, psychological empowerment, fault-tolerant culture, and creativity. Third, demographic characteristics, including gender, monthly living expenses, subject category, site of the university, site of hometown. Among them, the questions in the main part are realized by Likert scale, using the existing research maturity scale for reference. The survey was conducted in China and all items were translated in Chinese. Besides, the original items were used in work context. This paper modified some words and expressions to suit the educational context after consulting the teachers and some students.

First of all, *Psychological Safety* is measured by the six items of Edmondson (1999), including “If you make a mistake in this team, it will be bad for you” (reversed) and “It is safe to take risks in this team.” *Psychological Empowerment* is measured

TABLE 2 | Reliability and convergent validity.

Variables	Cronbach's α	Composite reliability	AVE
Psychological safety	0.910	0.914	0.643
Psychological empowerment	0.965	0.966	0.761
Fault-tolerant culture	0.940	0.938	0.790
Creativity	0.905	0.906	0.549

by Spreitzer's (1995) classic scale, which consists of nine items, including "I have great independence and autonomy in how to study." The dimensions of these two variables range from "strongly disagree" (1) to "strongly agree" (7).

Secondly, four items adapted by van Dyck et al. (2005) are used to measure the *Fault-tolerant Culture*, such as "Teachers and classmates will tolerate or forgive mistakes made by others in their studies." The scale of George and Zhou (2001) is used for reference to measure *Creativity*. There are eight items, including "I often have new and creative ideas" and "I propose new ways to achieve learning goals." The dimensions of these two variables range from "strongly disagree" (1) to "strongly agree" (5).

In addition, it should be noted that hard subject is a general term for to the cross-development of natural science and technological science. Soft subject is a group of new subjects formed by the cross development of modern natural science and social science. For this study, the difference between them lies in the degree of empowerment and autonomy of students in project learning, and the autonomy of students in soft subject is stronger than that in hard subject. Therefore, this paper holds that soft and hard subject will affect the effect of students' psychological empowerment, which needs to be controlled.

Common Method Bias

Since the data were collected from the same group of respondents at the same time, and all the variables were in the same environment, concerns about common method bias (CMB) became apparent (Lindell and Whitney, 2001). As a diagnostic measure, we applied Harman's single-factor test to enter all 29 items into an unrotated principal components factor analysis to determine the number of factors required to explain the variance in the variable (Podsakoff et al., 2003). Our results suggested that there were three potential factors (all eigenvalues greater than 1) that account for 73.5% of the variance, with the highest variance explained by a single factor being 46.3% (Less than 50%), which cannot explain the majority of the differences in the study. Therefore, we concluded that CMB was not a problem in this study.

RESULTS

Assessment of Measurement Models

Based on the criteria proposed by Hair et al. (2012), this study focuses on evaluating the reliability and validity of variables before evaluating the quality of structural models. Firstly, as shown in **Table 2**, all loadings are well above the threshold of above 0.7, indicating satisfactory indicator reliability (Bagozzi et al., 1991). In addition, the values for Cronbach's Alpha (α)

TABLE 3 | Discriminant validity (Fornell-Larcker criterion).

Variables	1	2	3	4
1. PS	0.802			
2. PE	0.590***	0.872		
3. FC	0.184***	0.496***	0.889	
4. CV	0.449***	0.563***	0.502***	0.741
Mean	4.087	4.503	4.899	3.961
S.D.	1.284	0.986	1.038	1.078

Significant at $p < 0.05$ (***) $p < 0.001$ level.

PS, Psychological Safety; PE, Psychological Empowerment; FC, Fault-tolerant Culture; CV, Creativity.

Bold values on the diagonal are the square root of the average variance extracted of each variable.

TABLE 4 | Results of confirmatory factor analysis.

	χ^2	df	CFI	TLI	SRMR	RMSEA
Four-factor model	319.38	98	0.951	0.940	0.034	0.098
Three-factor model ^a	708.57	101	0.865	0.840	0.086	0.159
Three-factor model ^b	1019.35	101	0.796	0.758	0.196	0.114
Three-factor model ^c	1057.91	101	0.787	0.747	0.137	0.143
Two-factor model ^d	1808.93	103	0.621	0.559	0.238	0.264
Single-factor model	1991.87	104	0.581	0.516	0.182	0.277

^aPsychological Safety and Psychological Empowerment merged as a potential factor.

^bFault-tolerant Culture and Creativity merged as a potential factor.

^cPsychological Empowerment and Fault-tolerant Culture merged as a potential factor.

^dPsychological Safety and Fault-tolerant Culture merged as a potential factor. Psychological Empowerment and Creativity merged as one factor.

and composite reliability (CR) exceed the threshold of 0.7, indicating strong internal consistency reliability (Bagozzi and Yi, 1988). Secondly, all average variance extracted (AVE) is higher than the minimum threshold of 0.5, which indicated a high degree of convergence effectiveness (Fornell and Larcker, 1981). Thirdly, discriminant validity is evaluated based on the Fornell and Larcker criteria and the Heterofactorial-Monotrait ratio. As shown in **Table 3**, diagonal elements are larger than off-diagonal elements, so the square root of the AVE of each construct was higher than the correlation coefficients between constructs. Both methods have proved that discriminant validity was supported. Finally, a series of confirmatory factor combinations (CFA) are conducted to estimate the fitness of the four variables and corresponding items. As shown in **Table 4**, using "item parceling" method, the four-factor model indices showed that the data fit well [$\chi^2(988) = 319.38$, CFI = 0.951, TLI = 0.940, SRMR = 0.034, RMSEA = 0.098] and all the standardized factor loadings were greater than 0.5 significantly. What's more, the model indices of competitive CFA models showed that the four-factor fitted the data considerably better than any of the competitive CFA models, which indicated the construct validity between the variables was qualified (Cheung and Rensvold, 2002).

Descriptive Statistics

Table 3 presents the correlations of all the variables. From the table, psychological safety was positively correlated with

TABLE 5 | Regression analysis results.

	Creativity				Psychological empowerment			
	M ₁	M ₂	M ₃	M ₄	M ₅	M ₆	M ₇	M ₈
Control variables								
Gender	0.046 (0.459)	0.017 (0.185)	0.083 (0.984)	0.066 (0.786)	−0.077 (−0.675)	−0.123 (−1.343)	−0.160* (−2.009)	−0.159* (−2.264)
Monthly living expenses (¥)	0.244* (2.412)	0.201* (2.183)	0.118 (1.368)	0.123 (1.447)	0.263* (2.291)	0.194* (2.098)	0.226** (2.807)	0.234** (3.313)
Education	0.095 (0.822)	0.068 (0.642)	−0.007 (−0.074)	0.000 (0.001)	0.213 (1.622)	0.169 (1.597)	0.124 (1.348)	0.193* (2.368)
Subject category	−0.218* (−2.118)	−0.202* (−2.160)	−0.180* (−2.079)	−0.181* (−2.104)	−0.079 (−0.679)	−0.053 (−0.568)	−0.019 (−0.226)	0.030 (0.410)
Site of the university	0.137 (1.791)	0.117 (1.675)	0.065 (1.004)	0.070 (1.086)	0.150 (1.727)	0.117 (1.673)	0.116 (1.908)	0.061 (1.124)
Site of hometown	0.203 (1.388)	0.062 (0.460)	0.030 (0.245)	0.008 (0.064)	0.359* (2.164)	0.135 (0.998)	0.141 (1.207)	0.126 (1.224)
Independent variable								
Psychological safety		0.391*** (7.135)		0.144* (2.296)		0.619*** (11.233)	0.542*** (11.146)	0.357*** (7.396)
Mediation								
Psychological empowerment			0.481*** (9.871)	0.399*** (6.639)				
Moderator								
Fault-tolerant culture							0.383*** (8.742)	0.419*** (10.809)
Interaction								
Psychological safety × fault-tolerant culture								0.334*** (8.266)
Constant	−0.478 (−1.431)	−0.328 (−1.082)	−0.065 (−0.229)	−0.080 (−0.286)	−0.858* (−2.267)	−0.621* (−2.034)	−0.644* (−2.429)	−0.716** (−3.070)
R ²	0.056	0.227	0.337	0.352	0.059	0.392	0.544	0.649
Adj. R ²	0.032	0.204	0.317	0.329	0.034	0.374	0.528	0.636
F	2.291*	9.661***	16.704***	15.546***	2.405*	21.205***	34.191***	46.918***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Bracketed values in the table are standard errors.

psychological empowerment ($r = 0.590$, $p < 0.001$) and creativity ($r = 0.449$, $p < 0.001$), psychological empowerment was positively correlated with creativity ($r = 0.563$, $p < 0.001$). This provides a basis for further hypothesis verification. According to Tsui et al. (1995), a correlation level between two variables higher than 0.75 indicates a serious multicollinearity problem. Therefore, there is no multicollinearity problem for the main variables in this study.

Hypotheses Testing

Hierarchical multiple regression analyses were conducted to test the hypotheses. The main effect test of this paper was shown in Table 5. In terms of direct effects, since psychological safety was positively related to creativity ($\beta = 0.391$, $p < 0.001$, Model 2), H1 was accepted. Similarly, in Model 6, psychological safety was positively related to psychological empowerment ($\beta = 0.619$, $p < 0.001$), and H2 was supported. In Model 3, psychological empowerment was positively related to creativity ($\beta = 0.481$, $p < 0.001$), and H3 were supported.

In terms of mediating effect, Model 4 indicted that, when both psychological safety and psychological empowerment entered the model, the regression coefficient of psychological safety became

lower than Model 2 ($\beta = 0.144$, $p < 0.05$), while the regression coefficient of psychological empowerment was still significant ($\beta = 0.399$, $p < 0.001$). Thus, psychological empowerment played a partial mediating role in the relationship between psychological safety and creativity, which supported H4.

In terms of moderating effect, an interaction term was included in Model 8. As shown in Table 5, the interaction term between psychological safety and fault-tolerant culture was positively related to psychological empowerment ($\beta = 0.334$, $p < 0.001$), which supported H5. Simple slope analysis was performed to better show the moderating effect of fault-tolerant culture. As shown in Figure 2, when the fault-tolerant culture was low-level, psychological safety had less impact on psychological empowerment, while when the fault-tolerant culture was high-level, the relationship was strengthened. Thus, H5 was supported.

In terms of the moderated-mediation effect, the conditional indirect effect was examined to test H6 (Preacher et al., 2007). In this paper, the Process program, which involved the bootstrapping (5,000 resamplings) technique with 95% bias-corrected confidence intervals, was used to directly obtain the indirect effect when the moderator variable is low (mean−1

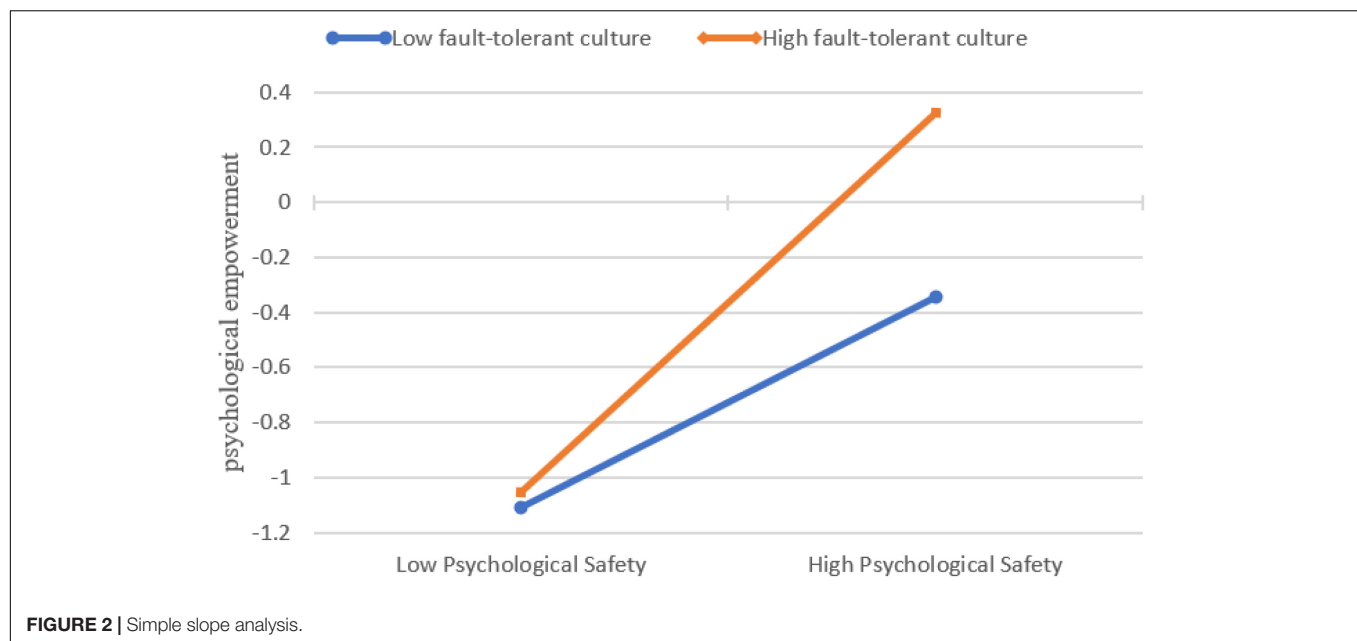


TABLE 6 | Bootstrap analysis of moderated mediation.

Moderator	Conditional direct effect				Index of moderated mediation			
	Effect	SE	LLCI	ULCI	Effect	SE	LLCI	ULCI
Low-level	0.023	0.041	-0.059	0.101	0.158	0.063	0.035	0.282
Middle-level	0.142	0.033	0.080	0.206				
High-level	0.262	0.044	0.174	0.342				

standard deviation), medium (mean), and high (mean+1 standard deviation), and the control variables were introduced as covariates. As shown in **Table 6**, the indirect effect of psychological safety on creativity through psychological empowerment varied significantly across different levels of fault-tolerant culture. The difference between the three conditions was 0.158 (95% CI = [0.035, 0.282]). Specifically, when fault-tolerant culture was of a low-level (M-1 SD), the indirect effect of psychological safety on creativity through psychological empowerment was not positively significant (Effect = 0.023, 95% CI = [-0.059, 0.101]); when fault-tolerant culture was of a high-level (Mean+1 SD), the indirect effect of psychological safety on creativity through psychological empowerment was significant (Effect = 0.262, 95% CI = [0.174, 0.342]). With the continuous increase of the level of fault-tolerant culture, the conditional indirect effect of psychological empowerment gradually increased. Thus, Hypothesis 6 was supported.

DISCUSSION

Findings

This study aims to add insights on project-based learning by exploring the mediating role of psychological empowerment

in the influence of psychological safety on creativity and the moderating role of fault-tolerant culture in it.

The first research question of this paper is whether psychological safety positively affects creativity. The results show that in the context of project-based learning, psychological safety is the key factor to enhance creativity. This is consistent with the research conclusion of Javed et al. (2019) in the enterprise context, which has shown that psychological safety can support the innovative work behavior by enabling risk-taking and the willingness to suggest new ideas.

The second research question discusses the internal mechanism of psychological safety to enhance creativity. The results show that psychological empowerment plays a mediating role in the influence of psychological safety on creativity. This result reveals the significance of student empowerment in project-based learning and helps to explain why there are differences in creativity among students who both perceive psychological safety support.

The third research question discusses the boundary conditions for psychological safety to enhance creativity. The results show that the fault-tolerant culture positively moderates the positive influence of psychological safety on psychological empowerment, and then positively moderates the mediating role of psychological empowerment between psychological safety and creativity.

Theoretical Contributions

This study provides important theoretical implications for several research streams. Firstly, this paper discusses the influence of psychological safety on students' creativity in project-based learning, which is helpful to understand the stable influence of individual factors on students' creativity comprehensively and deeply, it provides new empirical evidence for expanding and enriching the research on the successful mechanism of the new education model. The existing research mainly focuses

on the formation mechanism of students' creativity in the traditional educational context, and lacks empirical research on the teaching effect of new educational models such as project-based learning, this paper is the first attempt to explore whether and why psychological safety is more helpful to enhance students' creativity in project-based learning, and expands the explanation scope and research results of psychological safety.

Secondly, based on self-determination theory, this paper discusses the mediating effect of psychological empowerment in the relationship between psychological safety and students' creativity, and reveals the "black box" of psychological safety's influence on students. Different from the previous literature on empowerment under the educational background, which paid attention to the empowerment of teachers (Edwards et al., 2002; Dee et al., 2003; Moya et al., 2005; Wan, 2005), this research is based on the fact that students in project-based learning have changed from passive to self-directed learning, and introduces self-determination theory, to explore the mediating role of psychological empowerment in the relationship between psychological safety and creativity. This finding not only enriches the application of self-determination theory to a certain extent, but also contributes to students' subjective initiative and sense of responsibility in project-based learning.

Finally, this paper introduces the new concept of fault-tolerant culture, discusses the moderating variables that affect the intensity of psychological safety, and finds an important boundary condition that psychological safety affects students' creativity. Considering the negative emotions and negative consequences caused by inevitable mistakes in innovation, this study responds to Singh and Sarkar's (2018) discussion on the influence of organizational working environment on innovation, draws lessons from the concept of fault-tolerant culture in management, and analyses how the fault-tolerant culture affects students' creativity by moderating the relationship between psychological safety and psychological empowerment.

Practical Implications

These findings provide convincing enlightenment for management practice. First of all, colleges and universities that implement project-based learning and their teachers should realize that psychological safety may contribute to students' creativity. That is to say, teachers should do some practical actions to encourage students to establish a kind of cognition and mentality to face up to interpersonal risks, dare to put forward different ideas, and make fruitful discussions in the team. For example, helping project members to share information and knowledge voluntarily and harmoniously (Iwamoto et al., 2016).

Secondly, colleges and universities and their teachers should be aware of the importance of student empowerment to enhance their creativity. Therefore, teachers need to change from classroom leaders to partners and assistants and act as catalysts, process assistants, and resources connectors when students are engaged in project learning (Hardika et al., 2018). For example, adjust the discussion rhythm and atmosphere of project team members, and provide

corresponding information support and manpower support for project implementation.

Finally, colleges need to build and maintain a culture of fault tolerance, allowing team members to learn by making mistakes and accepting and thinking differences among team members (Svensson de Jong, 2021), which will help to improve students' psychological empowerment and creativity through psychological safety. Specifically, teachers should respect and recognize students' efforts, guide students to exchange mistakes and discuss the reasons, and follow-up compensation measures through formative evaluation, to monitor student-as-master by creating opportunities for constructive criticism.

Limitations and Future Research

This study has several limitations, paving the way for future research. First, this study only investigates the situation of project-based learning in China, which may limit the explanatory power and universality of research conclusions. Therefore, future research can explore the adaptability of this conclusion in other cultural backgrounds and the influence of other new educational models such as problem-based learning, discovery learning, and guided inquiry on creativity.

Secondly, the results of the questionnaire survey in this study are all from students' self-reports. Future research can directly collect students' behavior traces and data records from schools, and conduct more accurate and comprehensive longitudinal research and investigation through actual quantitative data (such as frequency and intensity of project participation, quality, and quantity of project results).

Thirdly, the model of psychological safety affecting creativity through psychological empowerment needs further exploration. First of all, according to "The too-much-of-a-good-thing effect" (Pierce and Aguinis, 2013), the negative effects of excessive psychological safety also need to be studied and paid attention to. Moreover, this paper only considers the moderating effect of fault-tolerant culture. Among the control variables in this paper, monthly living expenses and soft and hard science have a marginally significant influence on creativity. Although they do not influence the research conclusion of this paper, they are indeed interesting phenomena worthy of attention. In the future, based on this result, the promotion mechanism of creativity in project-based learning can be further studied.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants was not required to participate

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AUTHOR CONTRIBUTIONS

SH contributed to conceptualization, investigation, writing, visualization, review, and editing. DL and YL contributed to the substantial revision. YL successfully applied for the sponsorship of our research. DL contributed to conceptualization,

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Facilitating Students' Creativity, Innovation, and Entrepreneurship in a Telecollaborative Project

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In this study, telecollaborative learning activities were carried out in virtual learning environments created by the 360-degree video technology. We aimed to facilitate students' creativity, innovation, and entrepreneurship. Two groups of students, a group of junior high school students from China ($n = 15$) and a group of university students from Indonesia ($n = 10$), participated in the study. Students created cultural learning content using the 360-degree video technology which considered to be creative, innovative, and entrepreneurial, shared it with their international partners on the telecollaborative platform and then watched content of their partners to experience virtual panoramic tours. After that, students exchanged their ideas and comments with each other in order to improve content quality. We investigated whether participation in telecollaborative learning activities positively impacts students' creativity, innovation, and entrepreneurship. The data were collected through questionnaires and interviews. We also analyzed content created by the participants in learning activities. Two main findings were obtained: (1) technology-supported learning activities improved participants' creativity, innovation, and entrepreneurship and (2) the participants positively perceived their learning experiences. Based on our results, we proposed several suggestions and derived some implications.

Keywords: 360-degree video technology, creativity, cross-cultural learning activities, entrepreneurship, innovation, telecollaboration platform, virtual panoramic tour, contextual learning

INTRODUCTION

To promote social and economic development of society, we need talented people with variety of twenty-first century skills, e.g., cross-cultural communicative competence, creativity, innovation, and entrepreneurship. Twenty-first-century skills development is a target of many educational programs worldwide (Trilling and Fadel, 2009; Core Competencies Research Group, 2016; Huang et al., 2017; Halinen, 2018). These programs consider a learning process to be in a way in which students learn new knowledge and then apply it to solve real-world problems in creative and innovative ways (Lin et al., 2020).

With recent technological advancement, the application of technology in the field of education has dramatically increased, including its usage to promote cross-cultural communicative competence. For example, variety of technologies (e.g., email, Skype, discussion board, social networks, etc.) were used to support communication and information exchange among students from different cultural backgrounds in cross-cultural learning projects (Chen and Yang, 2016;

Shadiev and Huang, 2016, 2020; Shadiev et al., 2021a; Shadiev and Dang, 2022). Chen and Yang (2016) explored how Web 2.0 technology (i.e., Wiki platform) and learning management system (i.e., Moodle) can be effective in developing language skills and intercultural communicative competence of participants from different countries. Shadiev et al. (2021a) investigated whether learning activities arranged in virtual reality (VR) environments could facilitate cross-cultural understanding and the trait emotional intelligence of the participants with diverse cultural backgrounds. Participants representing “West and East” in Yang et al. (2014) learned about educational technologies, and various strategies for effective cross-cultural online learning were explored. The results of these above-mentioned studies suggest that student communication and information exchange were important for success of cross-cultural learning projects, and technology effectively supported interaction among participants. Most results were positive, and they demonstrated that cross-cultural competencies of the participants were improved.

Our review of the literature also demonstrated that technology supported cross-cultural learning projects helped the participants learn targeted skills (e.g., linguistic, communication or instructional skills). Therefore, we assume that students’ creativity, innovation, and entrepreneurship can be improved through cross-cultural learning activities too. Firstly, intercultural learning emphasizes the interaction and communication of students from different cultures. Students try to communicate information about local cultures to their foreign partners so that foreign partners can learn about them. We speculate that students’ creativity and innovation can be improved through active interaction and communication. That is, students prepare content regarding their local culture in creative and innovative ways and then interact with each other to exchange local cultural information. Such exchange can help them learn about their partners’ cultures. Cross-cultural learning projects can be useful for students to learn how to introduce their culture better, e.g., use creative and innovative approaches to create content and communicate it. Furthermore, interaction and communication with peers and representatives of different cultures can be useful for ideas exchange and getting inspirational ideas. Secondly, by introducing local culture in details, students may improve their entrepreneurial skills. They may think about how to make foreign partners be interested in their local culture or what kind of information can help them attract foreign peers, e.g., to visit them and try their local products.

Our review of studies on technology-assisted cross-cultural learning demonstrated that most of them focus on improving cross-cultural competencies (e.g., knowledge or skills of discovery and interaction), and development of other skills (e.g., creativity, innovation, and entrepreneurship) received very little attention in the related literature. This study was set to address this gap and to add missing knowledge to the field which can be useful for educators and researchers.

Therefore, the present study designed cross-cultural learning activities based on various themes to facilitate creativity, innovation, and entrepreneurship. Activities were carried out in virtual reality learning environments created by the 360-degree video technology.

In our telecollaborative project, students created culture-related learning content such as panoramic tours, and content then was shared with foreign partners and discussed in order to improve it. We investigated whether participation in telecollaborative learning activities supported by technology can facilitate students’ creativity, innovation, and entrepreneurship. The following research questions were addressed in the study: (1) Can learning activities of the study promote students’ creativity? (2) Can learning activities of the study facilitate students’ innovation? (3) Can learning activities of the study develop students’ entrepreneurship? (4) What are students’ perceptions of their learning experiences?

LITERATURE REVIEW

Creativity

Scholars believe that creativity is associated with divergent thinking (Shadiev et al., 2022a). Mumford (2003) and Sternberg et al. (2012) suggested that creativity means producing original, valuable, novel, and useful products and things. Creativity refers to using individual information and knowledge to generate new and valuable ideas (Zhang and Zhang, 2018). It is an essential component of individual cognitive processing and the psychological quality necessary for completing creative activities (Lin et al., 2020). Creativity is the comprehensive optimization of complex and multi-factors such as knowledge, intelligence, ability, and excellent personality qualities. The following contents, such as creating new concepts, new theories, updating technology, inventing new equipment, new methods, and creating new works, are the manifestations of creativity.

Many studies on students’ creativity have been carried out up to present. Rahimi and Shute (2021) investigated the effectiveness of an educational game to improve college students’ creativity. Muldner and Burleson (2015) collected data from a creative problem-solving task in a digital environment and then devised computational models to classify students’ creativity automatically. Jang (2009) surveyed how web-based technology could be integrated with real-life to stimulate the creativity of secondary school students, and students’ creativity was facilitated by online interactions and the teacher’s inquiry. The above-mentioned studies indicated that technology was beneficial for cultivating students’ creativity.

Innovation

Innovation refers to any hypothetical, technological, cultural, commercial, or social relationship that has not existed before under the subjective drive of the individual (Kline and Rosenberg, 2010; Kahn, 2018). According to Marin-Garcia et al. (2016), innovation is the process of coming up with, implementing, and using new ideas. Therefore, innovation emphasizes new things. It is guided by the existing thinking mode to put forward opinions different from conventional ideas. Innovation uses the existing knowledge and materials to change the whole or some parts of things so that they can be updated and developed.

Innovation has received considerable attention in education too. Keinänen et al. (2018) measured students’ innovation competencies in the authentic learning environments through

various assessment tools. Erdogan et al. (2013) investigated whether the robotics project can help improve students' innovation literacy. Moyle (2010) built students' innovation capabilities through information and communication technologies. Their results showed that researchers and scholars cultivated and developed students' innovation in different situations. Various teaching approaches were applied to cultivate innovation abilities, and students' innovation was positively influenced and improved.

Entrepreneurship

According to Lans et al. (2010), entrepreneurship covers the creation of new businesses, generation of self-employment, and detection of opportunities. Entrepreneurship refers to the pioneering thoughts, concepts, personalities and styles of entrepreneurs. Entrepreneurship is a kind of vitality that can continue innovating and growing (Cunningham and Lischeron, 1991; Stevenson and Jarillo, 2007). Individual entrepreneurship refers to creating a new enterprise by engaging in innovative activities under the guidance of personal strength and personal vision (Liñán and Chen, 2009).

Like creativity and innovation, entrepreneurship also attracted attention from scholars. Some studies investigated the students' attitude toward entrepreneurship (Peterman and Kennedy, 2003; Veciana et al., 2005). Tåks et al. (2014) examined how engineering students experience studying entrepreneurship in a course based on constructivist learning theory and the integrative pedagogy model. Von Graevenitz et al. (2010) surveyed whether entrepreneurship education affects intentions to be entrepreneurial uniformly. These results showed that most studies focused on students' perceptions, reflections and intentions (Boissin et al., 2009; Keat et al., 2011).

Studies Related to Creativity, Innovation, and Entrepreneurship

In previous sections, we reviewed studies that focused on one ability only. There are also studies that exist in which scholars covered all abilities at the same time. Edwards-Schachter et al. (2015) explored engineering students' perceptions about creativity, innovation, and entrepreneurship from two different cultural contexts. They found that most students were creative people and considered that creativity was strongly related to innovation and entrepreneurship. Shu et al. (2020) proposed sustainable-oriented creativity, innovation, and entrepreneurship education framework from an educational perspective. Boysen et al. (2020) explored the impacts of creativity and innovation on students' learning and teacher' teaching in entrepreneurship education. They found that creativity, innovation, and entrepreneurship brought challenges among students. Badran (2007) researched possible relations with engineering education for students' creativity and innovation to enhance their skills. Vaidyanathan (2012) discussed cultivating students' creativity and innovation through technology in STEM education. Jiang and Sun (2015) established a network platform to carry out activities to develop students' innovative quality and entrepreneurial ability.

These studies show that researchers have paid attention to creativity, innovation, and entrepreneurship. Nevertheless, we

cannot ignore the following: (1) There are only few studies that focus on creativity, innovation, and entrepreneurship as a whole, and mostly, scholars explore these abilities separately; (2) empirical studies mostly focus on students' attitudes, intentions, and perceptions but less on cultivating students' creativity, innovation, and entrepreneurship; (3) studies on whether students' creativity, innovation, and entrepreneurship can be developed with cross-cultural activities as the starting point is particularly scarce. In total, with the gradual deepening of the research on technology-supported cross-cultural activities, it is worthy to explore whether students' creativity, innovation, and entrepreneurship can be cultivated in cross-cultural activities by designing empirical research with the help of VR based on 360-degree video technology.

Panoramic Tours Created by 360-Degree Video Technology

Virtual reality technology has been proven to have many educational benefits (Slater and Sanchez-Vives, 2016). It is a technology that creates an artificial environment based on a computer's 3D model, allowing users to immerse in it and interact with the 3D world. The limitation of such technology is that it does not directly deliver the actual situation to the users, but uses the computer to design a similar situation to the real environment. By contrast, 360-degree VR technology can overcome this shortcoming. The difference between 360-degree VR technology and VR is that the former is generated by real-world footage, while the latter is created by computer software. 360-degree VR technology provides immersive experiences that combine images taken by several cameras or one spherical camera to create a spherical image (Shadiev et al., 2022b). 360-degree VR technology enables users to view content from multiple angles. At the same time, users can choose what content to watch according to their own needs. In addition, it supports the use of head-mounted devices to help users gain a higher level of immersion and experience (Rupp et al., 2019; Shadiev et al., 2022b). Therefore, 360-degree VR technology can provide users with contextual experience and a full range of visual, auditory and kinesthetic experiences to ensure the entire presentation of the real situation (Shadiev et al., 2021b).

Recently, researchers pay attention to panoramic tours created by 360-degree VR technology. Panoramic tours enable users to have panoramic view (i.e., horizontal and vertical). For example, in a panoramic photograph, the user can arbitrarily adjust the height and distance of viewing content. Several studies on 360-degree VR technology applications were carried out. Maach et al. (2018) presented virtual tours based on 360-degree technology to promote tourism and help tourists enter inaccessible areas. Ritter and Chambers (2021) examined response factors such as sense of presence, cognitive image, and affective image developed by 360-degree video technology. Additionally, 360-degree video technology was applied to education. Pham et al. (2018) proposed an innovative educational system for bringing construction field trips to the classroom and providing practical experience and safety knowledge for students. Xiao (2000) investigated the potential of using panorama 360-degree VR technology

to enhance Web-based library instruction and found that panorama 360-degree VR could be a powerful tool to make a more helpful medium that allowed navigating, viewing, reading, hearing, and remote access to targeted learning content.

Previous studies show that panoramic tours based on 360-degree VR technology can be effectively applied in many fields, such as tourism, health care, and business. At the same time, the usage of this technology in education is also increasing. However, panoramic tours supported by 360-degree VR technology has received little attention in cross-cultural learning projects, specifically those that focused on creativity, innovation, and entrepreneurship. In this study, we plan to guide students to experience the panoramic tours based on 360-degree VR technology in the process of cross-cultural learning and facilitate their skills such as creativity, innovation, and entrepreneurship.

Telecollaboration

Telecollaboration is also called as virtual exchange. According to Byram (2021), telecollaboration is “generally understood to be an Internet-based intercultural exchange between people of different cultural/national backgrounds, set up in an institutional context with the aim of developing both language skills and intercultural communicative competence through structured tasks.” Several studies were carried out using telecollaboration approach. Ware and O’Dowd (2008) explored the impact of peer feedback on language development in telecollaboration project. Schenker (2012) strove to reveal the college students’ cultural understanding, interest in cultural learning through telecollaboration. Up to now, telecollaboration has been accepted by many scholars. It was identified as a positive trend as it is helpful to teachers’ and students’ development (Helm, 2015). In the study by Sadler and Dooley (2016), telecollaboration reflected a notable change in the mindset of the teachers and a more profound sense of responsibility from the students’ learning. O’Dowd (2013) reported that telecollaboration was a potential tool for supporting cross-cultural development. Firstly, it provided learners with a different type of knowledge as electronic resources when learning about culture. Compared with traditional resources (e.g., textbooks), electronic resources were easier to access for learners. Secondly, telecollaboration could also contribute to the development of critical cultural awareness as learners have opportunities in online interaction to engage in discussion of meaning. Additionally, Belz and Kinginger (2002) highlighted the usefulness of telecollaboration for making learners aware of cultural differences in communication. The present study examined the cultivation of students’ creativity, innovation, and entrepreneurship based on a telecollaboration during cross-cultural learning activities. Students produced cross-cultural panoramic tours and exchanged them with foreign partners on the telecollaboration platform. We assumed that such activities as creating content, sharing it, and exchanging ideas with foreign partners may help cultivate students’ creativity, innovation, and entrepreneurship. We tested our assumption in the present study.

MATERIALS AND METHODS

Participants

Twenty-five students participated in the study. Ten participants (two females and eight males) were university students from Indonesia, and 15 participants (four females and 11 males) were secondary school students from China. We recruited participants using a convenience sampling method. That is, participants who were “convenient” to the researchers were recruited. One researcher in Indonesia and one researcher in China posted an announcement on online student groups of their university/school. In addition, the information about this study was spread through word-of-mouth advertising in researchers’ university/school. Then, the participants who indicated their interest in participating were recruited on a voluntary basis. The Indonesian students’ age ranged from 19 to 24 years old, and the Chinese students’ age was between 12 and 14 years old. Although the participants from China and Indonesia were of different academic levels, none of them withdrew from the study. All of them had intermediate English as a foreign language skills, and they were able to engage in simple conversations.

The ethical issues and approvals on which the research was carried out and the data were collected were considered in the study. Participants were informed of important details of the study (e.g., its purpose, learning activities, duration, etc.) in the beginning. All participants agreed to participate in the study. The participants had no previous experience in telecollaborative learning projects. Therefore, we thoroughly instructed them about learning activities, how to use technology and basic principles of cross-cultural communication.

Three researchers closely worked with the participants (i.e., two researchers were in China and one researcher was in Indonesia) to ensure their smooth participation. In addition, one secondary school teacher was involved to provide instant help to the participants in China given their relatively young age and intermediate English abilities. The teacher helped students when they could not understand certain information in English or needed assistance with technology. The researchers explained to the participants (in China and Indonesia) all steps of learning activities and guided them on how to effectively exchange information and interact with international partners. In addition, to help participants better understand the concepts of innovation, creativity, and entrepreneurship and then use these three concepts accurately, three researchers also provided guidance in learning activities. For instance, before filling out questionnaires, researchers emphasized these three concepts and gave some related examples to help participants understand them better. Before creating cross-cultural content, the researchers provided the participants with several examples in order to help them incorporate these concepts into their content better. When students were creating content, the researchers gave feedback to each participant to help them accurately incorporate innovation, creativity, and entrepreneurship into their cultural work or improve content.

Research Procedure

The research procedure is presented in **Figure 1**. In the first week, we explained the participants the purpose and learning

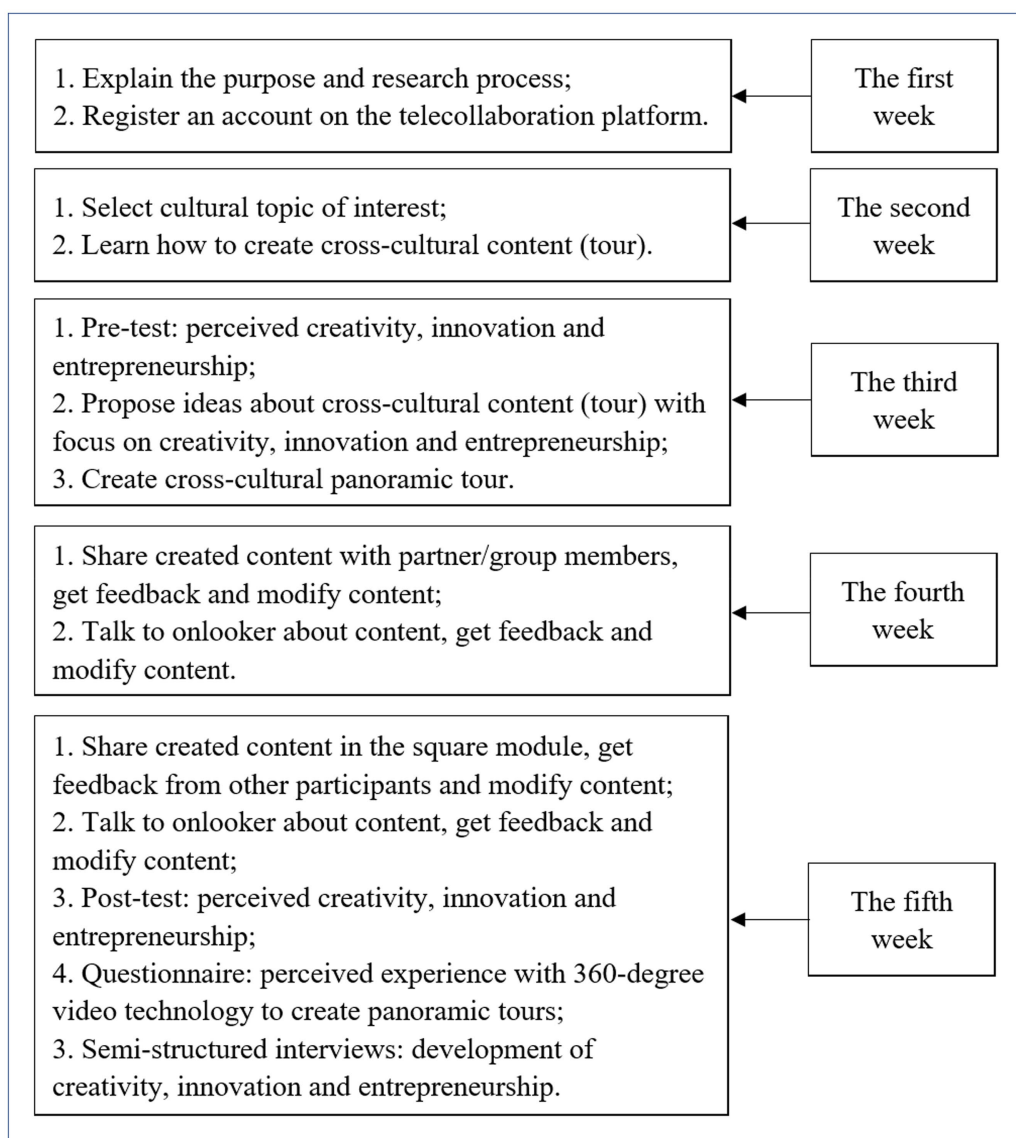


FIGURE 1 | Research procedure.

process of this study. After that, we asked them to register for an account on the online telecollaboration platform developed by the Chinese researchers. In the second week, students were divided into pairs or groups of three (i.e., one student from Indonesia and one or two students from China) according to cultural topics they were interested in, and learned how to create content of panoramic tours focused on creativity, innovation, and entrepreneurship. There were 10 topics, including library, traditional restaurant, classroom, scenic, gymnasium, public square, school playground, school building, community environment and school canteen.

In the third week, students needed to (1) submit their demographic information and their perceived self-efficacy about creativity, innovation, and entrepreneurship—it took about 15 min to provide this information, (2) submit ideas (also called as

self-reports) for expected panoramic tours they are going to create—it took about an hour to complete this task, and (3) create cultural panoramic tours—we gave students 5 days to complete their tours. In the fourth week, students needed to (1) upload their created panoramic tours on the telecollaboration platform and then (2) watch and discuss panoramic content shared by partners. The participants communicated with their peers freely using the online telecollaboration platform. After that, students modified their content based on suggestions of their partners. In addition, the participants were asked to show their revised content of panoramic tours to onlookers (i.e., someone who was related to content created by a student—this could be a library manager or staff if content was about a library) to get their feedback and then further improve it. In the fifth week, students uploaded their content to the square

TABLE 1 | Perceived creativity before and after learning activities.

#	Items	Questionnaire	Mean	SD	<i>t</i>	<i>p</i>
1	I often come up with creative solutions to problems.	pre- post-	3.920 5.120	1.115 0.726	−6.573	0.000
2	I am good at providing a fresh approach to problems.	pre- post-	4.080 5.200	0.954 0.707	−6.039	0.000
3	I often come up with new and practical ideas.	pre- post-	3.800 4.920	1.118 0.640	−4.956	0.000
4	I often have new and innovative ideas.	pre- post-	4.120 5.080	1.013 0.702	−3.977	0.001
5	I am good at generating creative ideas.	pre- post-	4.000 5.240	1.155 0.597	−5.167	0.000
6	I often promote and champion ideas to others.	pre- post-	3.760 5.000	1.165 1.041	−5.023	0.000
	Total	pre- post-	3.947 5.093	0.904 0.563	−7.006	0.000

module of the telecollaboration platform and discussed it with other students in the square. The square module is a different concept from pair or group because pair or group includes only two or three students but there are more students in the square module such as classmates and foreign partners. After that, students modified their works for the third time according to suggestions of their peers. In addition, final content of panoramic tours was demonstrated to onlookers again to get their concluding remarks. At the end of the fifth week, students were asked to complete a post-test questionnaire on perceived creativity, innovation, and entrepreneurship. In addition, we carried out semi-structured interviews with students to learn about their experiences in the telecollaboration project. Finally, students' content of panoramic tours was evaluated.

Data Collection

To address four research questions, both quantitative and qualitative data were collected: the questionnaire of creativity, innovation, and entrepreneurship, proposed ideas, panoramic tour, and one-on-one semi-structured interviews were used to answer the research questions 1, 2, and 3; the questionnaire of perceived experiences in telecollaborative project was used to answer the research question 4.

One-on-One Semi-structured Interviews

We interviewed students from China in Chinese and students from Indonesia in Indonesian. Through interviews, we learned about the changes in students' perceived creativity, innovation, and entrepreneurship in the process of creating panoramic content. Some interview open-ended questions were as follows: (1) Do you think the learning activities were beneficial to develop your creativity? (2) Do you think the learning activities have improved your innovation? (3) Do you think the learning activities were useful in facilitating your entrepreneurship? Each interview lasted approximately 30 min. All interviews were audio-recorded and then transcribed. To analyze content of interviews, two researchers used open coding approach (Strauss and Corbin, 1998). The researchers highlighted and coded those text segments that met the criteria for providing the best

research information. After that, the researchers sorted codes to form categories and codes with similar meanings were aggregated together. Established categories of codes then produced a framework to report findings to the research questions. The researchers coded content independently and then compared. If there were significant differences in coding, the researchers resolved them by discussion until a consensus was reached. Inter-rater reliability was over 90%.

Perceived Creativity, Innovation, and Entrepreneurship

We measured students' creativity by the creativity questionnaire from the study of Entrialgo and Iglesias (2020). The creativity questionnaire included six items (see **Table 1**) and they could be answered on a six-point Likert scale. We designed the endpoints of "strongly disagree" (1) and "strongly agree" (6).

Students' innovation was measured by the questionnaire of innovation from the study of Marín-García et al. (2013). The questionnaire included 12 items (see **Table 2**) and they could be answered on a six-point Likert scale. We designed the endpoints of "strongly disagree" (1) and "strongly agree" (6).

We measured students' entrepreneurship by the entrepreneurship questionnaire from the study of Liñán and Chen (2009). The questionnaire included 11 items (see **Table 3**), and they could be answered with a six-point Likert scale. We designed the endpoints of "strongly disagree" (1) and "strongly agree" (6).

We also measured the students' perceived changes about their creativity, innovation, entrepreneurship (see **Tables 4–6**) using a questionnaire adapted from Barroso-Tanoira (2017). The items could be answered with a five-point Likert scale. We designed the endpoints of "strongly disagree" (1) and "strongly agree" (5).

Rubric of Creativity, Innovation, and Entrepreneurship

Students proposed their ideas (also called as self-reports) for cultural panoramic tours with focus on creativity, innovation, and entrepreneurship and then created them in this study.

TABLE 2 | Perceived innovation before and after learning activities.

#	Items	Questionnaire	Mean	SD	t	p
1	I make proposals appropriate to the demands of the task.	pre- post-	3.720 5.080	1.100 0.862	-5.733	0.000
2	I offer ideas that are original in content.	pre- post-	3.960 5.320	1.136 0.748		
3	I offer new ways to materialize the ideas.	pre- post-	3.800 5.240	1.080 0.831	-5.866	0.000
4	I critically evaluate the fundamentals of contents and actions.	pre- post-	3.680 4.920	1.406 1.038		
5	I identify relationships among different components of the task.	pre- post-	4.040 5.040	1.428 0.790	-3.273	0.003
6	I approach the task from different perspectives.	pre- post-	4.200 5.120	1.118 0.726		
7	I use resources ingeniously.	pre- post-	4.040 5.320	1.207 0.802	-4.389	0.000
8	I foresee how events will develop.	pre- post-	4.000 4.880	1.291 0.833		
9	I show enthusiasm.	pre- post-	4.680 5.560	1.376 0.712	-3.029	0.006
10	I am tenacious.	pre- post-	4.520 5.400	1.046 0.707		
11	I take intelligent risks.	pre- post-	4.120 5.080	1.201 0.702	-3.172	0.004
12	I orient the task towards the target.	pre- post-	4.000 5.240	1.258 0.831		
Total		pre- post-	4.063 5.183	0.941 0.515	-5.830	0.000

TABLE 3 | Perceived entrepreneurship before and after learning activities.

#	Items	Questionnaire	Mean	SD	t	p
1	I am ready to do anything to be an entrepreneur.	pre- post-	3.360 4.440	1.411 1.193	-3.540	0.002
2	My professional goal is to become an entrepreneur.	pre- post-	3.280 4.240	1.768 1.393		
3	I will make every effort to start and run my own firm.	pre- post-	4.000 5.200	1.384 0.866	-3.565	0.002
4	I am determined to create a firm in the future.	pre- post-	3.840 4.600	1.313 1.118		
5	I have very seriously thought of starting a firm.	pre- post-	3.360 4.560	1.497 1.261	-3.860	0.001
6	I have the firm intention to start a firm someday.	pre- post-	3.600 4.360	1.472 1.381		
7	Being an entrepreneur implies more advantages than disadvantages to me.	pre- post-	4.040 4.720	1.172 1.308	-2.722	0.012
8	A career as entrepreneur is attractive for me.	pre- post-	3.680 4.240	1.574 1.589		
9	If I had the opportunity and resources, I would like to start a firm.	pre- post-	4.160 5.040	1.344 1.060	-3.894	0.001
10	Being an entrepreneur would entail great satisfaction for me.	pre- post-	3.640 5.120	1.411 0.781		
11	Among various options, I would rather be an entrepreneur.	pre- post-	3.360 4.000	1.578 1.472	-2.551	0.018
Total		pre- post-	3.666 4.593	1.211 0.952		

We used a rubric to measure students' creativity, innovation, and entrepreneurship objectively based on their proposed ideas (before this study) and created content of panoramic tours (during this study) to compare and explore changes in these abilities. The rubric was designed based on relevant literature

and standards of several entrepreneurial and innovative competitions. For creativity, we referred to the study of Ferrándiz et al. (2017). For innovation and entrepreneurship, we referred to standards of competitions in two fields (Sun, 2019; Zhao et al., 2020). To ensure the scientific validity of the rubric,

TABLE 4 | Perceived changes in creativity.

#	Items	Mean	SD
1	Panoramic tour activity helped me realize I'm creative.	5.440	0.651
2	Panoramic tour activity helped me use my creativity.	5.640	0.567
3	I'm more creative now than before this activity.	5.400	0.707
	Total	5.493	0.537

TABLE 5 | Perceived changes in innovation.

#	Items	Mean	SD
1	Panoramic tour activity helped me realize I'm innovate.	5.560	0.712
2	Panoramic tour activity helped me use my innovation.	5.440	0.712
3	I'm more innovate now than before this activity.	5.280	0.737
	Total	5.427	0.656

TABLE 6 | Perceived changes in entrepreneurship.

#	Items	Mean	SD
1	Panoramic tour activity helped me realize I'm entrepreneurial.	5.200	0.817
2	Panoramic tour activity helped me use my entrepreneurship.	5.480	0.586
3	I'm more entrepreneurial now than before this activity.	5.200	0.646
	Total	5.293	0.547

two experts in the field were invited. They checked the rubric and gave their comments and suggestions, and then we revised the rubric accordingly.

The Questionnaire of Students' Perceived Experiences to Create Panoramic Tours

We investigated students' perceptions of their experiences to create panoramic tours using a questionnaire adapted from Bhattacharjee (2001). It included three dimensions (see **Table 7**): continuance intention (three items), satisfaction (four items), and confirmation (five items). The items could be answered with a five-point Likert scale. We designed the endpoints of "strongly disagree" (1) and "strongly agree" (5).

All instruments used in the present study were adopted from existing instruments: the creativity questionnaire (Biraglia and Kadile, 2017; Entrialgo and Iglesias, 2020), the innovation questionnaire (Marín-García et al., 2013; Watts et al., 2013), the entrepreneurship questionnaire (Liñán and Chen, 2009; Karimi et al., 2012; Entrialgo and Iglesias, 2020), the perceived changes in creativity, innovation, entrepreneurship questionnaire (Barroso-Tanoira, 2017), and the perceived learning experience questionnaire (Bhattacharjee, 2001; Henriksen et al., 2021;

Juliana et al., 2021). All of them were widely used in educational research, and scholars proved their validity and reliability. Nevertheless, two professors who are experts in educational science checked items of these questionnaires to ensure that they are valid and can be used for the present research. No issues aroused during the validation and the questionnaires were used after the experts' confirmation.

RESULTS

Creativity

To answer the first research question, we analyzed the results of pre- and post-questionnaire. In addition, we used evaluation of students' proposed ideas (also called as self-reports) and their created content to see differences in their creativity before and during the study. The paired sample *t*-test was employed to compare the pre- and post-questionnaire results. **Table 1** presents the results and according to them, students scored higher on the post-questionnaire (total $M=5.093$; $SD=0.563$) than on the pre- test questionnaire (total $M=3.947$; $SD=0.904$), $t=-7.006$; $p<0.000$. **Table 4** presents results of perceived changes in creativity, and they show that students believed that the learning activities were helpful in improving their creativity ($M=5.493$; $SD=0.537$). **Table 8** shows the results of content evaluation (i.e., proposed ideas before the activity vs. created virtual tours), and according to them, students' scores on creativity are higher for created virtual tours (total $M=3.310$; $SD=0.761$) than for proposed ideas (total $M=2.110$; $SD=0.495$), $t=-10.733$; $p=0.000$.

In addition, we provide two extracts from interviews with students that evidence how their creativity improved.

Student ID1

This activity has boosted my creativity, and I have more ideas now for presenting my work. The theme of my work is about the classroom, and at the beginning of my self-report (or proposed ideas), I only thought about introducing items like "what is it?" But after discussing and exchanging ideas, it occurred to me that I could describe the items in detail. Thus, in my final work, I introduced a lot of objects from different angles. For example, when I introduced the flag, I thought about these questions, "What is it? Why is it in the classroom? What are the implications of the flag?" Until now, I have a lot of ideas.

Student ID2

My creativity has increased through this activity. In this project, I used 360 video technology to show a duck blood vermicelli soup restaurant in Nanjing. In my self-report (or proposed ideas), I only briefly introduced the menu and facade decoration. And after the exchange of information, I came up with other ideas about introducing food culture, so I think my creativity has improved.

TABLE 7 | Perceive learning experience to create panoramic tours using technology.

#	Items	Mean	SD
Continuance intention			
1	I want to continue creating panoramic tours rather than discontinue its use.	4.520	0.653
2	My intentions are to continue creating panoramic tours rather than any alternative means.	4.200	0.764
3	If I could, I would like to continue creating panoramic tours.	4.640	0.638
	Total	4.453	0.552
Satisfaction			
1	I am satisfied with my decision to create panoramic tours.	4.640	0.490
2	My choice to use 360-degree video technology to create panoramic tours was a wise one.	4.400	0.577
3	I am happy with my earlier decision to create panoramic tours.	4.640	0.490
4	My experience with using this technology to create panoramic tours was very satisfactory.	4.600	0.500
	Total	4.570	0.379
Confirmation			
1	The creation of panoramic tours for intercultural learning meets my expectations.	4.680	0.476
2	This 360-degree video technology gives me all the information and tools needed for intercultural learning.	4.200	0.0707
3	My intercultural learning experience via creating panoramic tours falls short of my expectations.	4.400	0.764
4	The sense of presence provided by panoramic tours meets my expectations.	4.520	0.653
5	I generally get the level of service I expect from panoramic tours.	4.200	0.866
	Total	4.400	0.526

TABLE 8 | Changes in creativity: evaluation of proposed ideas and created content and their comparison.

#	Items	Variable	Mean	SD	t	p
1	Fluency	Proposed ideas	2.040	0.539	-10.007	0.000
		Created content	3.800	1.041		
2	Flexibility	Proposed ideas	2.040	0.539	-11.298	0.000
		Created content	3.800	1.041		
3	Originality	Proposed ideas	2.160	0.554	-7.905	0.000
		Created content	3.520	1.046		
4	Elaboration	Proposed ideas	2.200	0.577	-8.777	0.000
		Created content	3.920	1.116		
	Total	Proposed ideas	2.110	0.495	-10.733	0.000
		Created content	3.310	0.761		

Another evidence about improvement of creativity through this project is comparison between student content of proposed ideas (before learning activities) and their final work such as created panoramic tours (after learning activities). Here is the extract from self-report (or proposed ideas) of student ID3:

My selected theme is classroom. My school, Nanjing Zhonghua Middle School, has a long history so my work aims to show the style of the junior high school classroom and daily life of students. In my work, my idea is to introduce the infrastructures of the classroom, because it can reflect Chinese classroom culture. I want to make foreign friends know more about the study life of Chinese students through my work.

In proposed ideas, student ID3 just had an idea to introduce his work through the classrooms' infrastructures such as desk, clock, and whiteboard. After communicating with peers and onlookers, he was inspired to introduce some objects in classroom and their characteristic. Final work of student ID3 is captured in **Figure 2**. We can see in the figure that he explained about the school motto, team corner, national flag, class

photographs, students and many other things in his final panoramic tour. So we think that students had more ideas for their final work compared to their ideas they proposed in the beginning of learning activities. All above-mentioned findings (from questionnaire, interviews, and content analysis) suggest that students' creativity has increased in learning activities.

Innovation

We answer the second research question through comparing the results of the pre- and post-questionnaire and evaluation of students proposed ideas and created content such as cultural panoramic tours. The paired sample *t*-test was employed to compare pre- and post-questionnaire scores, and the results are reported in **Table 2**. According to the table, students scored higher on the post-questionnaire (total $M=5.183$; $SD=0.515$) than on the pre- questionnaire (total $M=4.063$; $SD=0.941$), $t=-5.830$; $p<0.000$. The results of perceived changes in innovation are included in **Table 5**, and they show that students believed that learning activities were useful to improve participants' innovation ($M=5.427$; $SD=0.656$). Our evaluation

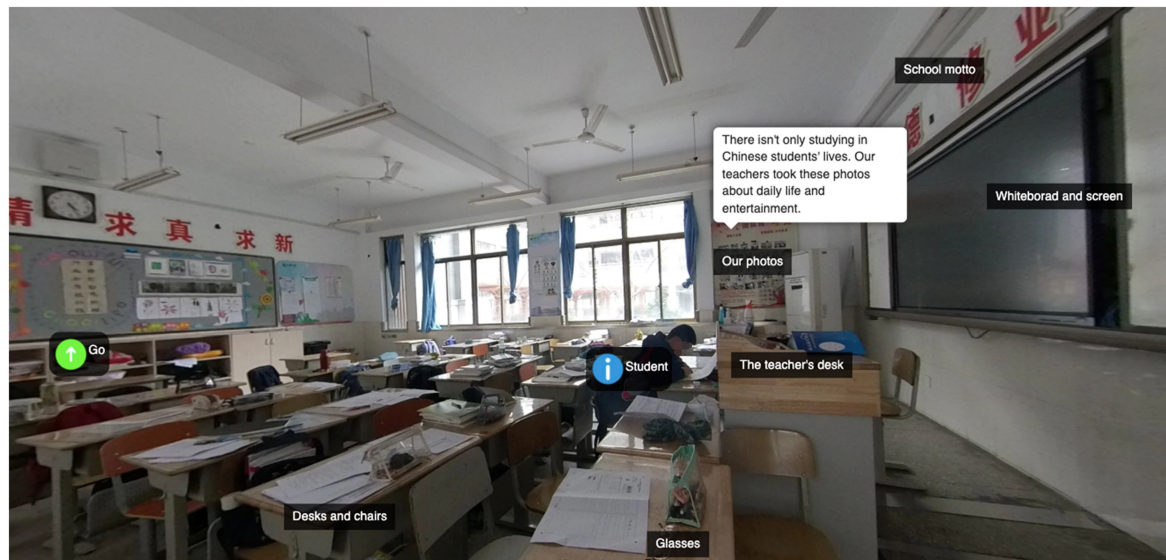


FIGURE 2 | Created content (panoramic tour) of student ID3.

TABLE 9 | Changes in innovation: evaluation of proposed ideas and created content and their comparison.

#	Items	Variable	Mean	SD	t	p
1	Theme innovation	Proposed ideas	2.480	1.005	-7.905	0.000
		Created content	3.840	1.143		
2	Content innovation	Proposed ideas	1.880	0.726	-7.895	0.000
		Created content	3.400	0.957		
3	Structural innovation	Proposed ideas	2.000	0.646	-9.867	0.000
		Created content	3.520	0.963		
4	Emotional resonance	Proposed ideas	1.960	0.935	-7.268	0.000
		Created content	3.480	0.963		
5	Total	Proposed ideas	2.080	0.728	-9.031	0.000
		Created content	3.560	0.958		

results of proposed ideas and created content and their comparison are reported in **Table 9**. The results show that scores of created content are higher (total $M = 3.560$; $SD = 0.958$) compared to scores of proposed ideas (total $M = 2.080$; $SD = 0.728$), $t = -9.031$; $p < 0.000$.

The following are extracts from interviews with students to support our findings about improved innovation.

Student ID4

After comparing the initial self-report with the final work, I think my innovation has improved. In this activity, the theme of my work is the school canteen. In proposed ideas, I only intended to label the canteen's food. In my final work, I added labels such as sinks, meal card recharge machines, payment machines, and even dining rules, which greatly enriched the details of the work and made it closer to the actual scene I observed. At the same time, I also found that these details are not presented and are different in works of the same theme. So I think my innovation has been boosted.

Student ID5

This activity has increased my creativity as I label my final work more and introduce more content than my self-reports. My work is about the library, and in the self-report, there were only labels about the book, including the book's price, the category of the book, the content, etc. In my final work, in addition to the above, I also described the store next to the library in the final work. Moreover, I found my work unique compared to works on the same topic, and I provided links to purchase the book, which was not found in other works. Overall, my final panoramic work looks more complete than before.

Additionally, we tried to get objective evidence to support our claim that participants' innovation improved in learning activities of the study by comparing content of proposed ideas and final panoramic tours. Here are proposed ideas of student ID6:

I chose "Gedung Serbaguna Unila" to accomplish my work related to public square. I am going to show the following



FIGURE 3 | Created content (panoramic tour) of student ID6.

TABLE 10 | Changes in entrepreneurship: evaluation of proposed ideas and created content and their comparison.

#	Items	Variable	Mean	SD	<i>t</i>	<i>p</i>
1	Propaganda value	Proposed ideas	2.120	0.666	-8.241	0.000
		Created content	3.760	1.052		
2	Economic value	Proposed ideas	1.880	0.526	-9.655	0.000
		Created content	3.600	1.000		
3	Practical value	Proposed ideas	1.960	0.539	-11.289	0.000
		Created content	3.840	0.987		
4	Prospect value	Proposed ideas	1.960	0.539	-9.859	0.000
		Created content	3.760	1.052		
5	Total	Proposed ideas	1.980	0.494	-11.018	0.000
		Created content	3.740	0.959		

points: (1) Gedung Serbaguna Unila, including its function, location, etc.; (2) because Lampung culture has a uniqueness, so I also show the cultural value of the building, such as carvings, the colors of building, etc.; (3) of course, I also will introduce the interior and exterior of the building, including typical Lampung patterns, carvings, history and so on.

Student ID6 planned to introduce his work through various objects and artifacts, such as carving, parking lot, and building and so he proposed such ideas. After communicating with peers and onlookers, in his final panoramic work (Figure 3), he introduced the library and road next to this place, this is new and different from others' works. Moreover, he also made a more specific description of the interior and exterior of the building than that at the beginning of the study. This evidence demonstrates that innovative skills of students ID6 improved. Based on the above-mentioned results (from questionnaire, interviews and content analysis), we may conclude that our learning activities were beneficial to improve students' innovative abilities.

Entrepreneurship

To address the third research question, we analyzed pre- and post-questionnaire results and evaluation scores of proposed ideas and created content. The paired sample *t*-test was employed to compare the scores of pre- and post-questionnaire, and the results are reported in Table 3. We can see from the results that students scored higher on the post-questionnaire (total $M=4.593$; $SD=0.952$) than on the pre-questionnaire (total $M=3.666$; $SD=1.211$), $t=-4.989$; $p<0.000$. The results of perceived changes in entrepreneurship are demonstrated in Table 6. According to the results, the participants felt that learning activities were useful in improving their entrepreneurship (total $M=5.293$; $SD=0.547$). In Table 10, scores of proposed ideas and created content are included and compared. The results show that students were scored higher on created content (total $M=3.740$; $SD=0.959$) than on proposed ideas (total $M=1.980$; $SD=0.494$), $t=-11.018$; $p<0.000$.

Below are two extracts from interviews with students to support our findings:

Student ID7

The activity improved my entrepreneurship. Now I understand how to promote something for sale. With panoramic tours, one way to let someone know and get their attention, like the Padang cuisine that I introduced in my work. With the help of panoramic photos taken using VR 360, I was able to explain how the food was made and how much it cost and promote the best-selling items. This will make it easier for someone in entrepreneurship. People can also see the menu, place, dining conditions, and location beforehand so they can determine if they what to go there and what they want to try there.

Student ID8

My entrepreneurship was improved through this activity. This project is an excellent platform for introducing interesting local places and learning about the culture. The 360-degree panoramic tours technology will increase the interest of tourists to visit the site. And if many tourists visit, it will undoubtedly increase the economy of the surrounding community, such as in housing, tour guidance or catering business.

Comparing content of proposed ideas and final work helped us see the improvement in students' entrepreneurial abilities. Here are proposed ideas by student ID 9:

This is the school canteen of the University of Lampung. The special thing about this canteen is that it just serves Indonesian food. There are a lot of food on menu and it is

not only for students but also for faculty and workers. Regarding entrepreneurship, I intend to provide menus in this canteen to tell you about the prices of foods and beverages.

In proposed ideas, student ID9 provided menus of foods and beverages. However, he did not introduce various foods and their prices. After communicating with peers and onlookers, he understood that more information is needed. Final work of student ID9 is captured in **Figure 4**. Student ID9 introduced foods and their prices on display showcase in detail in his final panoramic work. Moreover, he also introduced various methods of payment. According to the above contents, we concluded that the students' entrepreneurship was improved. Furthermore, the above-mentioned findings (from questionnaire, interviews, and content analysis) suggest that learning activities were beneficial in enhancing students' entrepreneurship.

Perceive Learning Experience

To answer the fourth research question which is related to perceive learning experience to create panoramic tours, we carried out questionnaire survey with the participants. **Table 7** reports the results and they show that the participants had positive perceptions of their learning experience. Their level of continuance intention to use technology for creating panoramic tours was high (total $M=4.453$; $SD=0.552$). The participants' satisfaction to use technology for creating panoramic tours was also high (total $M=4.570$; $SD=0.379$). In addition, the participants confirmed in the questionnaire that using technology for creating panoramic tours met their expectations (total $M=4.400$; $SD=0.526$). The results of the questionnaire showed that the students positively perceived their learning



FIGURE 4 | Created content (panoramic tour) of student ID9.

experience using 360-degree video technology to create panoramic tours.

DISCUSSION

Main purpose of this study was to learn whether our learning activities to create, share and experience panoramic tours using technology can facilitate students' creativity, innovation, and entrepreneurship. We analyzed students' responses to questionnaires, evaluated content of proposed ideas and content of panoramic tours, and studied content from interviews. The results showed that technology-supported learning activities helped students improve their creativity. Students had more novel ideas that were reflected in their created panoramic tours. Although few studies involve creativity in cross-cultural learning, this finding aligns with those obtained in previous related studies (Jang, 2009; Zhang et al., 2012; Shadiev and Huang, 2016; Yilmaz and Goktas, 2017; Shadiev and Dang, 2022). The students' creativity in previous studies were enhanced by various technologies (e.g., smartphones in Shadiev et al. (2022a) or computers in Lin et al. (2020)). The study results of Zhang et al. (2012) showed that visual tools made students more creative. Jang (2009) found that web-based technology stimulated students' creativity in a science course. In the study of Yilmaz and Goktas (2017), AR was an effective technique to improve students' creativity in storytelling activities.

In terms of innovation, the results showed that it was enhanced by our technology supported learning activities. That is, after participating in learning activities, students implemented and used more new ideas to create their works. On the one hand, they tag more content than before in their works; on the other hand, they also tag something new and different from others' works. Our results are consistent with those from previous related studies (Zhang et al., 2012; Erdogan et al., 2013). In the study of Erdogan et al. (2013), scholars found that students' innovation skills were developed through the robotics programs. Zhang et al. (2012) also found that students' innovation competence was increased significantly through visual tools.

For entrepreneurship, the results demonstrated that it was improved through our learning activities supported by technology. That is, students' entrepreneurial intentions and entrepreneurial attitudes were enhanced. Students learned to introduce the price of items for sell to reflect economic value. Moreover, they improved their works' quality constantly and described their works specifically so as to attract peers and others to go to this place to study, travel, and consume promoted products. This makes students be aware of their entrepreneurial potential. It was also an entrepreneurial manifestation. This result is similar to other related studies about students' entrepreneurship cultivation after training (Souitaris et al., 2007; Küttim et al., 2014). For example, the entrepreneurship program raised the entrepreneurial intention of science and engineering students in Souitaris et al. (2007).

Another aim of this study was to investigate students' perceived learning experiences using technology. The results

showed that students had positive perceptions in terms of continuance intention, satisfaction, and confirmation. That is, the participants were willing to continue their technology-assisted learning and they were satisfied with it. Our findings are similar to previous studies (Huang et al., 2017; Shadiev et al., 2021a,b). In the study of Shadiev et al. (2021b), the students had a positive attitude toward the learning activities supported by 360-degree technology, were satisfied with the technology, and had intentions to use it in the future for learning. Shadiev et al. (2021a) also reported that the participants accepted 360-degree VR technology in terms of its usefulness for cross-cultural learning and ease of use. We need to acknowledge that we cannot directly compare our results with those in previous studies on students' creativity, innovation, and entrepreneurship because not many researchers explored such important abilities in the context of cross-cultural learning.

Our results suggest that students' creativity, innovation, and entrepreneurship were significantly enhanced after participating in learning activities. The following reasons may explain such benefits. Firstly, in this study, peer communication was designed, including pair/group and square discussion. Students can show their individual differences such as cognitive tendency, thinking style, and individual values. Through peer communication. Therefore, communication promoted the collision of sparks of thinking among students, let students learn from each other's strengths and weaknesses, helped students gain the cultural knowledge of different nationalities, and then improved students' creativity, innovation, and entrepreneurship in learning activities (Ann Bainbridge Frymier, 2005; Holliday et al., 2021).

Secondly, we also found an interesting phenomenon, in the cultivation of such abilities as creativity, innovation, and entrepreneurship, the existence of a facilitator was important and necessary. In this study, facilitators were onlookers. After communicating with peers, facilitators intervened in a timely manner to guide students to comprehensively consider and modify their content. The role of a facilitator was to help students improve their content, discuss ideas how to improve content or facilitator could point out issues that students failed to notice (Goodyear and Dudley, 2015). Therefore, the help of the facilitator in this learning project was beneficial in improvement of students' innovation, creativity, and entrepreneurship.

Thirdly, students conducted self-reflection after communicating with peers and onlookers. Students evaluated their content, thought about feedback such as comments and suggestions from peers and onlookers, and then modified content to improve its cultural, creative, innovative, and entrepreneurial value (Bower et al., 2011).

Fourthly, the cultural topics and locations to create panoramic tours were selected by students themselves. Therefore, the learning process was meaningful to students and relevant to their daily life situations. This could stimulate students' interest and make their learning process not so difficult or challenging (Huang et al., 2017; Lin et al., 2020; Shadiev et al., 2022b). At the same time, the participants signed up voluntarily, they collaborated with international partners, and used new technologies; all of these could highly

motivate their participation (Shadiev et al., 2021b). They developed a certain novelty and curiosity about the whole learning activity. Therefore, the students were very actively involved in the entire study, and their innovation, creativity, and entrepreneurship were enhanced.

Finally, technology used in the study was easy to use and useful for learning. After selecting their preferable cultural topics, students could create panoramic tours that showed cultural location, objects and people there with 360-degree view. In addition, students could experience foreign culture more contextually, immersively, and intuitively through VR panoramic tours. Therefore, students had positive perceptions of their experiences with technology (Huang et al., 2017; Lin et al., 2020; Shadiev et al., 2022a).

CONCLUSION

To the best of our knowledge, most studies on cross-cultural learning supported by technologies focused on improving participants' cross-cultural competencies such as knowledge or interaction skills. Little attention was paid to development of high-order skills such as creativity, innovation, and entrepreneurship. This study aimed to address this research gap. To this end, learning activities supported by 360-degree video technology were developed with focus on students' creativity, innovation, and entrepreneurship.

Our results showed that learning activities were beneficial for creativity, innovation, and entrepreneurship, and students had positive perceptions of their learning experiences. Based on our results, we make the following two suggestions. First, we recommend using panoramic tour based on 360-degree video technology in the learning process. It can create authentic, contextual cross-cultural learning environments. Such environments are virtual, immersive and give good sense of presence. One of the advantages is that technology was easy to use. Students can take panoramic photographs according to their ideas and then create cross-cultural panoramic works, which is conducive to students' full use of their subjective initiative and enthusiasm to participate in cross-cultural learning activities. At the same time, the advantage of 360-degree video technology is that it can provide students with immersion to their learning experiences and a high sense of presence. It can completely restore the virtual environment in reality, allowing students to be immersed in the scene and better experience foreign cultures. Therefore, students participating in our learning activities had an enjoyable experience. Moreover, this study designed a telecollaboration platform, where students could freely communicate with their peers and constantly modify and improve their content, providing a novel and convenient way for learning.

Second, it is suggested to have representatives of different cultures in cross-cultural learning activities. Representatives from two cultures participated in this research. The technology used in the study created learning environments in which the participants were able to exchange authentic information related to culture in creative, innovative, and entrepreneurial way,

interact with each other, and experience authentic culture of their partners from different culture. Such design can be beneficial for cross-cultural learning as well as for developing such skills as creativity, innovation, and entrepreneurship.

Third, we suggest that the development of students' abilities such as creativity, innovation, and entrepreneurship in cross-cultural learning activities supported by technology needs to be further explored in the future. We found that our learning activities effectively facilitated students' creativity, innovation, and entrepreneurship. However, related studies paid little attention to this aspect. For example, future studies may explore such factors as peer communication, guidance of the instructor, and student self-reflection in learning activities, and how helpful each of them can be in enhancing participants' creativity, innovation, and entrepreneurship.

LIMITATION AND FUTURE DIRECTIONS

In this study, the sample size of participants was small. Therefore, generalizing the results to wider population can be problematic. Future studies may consider this limitation and involve more participants. Although, this study collected and triangulated the data from different data sources to make our findings more nuanced and robust, we did not involve a control group. For this reason, we do not have any experimental evidence of the effectiveness of our intervention on creativity, innovation, and entrepreneurship. Future studies may consider testing the effectiveness of intervention in the experiment by involving control and experimental groups and comparing their learning outcomes.

In the future study, we also look forward to exploring more students' higher-order thinking abilities, such as critical thinking, synthesis and evaluation of cultural learning content in a technology-assisted learning environment. From this perspective, we can explore how technology-supported cross-cultural learning affects these higher-order thinking abilities more specifically. Additionally, we discussed students' creativity, innovation, and entrepreneurship from an individual perspective in this study. In the future, we plan to design teamwork sessions to investigate whether teamwork affects students' creativity, innovation, and entrepreneurship in cross-cultural panoramic VR tours.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the School of Education Science, Nanjing Normal University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

RS, SY, and CD contributed to the conception and design of the study. SY, CD, and WS carried out the learning activity,

collected the data, and analyzed the data. SY wrote the first draft of the manuscript. RS prepared the final version of the manuscript. All authors contributed to the article and approved the submitted version.

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Predicting College Students' Adoption of Technology for Self-Directed Learning: A Model Based on the Theory of Planned Behavior With Self-Evaluation as an Intermediate Variable

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Many studies assume a significant relationship between intention and behavior. However, the data do not always support this assumption. This study used a modified version of social cognitive theory with self-evaluations as an intermediate variable to explore and resolve the problems associated with applying the theory of planned behavior to explain students' adoption of technology for self-directed learning. We surveyed 285 college students who enrolled in an e-book publishing course using multifaceted technological learning tools. We found that, as an intermediate variable, self-evaluation enhanced the influence of intentions on behavior and improved the accuracy of predictions of college students' adoption of technology for self-directed learning. Students' attitudes and perceived behavioral control were important factors influencing their adoption of technology for self-directed learning through their effects on intention; subjective norms were not important in this respect.

Keywords: intention, intermediate effect, self-directed learning behaviors, self-evaluation, theory of planned behavior

INTRODUCTION

The application of new technologies, such as the Internet, social media, cloud computing, certain types of media, and mobile learning, has changed the face of education. Students have gradually transitioned from learners with external beliefs to internally motivated knowledge seekers. Researchers generally believe that the modern digital world, i.e., the Internet and social media, has encouraged self-directed learning behaviors. Researchers are increasingly applying social cognitive theory (SCT) to explore the use of technology by students (Lee, 2010; Chang et al., 2011, 2020; Lin, 2012; Lin and Wang, 2012; Cator and Adam, 2013; Dede and Grimsen, 2013; Camilleri and Camilleri, 2021).

One of the fundamental principles of SCT is that learners wish to develop ways to control events (self-directed learning behavior; Bandura, 1977). In terms of the conceptual framework for learning, SCT emphasizes the interactions among learners' perceived intrinsic motivation,

learning behaviors, and learning environments. SCT principles have been extensively applied to self-regulation (Zimmerman, 2000, 2001), cognition-motivation-control (Shih, 2008; Chang et al., 2020; Camilleri and Camilleri, 2021), expectation-confirmation (Lee, 2010; Chang et al., 2011; Hung et al., 2011; Lin, 2012; Lin and Wang, 2012), and expectancy-value models of motivation (Jodl et al., 2001; Watt et al., 2012; van Tuijl and van der Molen, 2016). Based on self-evaluation data, SCT posits that self-directed learning behaviors result from an intrinsic evaluation of the self, including one's behavior, as well as the environment. Self-evaluation is an important factor in students' perceived intrinsic motivation to learn.

Many empirical studies on education employ Ajzen's (1985, 1991) theory of planned behavior (TPB) to explain students' adoption of technology (Liaw et al., 2007; Liaw, 2008; Shih, 2008; Sanchez-Franco et al., 2009; Cheon et al., 2012; Agudo-Peregrina et al., 2014). However, the TPB only explores behavioral attitudes, subjective norms, perceived behavioral control (PBC), intention, and behaviors. The TPB emphasizes extrinsic sources of control of an actor's beliefs regarding behavior. The self-perceived intrinsic motivations highlighted in SCT (i.e., outcome expectations, satisfaction, values, goal setting, and goal progress) are lacking from the TPB; therefore, some researchers have integrated SCT to modify the theory (e.g., Liaw, 2008; Shih, 2008). Studies that use TPB are limited in their ability to explain self-directed learning behaviors.

We took an SCT perspective to overcome the shortcomings of using the TPB to explore students' adoption of technology for self-directed learning. The TPB assumes that self-directed learning behaviors result from increasing or maintaining self-evaluation relationships. We used self-evaluations as intermediate variables to modify the TPB and thus strengthen the causal relationship between intention and behavior.

Our main research questions are as follows: (1) Can self-evaluations be used to modify the TPB to accurately predict the adoption of technology for self-directed learning? and (2) How do the various factors in the modified TPB model interact?

THEORETICAL BACKGROUND

Investigation of the Adoption of Technology for Self-Directed Learning

Developments in information technology have driven interest in its application to research on self-directed learning behaviors. Technology has influenced the overall learning environment; starting with computer-assisted instruction, technology has evolved to encompass web-based learning, e-learning, and mobile learning, etc. Adopting technology for self-directed learning is operationally defined as using technology to enhance learning behaviors (Pellegrino and Hilton, 2012; Cator and Adam, 2013; Dede and Grimsen, 2013). Students use technology for different types of learning, including e-learning, learning based on the application of tools for specific tasks (Lin and Wang, 2012), and learning pertaining to access logs (Agudo-Peregrina et al., 2014), examinations (Mohammadi, 2015), participation on social platforms (such as blogs or Facebook) (Zhang et al., 2012);

sharing (Chen et al., 2009; Lai and Chen, 2011) and cloud computing for collaborative projects (e.g., Google applications) (Cheung and Vogel, 2013). Study management systems providing data on logins, downloads, uploads, pages viewed, and reactions are also used (Pynoo and Van Braak, 2014); moreover, technology can facilitate teaching (Motaghian et al., 2013; Chen et al., 2015).

Researchers from different eras have posited technological theories. Early education researchers focused on stimulus and response learning, for example by using artificial intelligence to provide students with personalized practice questions based on their strengths and weaknesses to improve knowledge and skills (Carbonell and Collins, 1973; Brown and Burton, 1978). Other researchers focused on the relationships of psychological factors with technology use to achieve learning goals. Several theoretical models, such as the technology acceptance model (Davis, 1986), were proposed that focused on the influence of personal attitudes toward technology. The influence of such attitudes and social norms have also been explored (Fishbein and Ajzen, 1975; Venkatesh and Davis, 2000). Moreover, many researchers explored the influence of environmental factors, such as opportunities, skills, conditions, and resources, as exemplified by the TPB (Ajzen, 1985, 1991), technology acceptance model 3 (Venkatesh and Bala, 2008), unified theory of acceptance and use of technology (Venkatesh et al., 2003), and extended unified theory of acceptance and use of technology (Venkatesh et al., 2012). Based on previous analyses, we believe that personal attitudes, subjective social norms, and personal beliefs are key factors in the utilization of technology for self-directed learning. The TPB (Ajzen, 1985, 1991) was adopted in this study as the basic theoretical model.

With the advent of the Internet, cloud computing, and social media, researchers have begun to apply models based on SCT to understand students' motivations and adoption of technology for self-directed learning, such as the cognition-motivation-control model (Shih, 2008; Chang et al., 2020; Camilleri and Camilleri, 2021), expectation-confirmation model (Lee, 2010; Chang et al., 2011; Hung et al., 2011; Lin, 2012; Lin and Wang, 2012), and expectancy-value model of motivation (Jodl et al., 2001; Watt et al., 2012; van Tuijl and van der Molen, 2016). Educational technology is not as limited as before due to the emergence of personal desktop computers and unlimited Internet access. Education technology has transformed learning into a more self-directed process, facilitated by the wide variety of devices and operating systems, and opportunities for collaborative learning. Against this background, research' interest is moving from extrinsic to intrinsic motivation. The intrinsic motivation factors according to SCT are gaining more attention, and some studies have attempted to combine SCT with the TPB (Shih, 2008). This study expands on previous SCT researchers' ideas to reevaluate students' perceived intrinsic motivation (i.e., self-evaluation) and technology adoption for self-directed learning.

Role of Self-Evaluation in the Theory of Planned Behavior

According to Ajzen (1985, 1991), intention affects behavior. The TPB holds that beliefs determine an actor's intentions, which

are based on attitudes, subjective norms, and PBC. Although some research supports the assumptions of the TPB (Lin, 2012; Cheung and Vogel, 2013; Motaghian et al., 2013; Chen et al., 2015; Mohammadi, 2015; Chu and Chen, 2016), other studies did not show a link between intention and behavior (Liaw, 2008; Agudo-Peregrina et al., 2014; Pynoo and Van Braak, 2014). Pynoo and Van Braak (2014) call this the “intention-behavior gap.” In Taiwan, Liaw (2008) studied the use of the blackboard e-learning system for college students, and found that intention was not significantly correlated with the students' self-reported study behaviors. This may be because the technology did not increase the effectiveness of e-learning. Agudo-Peregrina et al. (2014) compared learning behavior associated with the adoption of e-learning technology between graduates and lifelong learners in Spain, and found that only lifelong learners' intention had a significant effect on behavior. They concluded that this was due to lifelong learners' intrinsic motivation to enroll in online courses, to access new opportunities in the labor market. However, much research ignores the relationship between intention and behavior entirely (Tao et al., 2009; Lee, 2010; Liu et al., 2010; Teo and Lee, 2010; Hung et al., 2011; Cheon et al., 2012; Lin and Wang, 2012). This may be because standard surveys simply do not reveal this relationship, so researchers limit their models to take account of intention only. Therefore, we excluded extrinsic motivation from our analyses, and instead focused on the influence of students' intrinsic motivation.

In TPB Ajzen's (1985, 1991), behavioral factors are composed of several beliefs. However, they are often mistaken for intrinsic motivation because beliefs, attitudes, norms, and PBC depend on the environment. Intention is a reasonable concept to explain consumer behavior when applying the TPB; when the environment is favorable, consumers will consume. However, when the TPB is used to analyze students' adoption of technology for self-directed learning, although there may be a positive intention to adopt technology for learning due to a lack of intrinsic motivation, this may not translate into actual adoption of technology for self-directed learning.

Based on self-evaluation data, SCT holds that self-directed learning behaviors result from an intrinsic evaluation of the self, including one's behavior, as well as the environment (Bandura, 1986). Schunk (2020) further emphasizes that self-evaluation, involving self-judgments of current performance based on the progress toward the current goal, is an important factor in a student's intrinsic motivation. From the perspective of SCT, self-evaluation is based on outcome expectations, satisfaction, values, and goal setting and progress. For example, Shih's (2008) research based on a cognition-motivation-control perspective suggests that personal outcome expectations are a form of behavioral motivation. Personal outcome expectations significantly influence the intention to use the Internet for academic learning.

Using the expectation-confirmation model, many researchers have shown that satisfaction with a learning management system can influence behavioral performance and intention (Lee, 2010; Chang et al., 2011; Hung et al., 2011; Lin, 2012; Lin and Wang, 2012). Lin (2012) suggested that students may not adopt technology if they perceive it as unimportant for the learning

process, do not understand the material to be learned, cannot easily achieve their goals during the study process, or believe that technology is not easy to use, etc.

The expectancy-value model of motivation focuses on beliefs regarding one's own ability, referred to as success expectancies or self-concept (Jodl et al., 2001; Watt et al., 2012; van Tuijl and van der Molen, 2016), where the actors consider the following: “Can the behavior be performed successfully?” and “Can the technology help me learn more efficiently?” In the expectancy-value model of motivation, self-evaluation describes beliefs regarding one's ability to adopt technology for self-directed learning, referred to as success expectancies (Watt et al., 2012) or self-concept (Jodl et al., 2001), as stated above. These definitions are identical to that for self-efficacy (van Tuijl and van der Molen, 2016); all of these concepts of self-evaluation help predict whether a student will adopt a given technology. We speculate that students' self-evaluations of outcome expectations, values, and goal setting and progress will influence the relationship between intention and behavior.

Self-evaluation promotes understanding of the relationship between intention and self-directed learning behaviors. Low self-esteem and negative self-perceptions will not necessarily diminish motivation if students believe they can succeed, even if their current approach is ineffective (Bandura, 1986). Such students may work harder, persist longer, or adopt what they believe is a better strategy (Schunk, 2020). Schunk (1991, 2020) stated that positive self-evaluations can lead students to believe that studying is effective, such that they work diligently because they believe that they have the intrinsic ability to improve. Students with more positive self-evaluations exhibit more effective and multifaceted self-directed learning behaviors. However, negative self-evaluations may render students unwilling to persist with learning (Liaw, 2008; Lin, 2012; Agudo-Peregrina et al., 2014), because they believe that their abilities or strategies are insufficient. Therefore, positive self-evaluations will promote the adoption of a particular technology to aid learning. On the other hand, students with a positive intention but negative self-evaluation (perhaps due to previous failures or a lack of learning efficiency) will not demonstrate self-regulatory behaviors. This helps explain why students with positive intentions can lack self-directed learning behaviors, and may only use technology if forced to by a teacher. Against this background, we propose the following hypotheses:

- H1. Learners with more positive intentions will also have more positive self-evaluations.
- H2. Learners with more positive self-evaluations will adopt technology to aid multifaceted self-directed learning behaviors.

Antecedents of the Theory of Planned Behavior

Attitude is defined herein as students' perceptions of technology for learning. Fishbein and Ajzen (2010) proposed that the attitude toward a behavior is an essential aspect of learners' intentions. Studies have empirically proved the significance of learners' attitudes toward the intention to adopt technology

(Chen et al., 2009; Lee, 2010; Teo and Lee, 2010; Cheung and Vogel, 2013). Accordingly, we propose hypothesis (H3), as follows:

H3. A learner with a more positive attitude will have a greater intention to adopt technology.

Subjective norms are defined herein as the influence of instructors and peers on students' perceptions of technology adopted for learning. Fishbein and Ajzen (2010) proposed that subjective norms were important factors affecting intention. However, in some studies, subjective norms had a non-significant effect on intention (Lee et al., 2011; Cheung and Vogel, 2013). Lee et al. (2011) stated that subjective norms significantly affect behavioral intention. For example, students who use a platform that integrates text, images, and audio (e.g., Google or YouTube) can interact online through email, use electronic bulletin boards, and take online quizzes. New users of a technology can learn to use it easily if helped by others; however, over time, the intention to continue using a technology depends mainly on personal motivation. Nevertheless, other studies have reported a significant positive relationship between subjective norms and intention (Lee, 2010; Cheon et al., 2012; Chu and Chen, 2016). Thus, we propose another (tentative) hypothesis (H4), as follows:

H4. A learner with more positive subjective norms will have a greater intention to adopt technology.

Perceived behavioral control is operationally defined herein as students' beliefs about their degree of control over the technology to be adopted to aid the learning process. These beliefs may be informed by whether they have used the technology before and, if so, how often. PBC directly affects intention and behaviors (Fishbein and Ajzen, 2010). Students' beliefs (e.g., regarding opportunities, resources, and the environment) are key elements influencing their intention to adopt technology for learning purposes. Notably, Chen et al. (2009) showed that students' extrinsic and intrinsic PBC are both significantly correlated with behavior, but only extrinsic PBC is significantly correlated with intention. Although they reported that PBC had a significant effect on intention, Sawang et al. (2014) suggested otherwise. Because these findings conflict with H4, further clarification is needed. Thus, we propose two more tentative hypotheses (H5 and H6), as follows:

H5. A learner with a higher PBC will have a greater intention to adopt technology.

H6. A learner with a higher PBC will adopt technology for learning in a multifaceted way.

Intention is operationally defined herein as the intention of the learner to adopt a particular technology. According to Ajzen (1991) and Fishbein and Ajzen (2010), student behavior may be directly influenced by behavioral intention. Although previous studies showed that a positive intention does not have a significant positive effect on learning behaviors (Liaw, 2008; Lin, 2012; Agudo-Peregrina et al., 2014), some research supports the assumptions of the TPB (Pynoo et al., 2011; Lin, 2012; Cheung and Vogel, 2013; Motaghian et al., 2013; Chen et al., 2015;

Mohammadi, 2015; Chu and Chen, 2016). Thus, we propose another tentative hypothesis (H7):

H7. A learner with higher intention will adopt technology and show multifaceted self-directed learning behaviors.

RESEARCH METHODOLOGY

Research Framework and Hypotheses

Our model based on the TPB included self-evaluation as an intermediate variable. Conceiving of self-evaluation as a combination of perceived intrinsic motivations, as in SCT, should help us understand students' adoption of technology for self-directed learning. **Figure 1** depicts our research model, which extends Ajzen's TPB by adding one intermediate variable (self-evaluation) between intention and self-directed learning behaviors.

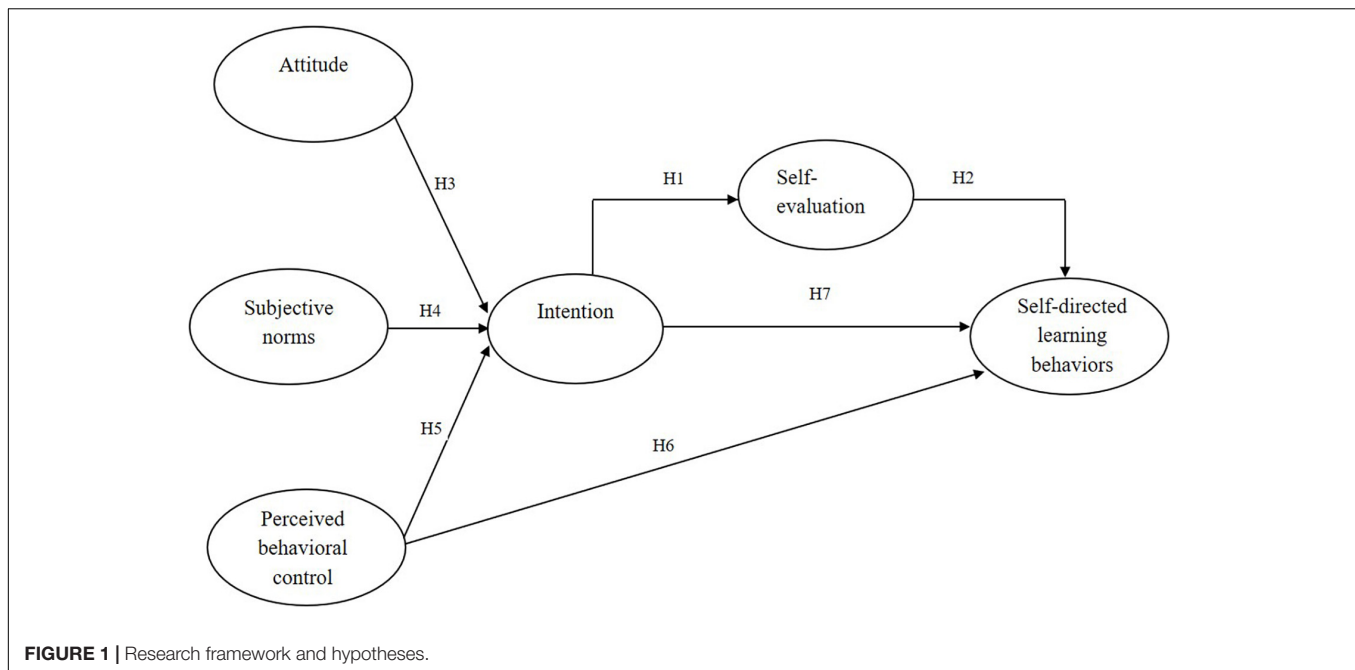
Variables and Questionnaire Items

The final questionnaire used in this study consisted of 27 items to assess the 6 constructs of the proposed research model. The items in the questionnaire were scored using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

The Adoption of Technology for Self-Directed Learning

This research uses subjective measures, as recommended by Ajzen (2019), and the binary choice technique to assess the extent of use of technology for self-directed learning according to the number of study behaviors exhibited that involve technology (Lai and Chen, 2011; Schunk, 2020); the more of those behaviors that the students demonstrate, the greater the degree of adoption of technology for self-directed learning. To this end, questionnaire items such as "When doing homework, do I use technological tools," "When producing graphics, I use technological tools," "When publishing articles, I use technological tools," "During discussions with team members, I use technological tools," "When working on an e-book project, I use technological tools," and "When participating in classroom competitions, do use technological tools" were included. The technological tools of interest included search engines (e.g., Google), video platforms (e.g., YouTube), social media platforms (e.g., Facebook, Line, and Instagram), and cloud computing for collaborative projects (e.g., Google Docs).

Behaviors are usually assessed based on objective (e.g., data from systematic records) or subjective (e.g., personal accounts) measures (Fishbein and Ajzen, 2010). As objective measurement of behaviors can be difficult (Fishbein and Ajzen, 2010), past research mainly used subjective self-report data, including assessment scales (Ngai et al., 2007; Wang and Wang, 2009; Chen, 2010; Cheung and Vogel, 2013; Chen et al., 2015), frequency data (for a given behavior) (Pynoo et al., 2011; Pynoo and Van Braak, 2014; Ajzen, 2019), reports of the time spent engaging in a particular behavior (Pynoo et al., 2011; Chu and Chen, 2016), and simple binary assessments



(use/non-use of a specific approach) (Lai and Chen, 2011). It is important to emphasize that using technology for learning is a multifaceted process, and to avoid missing data when using self-report surveys of students' adoption of technology for self-directed learning. A binary analysis approach is preferable to avoid differences between reported and actual behavior. Therefore, this study adopted Lai and Chen's (2011) binary choice technique.

Self-Evaluation

Self-evaluation questions were developed based on the studies of Jodl et al. (2001), Shih (2008), Lin (2012), and Watt et al. (2012). Notably, previous studies utilized self-evaluation questions related to expected consequences that were in the future tense (e.g., "will help," "will improve," etc.); however, the responses were not associated with behavior (McGill and Klobas, 2009). Thus, we did not use the future tense. Self-evaluation is defined herein as self-regulation of the adoption of technology by the learner. We were interested in the use of technology to solve academic problems encountered during their studies (outcome expectations) (Shih, 2008), as well as in successful self-initiated application of technology to study for major courses in an individualized manner (confirmation) (Lin, 2012), technology-aided goal setting and progress (Watt et al., 2012), and enhancement of knowledge and skills in the major field of study through the use of technology (values) (Jodl et al., 2001). Self-evaluation was assessed via questionnaire items such as "I always use technology on my own to solve problems I encounter during coursework," "I have my own methods of using technology to help with my major courses," "I can control the pace of my learning by using technology," and "I am very accustomed to using technology to improve my knowledge and skills."

Intention

Intention-related questions were developed based on Ajzen (1991) and Fishbein and Ajzen (2010), including "I always use technology to help me study for my major courses," "If it is permitted, I will use technology to the maximum extent possible in my major courses," "I will use technology in the future to obtain information related to my major," and "I am happy to recommend technology for cooperative study activities."

Attitude

Attitude-related questions were similarly developed based on Ajzen (1991) and Fishbein and Ajzen (2019), including "It is fun to use technology to do my coursework," "In my major classes, it is smart to use technology to learn," "I enjoy using technology as I study for my major courses," and "Technology promotes a self-directed study environment."

Subjective Norms

Subjective norm-related questions were again developed based on Ajzen (1991) and Fishbein and Ajzen (2010), including "If the majority of my friends and partner used technology to study, I would use it, too," "I adopt technology when respected teachers or friends recommend it to me for my studies," "The opinions of the important people around me affect my decision to use technology as a study tool," and "If my friends and partner all used technology to communicate, I would use it, too."

Perceived Behavioral Control

Perceived behavioral control-related questions were also developed based on Ajzen (1991) and Fishbein and Ajzen (2010), including "During my studies, I often use technology to enhance my learning abilities," "I often use technology to help me complete creative projects," "When I have problems with my coursework, I often use technology to solve them," and "I

am always trying new technologies to see if they can help me academically.”

Sampling

The students enrolled in this study were from two universities in northern Taiwan; a theoretical sampling approach was used. They were taking courses related to new media technology, such that they had to use technology for their coursework including mobile devices, the Internet, and cloud computing (smartphones, tablets, notebook computers, etc.). Education was provided face-to-face, i.e., in the classroom, as well as via the Internet, iOS and Android mobile devices. The students participated in virtual interactive activities with teachers and peers, through social media platforms (e.g., online peer discussions, collaborative group work, and online question and answer sessions with instructors). All of participants had enrolled in an e-book publishing course involving multifaceted technological learning tools. Our paper questionnaire survey was completed between weeks 13 and 15 of the semester, which lasted for 18 weeks. A total of 360 completed questionnaires were collected. After discarding 75 incomplete questionnaires, the remaining 285 were further analyzed.

Reliability and Validity of the Questionnaire

The original questionnaire was in English but was translated into Chinese for this study. One native English speaker verified that the Chinese version of the questionnaire was valid, based on suggestion Ary et al. (2018). The questionnaire content was also validated in a pilot study by an academic expert, e-learning specialist, learning theory specialist, and 30 students reporting technology-enhanced learning experiences. The subjects of the pilot study were college students who participated in the abovementioned courses. The 30 completed questionnaires were assessed for skewness, kurtosis, and variance. Analysis of individual survey items was conducted. Items that did not reach significance (average scores >6 or <2) were omitted based on the results of confirmatory factor analysis (10 items in total).

Regarding instrument reliability, Cronbach's alpha values should be >0.7 (Hair et al., 1998) and the average variance extracted (AVE) value should be >0.5 (Fornell and Larcker, 1981). All of our constructs had a Cronbach's alpha value >0.7 (range: 0.80–0.91). The AVE values for the latent constructs were all >0.5 (range: 0.51–0.70). In addition, the square root of the AVE value was larger than the correlation coefficient, indicating satisfactory discriminant validity (Chin and Newsted, 1999).

RESULTS

Subjects

All 285 subjects were undergraduate students (79.3% female). Most subjects were third- or fourth-year students (97.9%). In total, 70.9% of the students went online at any time, 23.2% went online at night, 4.6% went online during the day, and only 0.4% did not go online often. On encountering academic problems, the technology tools of choice were as follows: 97.2% of students

used the Google search engine, 54.7% used YouTube, 41.1% used Facebook, and 31.2% used Line. The technological platforms and tools were used for homework (93.0% of students), e-book project work (81.1% of students), publishing tasks (61.4% of students), classroom competitions (56.8% of students), and discussions with team members (50.2% of students). These results indicated that the respondents were primarily users of knowledge-based, as opposed to social, technology. Search engines were generally viewed as beneficial for self-directed learning, indicating that knowledge-based technologies were widely accepted as study tools by the respondents.

Model Fit

We used structural equation modeling (SEM) to test our research models and hypotheses. Due to the large number of samples (>200), we used the Bollen–Stine bootstrap p -value (Bollen and Stine, 1992). The TPB model with self-evaluation as an intermediate variable had an $\chi^2/df < 3$ (1.31), indicating a good data fit. This was supported by the other indices [comparative fit index (CFI) = 0.98, goodness of fit index (GFI) = 0.94, adjusted goodness of fit index (AGFI) = 0.91, standardized root mean square residual (SRMR) = 0.05, root mean square error of approximation (RMSEA) = 0.05]. For the TPB model, the χ^2/df was <3 (1.55), again suggesting a good data fit. This was supported by the other indices (CFI = 0.97, GFI = 0.93, AGFI = 0.91, SRMR = 0.04, and RMSEA = 0.03) (Table 1).

Structural Equation Modeling

Structural equation modeling was used to test the research hypotheses. Figures 2, 3 show all of the path coefficients, and the variance explained by the model with self-evaluation as an intermediate variable, and the model based on the original TPB.

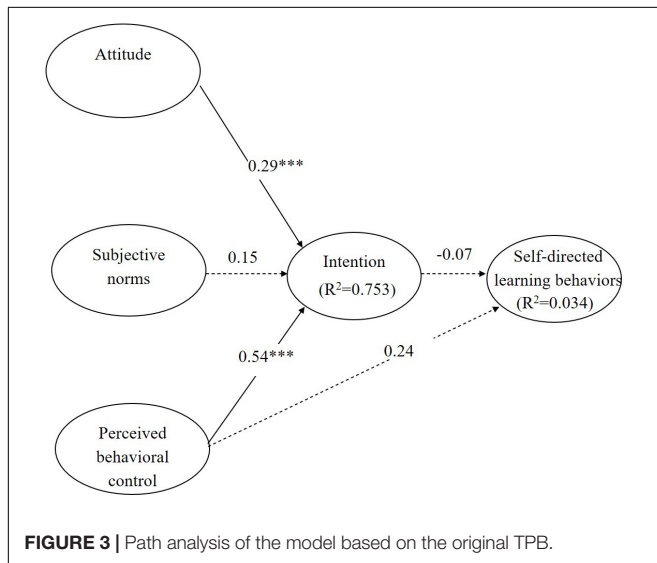
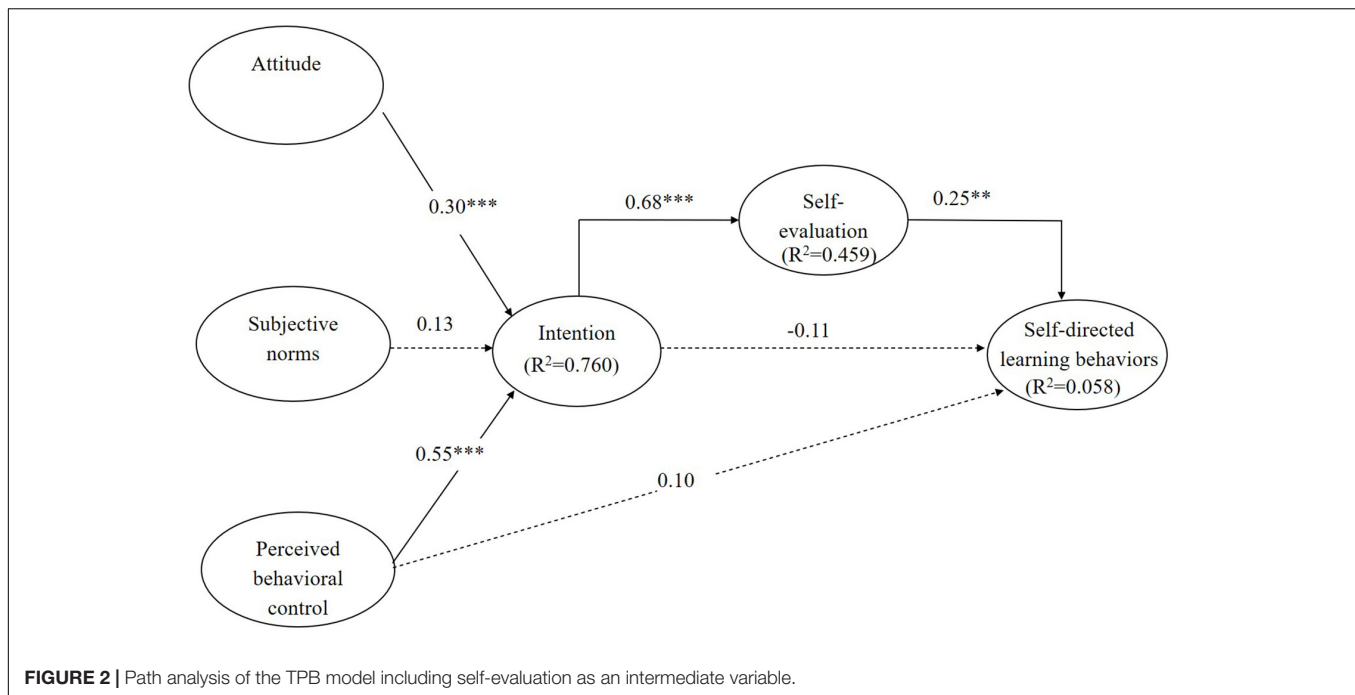
Model With Self-Evaluation as an Intermediate Variable

Self-evaluation significantly mediated the relationships between intention and self-evaluation ($\beta = 0.68$, $p < 0.001$), and self-evaluation and motivation to learn ($\beta = 0.25$, $p < 0.01$) (Figure 2), which supports H1 and H2. Regarding antecedents, in the model with self-evaluation as an intermediate variable, attitude ($\beta = 0.30$, $p < 0.001$) and PBC ($\beta = 0.55$, $p < 0.001$) had positive effects on intention, thereby supporting H3 and H5. However, subjective

TABLE 1 | Goodness-of-fit indices of the models.

Goodness-of-fit indices	Criteria	TPB model with self-evaluation as an intermediary	TPB model
χ^2 -statistic	Non-significant	*Non-significant	*Non-significant
χ^2/df	<3	1.31	1.55
CFI	>0.95	0.98	0.97
GFI	>0.90	0.94	0.93
AGFI	>0.80	0.91	0.91
SRMR	<0.08	0.05	0.04
RMSEA	<0.10	0.03	0.03

*Bollen–Stine-corrected p -value.



norms ($\beta = 0.13$, $p > 0.05$) did not significantly affect intention; thus, H4 was not supported. Moreover, PBC and intention did not have significant effects on self-directed learning behaviors in either model ($\beta = 0.10$, $p > 0.05$; $\beta = -0.11$, $p > 0.05$); thus, H6 and H7 were not supported.

Model Based on the Original Theory of Planned Behavior

In the model based on the original TPB, there was a non-significant relationship between intention and behavior. The direct path from intention to self-directed learning behaviors was non-significant ($\beta = -0.07$, $p > 0.05$) (Figure 3), which does not

support H7. Regarding antecedents, attitude ($\beta = 0.29$, $p < 0.001$) and PBC ($\beta = 0.54$, $p < 0.001$) had positive relationships with intention, supporting H3 and H5. However, subjective norms ($\beta = 0.15$, $p > 0.05$) did not significantly affect intention; thus, H4 was not supported. Moreover, PBC did not significantly affect self-directed learning behaviors ($\beta = 0.24$, $p > 0.05$); thus, H6 was not supported.

When self-evaluation was included as an intermediate variable (Figure 2), the influence of PBC on self-directed learning behaviors ($\beta = 0.095$, $p > 0.05$) was weaker than when self-evaluation was not an intermediate variable ($\beta = 0.239$, $p > 0.05$) (Figure 3).

DISCUSSION

This study examined the adoption of technology for self-directed learning by extending the TPB through inclusion of self-evaluation as an intermediate variable. We also explored the self-regulation concept of SCT as it pertains to the adoption of technology by students. Three noteworthy results were found and are discussed below.

Theory of Planned Behavior Model With Self-Evaluation as an Intermediate Variable

Self-evaluation was a significant intermediate variable between intention and actual adoption of technology (see Figure 2); this finding accords with Bandura (1977, 1986, 1991) and Schunk (2020). Self-evaluation is an important factor in student motivation. Students may strongly believe that using technology can help them develop their values. When students believe

that their studies are meaningful and they maintain a positive intention toward the use of technology, learning behaviors will naturally follow.

The findings regarding the intention to adopt technology for self-directed learning in this study echo previous research (Liaw, 2008; Agudo-Peregrina et al., 2014; Pynoo and Van Braak, 2014; see **Figures 2, 3**). However, the findings do not agree with Pynoo and Van Braak (2014), who believe that the gap between intention and behavior is mediated by subjective norms. Our findings suggest that intrinsic motivation (self-evaluation) rather than extrinsic motivation (intention) drives the adoption of technology for self-directed learning (Bandura, 1986).

Relationships Among the Various Factors Included in the Models

Individual attitudes and PBC were the most important variables determining the intention to adopt technology (see **Figures 2, 3**), in line with most previous research (Chen et al., 2009; Fishbein and Ajzen, 2010; Teo and Lee, 2010; Cheung and Vogel, 2013). However, subjective norms did not show a significant relationship with intention, in contrast to Lee (2010), Cheon et al. (2012), and Chu and Chen (2016). In those studies, the relationship between intention and extrinsic belief was mainly mediated by subjective norms. This discrepancy may be explained by the participants in this study being third- and fourth-year students, who were typically long-time technology users.

The lack of an effect of subjective norms on intention described above also accords with Lee et al. (2011). Text-, image-, and video-based platforms, such as Google and YouTube, enable communication with other students via email, electronic bulletin boards, and online quizzes, while closed networks do not provide opportunities for learning involving other students. The majority of the students also reported being online most of the time, and used Google to solve academic problems (i.e., believed that search engines facilitate self-directed learning). As the students' use of technology was relatively advanced, their study habits were not easily influenced by others.

The participants used technology to resolve academic problems and believed that technology was helpful for self-directed learning. Thus, social media platforms such as Facebook and Line were used less than Google and YouTube, and the influence of subjective norms on technology adoption for self-directed learning was weak.

A significant relationship between PBC and behavioral intention was found in this study, unlike that of Sawang et al. (2014). However, they mainly focused on social influences on student's behavior in the context of a collectivist society. In our study, we assumed that the students were free to adopt technologies of their choice to aid their studies, and were not resource-limited. Accordingly, PBC exerted a significant influence on intention.

Finally, PBC did not directly affect behavior (see **Figures 2, 3**), especially in the model in which self-evaluation was an intermediate variable. In contrast to Chen et al. (2009), who reported that extrinsic beliefs about technology (PBC) and

perceived intrinsic motivation to articulate ideas via technology (self-evaluation) significantly influenced behavior, we found that only self-evaluation had a significant effect on behavior. Although Fishbein and Ajzen's (2010) theory posits that PBC has a significant direct effect on behavior, we found while outcome expectations, values, goal-setting, and self-evaluations of progress toward goals directly affected behavior, PBC did not promote or impede the adoption of technology. In addition, students' perceptions of themselves were more important than PBC, i.e., self-evaluations regarding the adoption of technology were more important to self-directed learning than PBC.

CONCLUSION

Self-evaluation involves comprehensive assessment of one's abilities. Educators can improve students' motivation to study using self-evaluation strategies. When students become frustrated, self-evaluations change, as should the methods and strategies used to resolve difficulties. Students with negative self-evaluations may feel frustrated because they lack expectations, values, or goals. Therefore, enhancing students' self-perceived of success could be a target for further studies. Students with favorable self-evaluations are confident that they will succeed, even when they experience setbacks, and understand that it is only their approach that needs to change to achieve the desired outcome. To motivate students to keep studying, educators should set high goals for their students.

In the future, we recommend that the model in this study be applied only to groups of students studying the same major, because the use of technology may be very different among majors and departments. Similarly, we do not recommend that student data from different fields of study be combined. Our questionnaire survey took place during the semester to avoid any influence of final grades. However, the students could have been influenced by other courses or club activities; therefore, how best to adopt technology for self-directed learning requires further exploration.

There were some limitations to this study. For example, the study habits of students in different fields of study may not accord with the learning behaviors of interest in this study. Thus, the survey question items should be adjusted according to the likely applications of technology for specific subjects. The learning behaviors in this study were most relevant to design and communication students. Moreover, regarding SEM, the χ^2 value may be too large if there more than 200 samples, as in this study. Bollen–Stine-corrected *p*-values are recommended in such cases, as applied herein.

Future research should further explore learning behavior based on self-evaluations, and assess the limitations of such methods. For example, when used with in the context of the TPB, self-evaluations are only applicable to self-directed learning behaviors (i.e., not to consumer behavior or technology adoption for non-learning purposes). Also, only older students should be used as study subjects because the self-regulated process of self-evaluation requires the ability to make accurate self-judgments; this ability may not be fully developed in younger students.

The results of the final pathway model in this study pertained to learning behaviors involving technology that were already quite prevalent among the students, and did not require contact with other students. We did not cover closed social networks for teachers and students, as these campus-specific social and mobile learning technologies are not popular; the inclusion of such networks might have led to different results.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the link below: <http://dx.doi.org/10.13140/RG.2.2.19004.72328>.

AUTHOR CONTRIBUTIONS

S-YT was responsible for research design, conducting questionnaire survey, analyzing the data, and revised the

manuscript (contributions to this research: 50%). K-YL was responsible for research design, collecting and analyzing the related literature, conducting questionnaire survey, and revised the manuscript (contributions to this research: 30%). C-YL was responsible for collecting and analyzing the related literature, and writing the manuscript (contributions to this research: 20%). All authors contributed to the article and approved the submitted version.

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Enhancing Students' Self-Efficacy in Creativity and Learning Performance in the Context of English Learning: The Use of Self-Assessment Mind Maps

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Creativity is an important 21st Century skill that enhances students' ability to see new opportunities, confront new challenges, and adapt flexibly to the changing study, work and life situations. To nurture students with strong self-efficacy in creative thinking is as important as the contexts and strategies involved in its application. But how to develop sustainable interventions (without generating excessive workload for teachers) to promote students' self-efficacy in creativity is a long-lasting challenge. This study presents a simple and relatively cost-effective instructional intervention, i.e., self-assessment mind maps, and examines its effect on students' self-efficacy in creativity, self-efficacy in learning English, and academic performance in English language tests. A pretest-posttest non-equivalent design was adopted for the experimental and control groups of students in a Hong Kong primary school in 2021/22 Spring semester. The results show that students from the experimental group significantly outperformed those from the control group on self-efficacy in creativity after the intervention. However, the intervention did not improve students' self-efficacy and test performance in English learning. The findings demonstrate the potential of self-assessment mind maps as an effective and sustainable instruction intervention to promote students' higher-order abilities. This study sheds light on designing sustainable instructional strategies for empowerment in creativity.

Keywords: creativity, self-efficacy in creativity, English language learning, self-assessment, mind mapping, experimental design

INTRODUCTION

Mind mapping is a tool to scaffold visual thinking for and as learning (Buzan and Buzan, 2002, 2006). As mind mapping enables students to freely express ideas and connect those ideas in a non-linear manner, it stimulates divergent thinking (Leeds et al., 2019) and, therefore, has advantages in developing higher-order abilities, such as creativity. Due to its flexibility and simplicity, mind mapping has been widely used in various contexts. Although past studies have revealed a generally positive impact of mind mapping on academic and affective outcomes, the effect varied across

contexts (Liu et al., 2014). Thus, further empirical research is needed in this direction to identify effective interventions.

Considering that mind mapping could be cognitively demanding for some students, appropriate scaffolding is necessary. Moreover, reviewing students' mind maps and providing feedback could be time-consuming for teachers, making it less likely to be sustainable. Thus, it is desirable to design easy-for-use (for students) and cost-effective (for teachers) mind mapping strategies.

This study aims to examine the effectiveness of a simple intervention, i.e., the self-assessment mind map that combines the ideas of self-assessment and mind mapping, on primary school students' self-efficacy in creativity, self-efficacy in learning English, and academic performance in English language tests in a naturalistic learning environment. The findings can inform the design of sustainable mind mapping interventions to promote students' higher-order abilities.

What Is Mind Mapping

A picture is worth a thousand words. While verbal language is ubiquitous in routine teaching and learning, visualization captures less attention regardless of its potential to enhance higher-order abilities and offer an alternative pathway for learning. Mind mapping is such a tool to scaffold visual thinking for and as learning (Buzan and Buzan, 2002, 2006). Different from the strict rules in the language (e.g., grammar), mind maps offer more freedom and flexibility in information processing. Starting with a theme, relevant elements are freely represented in words, symbols, or pictures, reducing linguistic barriers to the thinking process, especially for younger children. The relation among elements is represented with lines, resulting in a network of information on this specific topic. The creation of a mind map is often an impromptu and non-linear process, with a high sense of autonomy and personalization. Due to its flexibility and simplicity, mind mapping has been widely used in various contexts. For example, enterprises can use it for knowledge management, especially in digital form (Lin and Faste, 2011). Professional workers can use it for brainstorming, communication, and planning, especially for people with impaired vision (Schnelle-Walka et al., 2014). Students can use it for note-taking, brainstorming in writing and group projects, as well as reflection (Vijayakumar, 2011; Tee et al., 2014).

From a constructivist perspective, the process of creating elements and making connections requires a deep and active way of information processing (Dhindsa et al., 2011), promoting personal engagement and enjoyment. On the other hand, because of its minimum restriction during creation, mind mapping stimulates divergent thinking instead of convergent thinking (Leeds et al., 2019). Ideas are freely expressed and connected in a non-linear manner without the necessity of following the strict rules as those enforced in writing. It is advantageous in incubating creativity. Furthermore, according to the multiple intelligence theory (Gardner, 1993, 2011), people are born with different talents and tendencies. Some excel in manipulating verbal tools, whereas some are good at thinking with visual elements. Mind mapping offers an alternative way of thinking and understanding

in formal education, which could benefit those with high visual-spatial intelligence but low linguistic intelligence.

The Impact of Mind Mapping

Due to the features elaborated earlier, mind mapping has attracted increasing research interest and past studies have documented the positive impact of mind mapping in enhancing a wide range of desirable learning outcomes, such as higher-order abilities (e.g., creativity), affective outcomes (e.g., self-efficacy in learning), and academic performance. Liu et al.'s (2014) meta-analysis of the effect of mind mapping included 52 studies. They found that, in general, the use of mind maps lead to positive changes in academic and affective outcomes. However, the effect varied across studies and some studies reported nil or even negative impact.

Mind mapping is an effective strategy to develop higher-order abilities, such as creativity. In their review, Wang et al. (2010) concluded that the strategy of mind mapping is helpful for creativity and problem-solving because drawing with words and non-word symbols can trigger students' learning motivation and evoke their abstract thinking. There is empirical evidence in the literature. For example, Hwang et al. (2012) conducted an experimental study investigating the effect of mind mapping in an undergraduate business planning course. There were two experimental groups: one with a mobile-based mind map application, the other with a computer-based mind map application. The control group adopted the conventional instruction. The results showed that students in both experiment groups (mobile-based and computer-based mind maps) are significantly superior to those from the control group in terms of creative thinking ability. They argued that the graphic representations and drawing in mind maps facilitate students' engagement in divergent thinking which, in turn, promote creativity. In another experimental study with university students, Malycha and Maier (2017) found that the use of the mind mapping technique significantly enhanced students' performance on each of the three creativity dimensions (i.e., fluency, flexibility, and originality).

The pedagogical impact of mind mapping on creative thinking has also been studied in the context of learning English, but the results are mixed. For example, Buran and Filyukov (2015) found that mind mapping was helpful for students to brainstorm creative ideas, learn new vocabulary, enhance reading skills, and organize presentations. Another study by Yunus and Chien (2016) revealed that the use of mind maps facilitated students to gain a deeper understanding of the writing topics, plan the writing, and enhance creativity in writing. Fu et al. (2019) designed a mind mapping-based contextual gaming approach and revealed that the new approach enhanced students' writing performance and ability to generate diverse ideas. In contrast, Ningrum et al. (2016) reported that mind maps did not significantly impact EFL students' idea development in argumentative writing. Nevertheless, most students had positive perceptions of mind maps and were willing to engage in mind-mapping-based activities (Yunus and Chien, 2016; Fu et al., 2019).

The conception of creativity encompasses a wide range of creative people, processes, and products (Beghetto and Kaufman, 2007). In this study, we assessed how the construct of “creative self-efficacy” varies to capture the magnitude of creativity during the learning process. Rooted in the work of Bandura (1986, 1993), creative self-efficacy, a special form of self-efficacy, is a person’s self-belief and judgment of one’s own ability to be engaged in creative activities (e.g., Tierney and Farmer, 2002; Tang et al., 2017). Self-efficacy contributes to human cognitive, motivational and affective development and functioning (Bandura, 1997). Thus, a strong sense of self-efficacy is a necessary condition for human creative productivity. Creative self-efficacy has a medium-size correlation ($r = 0.39$) with different creativity measurements, as shown in a meta-analysis synthesizing 41 papers (Haase et al., 2018). Many studies in the Asian context focused on teachers’ creativity beliefs (e.g., Huang and Lee, 2015; Huang et al., 2019a,b), but the understanding of students’ creative self-efficacy, particularly its relationship with mind mapping strategies, is limited. This study aimed to address this gap. In this study, creative self-efficacy is expressed as self-efficacy in creativity to stay consistent with the other variable (i.e., self-efficacy in learning English).

The use of mind maps can improve knowledge retention and clarify concepts that lead to an in-depth understanding of learning contents and deeper learning among students (Bressington et al., 2018). Thus, the repeated engagement in mind maps can offer students a sense of encouragement and success, leading to enhanced students’ self-efficacy (Nesbit and Adesope, 2006). Past studies have also investigated the impact of mind mapping on students’ self-efficacy in learning, but the findings are mixed. Some studies found that using mind maps in teaching could increase students’ self-efficacy in learning (e.g., Chularut and DeBacker, 2004; Zheng et al., 2020), while the others reported non-significant results. For instance, Bressington et al. (2018) found in their experimental study that students from the experimental group (using mind maps) showed lower self-efficacy than those from the control group (conventional teaching approach), although the difference was not statistically significant.

In addition to self-efficacy, mind mapping has been approved to be a useful learning and teaching tool to enhance students’ academic performance in various subject areas, such as Programming (e.g., Gul et al., 2017), Economics (e.g., Madu and Metu, 2012), and learning English (e.g., Wang, 2019; Hazaymeh and Alomery, 2022). Hazaymeh and Alomery (2022) found that mind mapping, using the web-based mind mapping software “MindMeister,” helped improve English language learners’ reading ability in an online learning environment. In learning English grammar, mind mapping helps students organize the knowledge points in a systematic and visual fashion that is useful to deepen their comprehension of the knowledge points and the connection between them (Wang, 2019). Such a positive impact of mind mapping is also applied to young EFL learners. Lan et al. (2015) reported that mind mapping significantly improved fifth graders’ grammar

knowledge compared to those who did not use this strategy. Merchie and van Keer (2016) investigated the effect of two instructional mind mapping strategies (researcher-provided or student-generated mind maps) on fifth and sixth graders’ graphical summarization skills. They found that students from the experimental group outperformed those from the control group on most, but not all, aspects of graphic summarization skills. Furthermore, student-generated mind maps showed a stronger impact than researcher-provided mind maps. However, some studies reported unfavorable results. Ritchie et al. (2013) conducted two experiments to test the effect of mind mapping on primary school students’ learning. Although they found a significantly positive impact of mind mapping on the retrieval practice in Experiment 1, they did not find any significant main or interaction effects in Experiment 2, which had a larger sample.

Combining Mind Mapping and Self-Assessment

The design and implementation of mind maps are associated with some challenges. In many cases, it is time-consuming for students to produce mind maps and for teachers to review mind maps. Furthermore, as mind mapping requires students to recall, organize, and visualize their cognitive structures, some students may find it cognitively demanding and need additional scaffolding (Stokhof et al., 2020). There are suggestions to provide students with pre-set templates (Prabha and Aziz, 2020) or worked-example mind maps (Merchie and van Keer, 2016) to facilitate the generation of mind maps and maximize its impact on student learning.

As producing mind maps relies on students’ reflection on the learning process they have experienced, scaffolds that facilitate self-reflection would be useful. In this sense, it is promising to combine mind mapping and self-assessment in instructional design. Self-assessment refers to “a process during which students collect information about their own performance, evaluate and reflect on the quality of their learning process and outcomes according to selected criteria to identify their own strengths and weaknesses” (Yan and Brown, 2017, p. 1248). In the self-assessment process, students are encouraged to take responsibility for their learning by acting as not only recipients of assessment but also designers and users of assessment (Wu et al., 2021b). Therefore, self-assessment is a learning process, rather than an assessment method, that provides students with ample learning opportunities (Yan and Carless, 2021).

Past studies have shown that students’ engagement in self-assessment can lead to improved academic performance (Brown and Harris, 2013; Yan et al., 2021). Self-assessment can also increase students’ self-efficacy (Panadero et al., 2017). This was because self-assessment can provide students with a better understanding of the gap between their current and desirable performance levels and adaptive strategies to close the gap. Thus, students are likely to perform better and the successful experience, according to social cognitive theory (Bandura, 1986), increase the perceived capability which, in turn, results in a higher level of self-efficacy. There is also a positive link between

self-assessment and creativity. In a recent review, Bolden et al. (2020) concluded that self-assessment or self-reflection could promote both creative products and processes. This was because self-assessment encouraged students to reflect on their learning process and products against assessment criteria. Such reflective thinking could result in adaptive learning strategies or innovative pathways to the learning goals. For example, students who were supported to self-assess or self-reflect demonstrated higher levels of creative perceptions (Eow et al., 2010) and divergent thinking skills (Doron, 2017). Kim et al. (2016) examined the relationship between self-reflection and creativity in the context of English learning. Students used visual thinking to represent their understanding of curriculum content. Students in the experimental group who were supported via tablet technology to reflect on and adjust their visual representations demonstrated significantly higher creativity scores than the control group.

By highlighting students' active and reflective role in the assessment process, self-assessment enhances students' agency in learning and avoids the constraints associated with teacher-directed assessment (e.g., big class size and teacher workload) and, therefore, makes self-assessment-based instruction more likely to be sustainable (Yan and Brown, 2021). More importantly, the self-assessment process has been unpacked as concrete and sequential actions (e.g., Yan and Brown, 2017) so that it is possible to scaffold students' self-assessment in a visual approach, i.e., in the mind map format. Thus, we designed a self-assessment mind map in this study to synergize the impact of mind mapping and self-assessment. On the one hand, the self-assessment framework can provide a generic structure as additional scaffolding for students who were new to mind mapping, making the mind maps concrete enough for easy implementation without burdening teachers. On the other hand, the visual approach of mind mapping makes self-assessment more interesting. Therefore, it could help develop students' self-assessment ability during the mind mapping process.

The Current Study

The current study aimed to examine the effectiveness of self-assessment mind maps on students' self-efficacy in creativity, self-efficacy in learning English, and academic performance in English language tests. We hypothesize that the use of self-assessment mind maps in an English course can enhance students' self-efficacy in creativity (H1), self-efficacy in learning English (H2), or academic performance in English language tests (H3).

MATERIALS AND METHODS

Participants

A total of 55 students participated the study (male = 32, female = 23, $M_{\text{age}} = 9.26$, $SD_{\text{age}} = 0.63$, age-range = 8–11 years, grade = primary 4). One class with 24 students was randomly assigned to the experimental group, whereas the other class from the same grade with 31 students was assigned to the control group. The two classes were taught by the same teacher. Four students from the experimental group were excluded from analysis due to the lack of either posttest or post-survey data. As a result, the valid sample size for this study was 51 (experimental = 20, control = 31).

The Design and Procedure

A quasi-experimental design with intact classes in naturalistic settings was applied. The two classes were randomly assigned one of the two conditions: self-assessment mind map group (the experimental group) or no mind map group (the control group). The research procedure is presented in **Figure 1**.

Students' self-efficacy in creativity and self-efficacy in learning were assessed before and after the intervention. The pre-intervention survey was administered 2 days before the intervention, and the post-intervention survey was administered 3 days after the intervention. To minimize the teacher's and students' workload, we used students' performance on the school exams as the indicator of their academic performance. The exam used as the pretest was administered 2 weeks before the intervention, and the exam as the posttest was administered 1 week after the intervention. All participants received the same instruction from the same teacher during the 8-week intervention. Students in the experimental group were asked to complete the self-assessment mind map twice a week. In total, students completed 16 mind maps during the intervention. In contrast, students in the control group were not required to complete the mind map. To minimize the teacher's workload, the teacher was not asked to review nor provide feedback on students' mind maps. To reduce the possible noise to the experimental results, such as *Rosenthal effect* (Rosenthal and Jacobson, 1992), the research team told the teacher that this study is exploratory and the impact of the intervention is unknown.

This study was approved by the ethical review committee of the author's affiliated university. All participants, including the teacher, students and their parents/guardians, signed written consent forms.

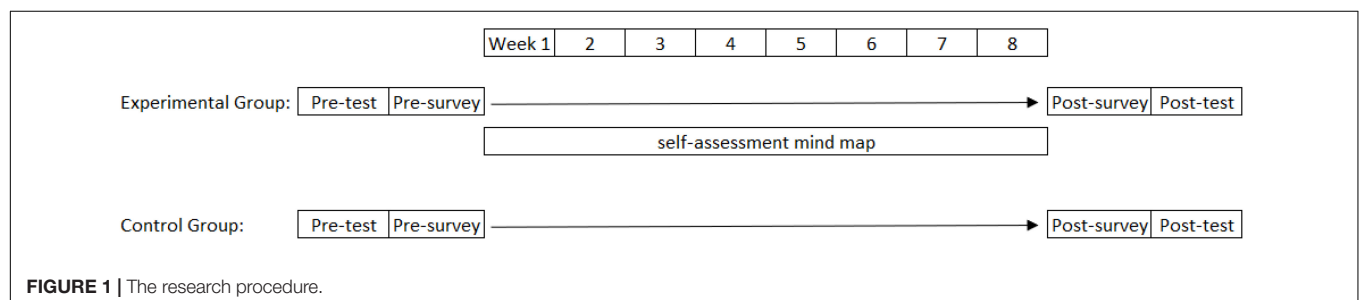


FIGURE 1 | The research procedure.

Measures

English Language Tests

For the sake of reducing workload for both the teacher and students, we used students' scores on the school exams as the indicator of their academic performance instead of using specifically designed tests.

Self-Efficacy in Creativity

Creative self-efficacy was measured by the scale *creative self-efficacy in English*, adapted from Beghetto et al. (2011). To better detect changes, creativity was set to be subject-specific rather than general. It was measured by five items (Cronbach $\alpha = 0.84$), with a sample item as "I have a lot of good ideas during English class."

Self-Efficacy in Learning English

Self-efficacy was measured by the *self-efficacy subscale* from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991), with seven items (Cronbach $\alpha = 0.86$). A sample item was "I am certain that I can understand the ideas taught in class." The items were designed in general, but the survey instruction was domain-specific. Participants were instructed to respond based on their learning experience in the subject of English. The questionnaire is attached in **Supplementary Appendix A** (English version) and **Supplementary Appendix B** (Chinese version).

The Self-Assessment Mind Map

A semi-structural mind map template was designed to maximize its learning benefits while minimizing teacher workload. The template integrated the self-assessment process model (Yan and Brown, 2017) as its generic structure across lessons, while maintaining its flexible and autonomous feature in content and format. Yan and Brown (2017) specified the self-assessment process into concrete and sequential actions. When engaging in self-assessment, students first determine a performance standard against which they will evaluate their learning process and outcomes in a lesson (i.e., *determining criteria*). They then reflect upon their learning and identify their strengths and weaknesses (i.e., *self-reflection*). Students may also take the initiative to seek additional resources or feedback for their learning (i.e., *feedback-seeking*) when their perceived learning resources are insufficient.

Corresponding to the three self-assessment steps, guiding questions were provided in the mind map template to facilitate students' reflection. One prompt (i.e., What is the study theme today?) was used to anchor students' self-assessment. It was not an assessment *criterion*, but it specified the scope for students' self-assessment. Two prompts (What have you learnt today? What confuses you?) were used to guide students to have more focused *self-reflection*. One prompt (i.e., Who/What can help you learn?) acted as a stimulus for students' *feedback-seeking* behavior. In addition to the guiding questions, an exemplar mind map with "animal" as the theme was provided to make students better understand what they were expected to do in the mind map. Two versions of mind map templates with different colors and progressive complexity were used to make them more attractive to students. The first version has four prompts, and the second version added one additional *self-reflection* prompt

(i.e., What tips can help you learn?) to stimulate reflection on their learning strategy. The first version was used for the first 4 weeks and the second version for the last 4 weeks. The mind map templates are attached in **Supplementary Appendix C**.

Apart from the basic structure, its content and format remain open to students, encouraging divergent thinking and creativity. Students at any ability level were free to create a mind map in their own way, simple or complex. Moreover, these mind maps were only used for the formative purpose, neither graded nor accounted for the final score. They were treated as alternative learning opportunities for students with adequate autonomy and minimal supervision.

Data Analysis

Within-group difference across time was examined using the paired *t*-test for the three outcome variables. To investigate between-group difference, three one-way analyses of covariance (ANCOVA) were conducted for the three outcome variables (Kenny, 1975; Gribbons and Herman, 1996), with pretest scores as covariates to account for the group difference before intervention. This was common in quasi-experimental design while the random assignment of participants was not feasible (e.g., Choi et al., 2014; Agboghorma, 2015; Reeves et al., 2017). SPSS 27.0 was used for all analyses.

RESULTS

Scale Quality

We examined the quality of scales used in this study before the primary analyses. Both the *self-efficacy in creativity* and *self-efficacy in learning English* scales had high reliability coefficients (see **Table 1**). The confirmatory factor analyses showed a good fit for both scales (see **Table 1**). All items loaded onto their respective latent constructs with factor loadings ranging from 0.404 to 0.865. All loadings were significant at $p < 0.05$. The item correlations and item-level statistics for both scales, which are available in **Supplementary Appendix D**, also demonstrated the high quality of the scales.

Within-Groups Comparisons

As shown in **Table 2**, students from the experimental group revealed a positive but non-significant change after the intervention for *self-efficacy in creativity*, whereas those from the control group had a significant decrease over time. As for *self-efficacy in learning English*, both groups decreased over time, with the experimental group showing a significant drop. Furthermore, compared with pretest, both groups significantly increased their *English language test performance* at posttest. The experimental group showed a larger gain than the control group, which had a lower pretest mean score. Graphic comparisons between pretest and posttest of the three dependent variables are shown in **Figures 2–4**.

Between-Groups Comparisons

Between-group differences were examined with one-way ANCOVA on posttest of *self-efficacy in creativity*, *self-efficacy*

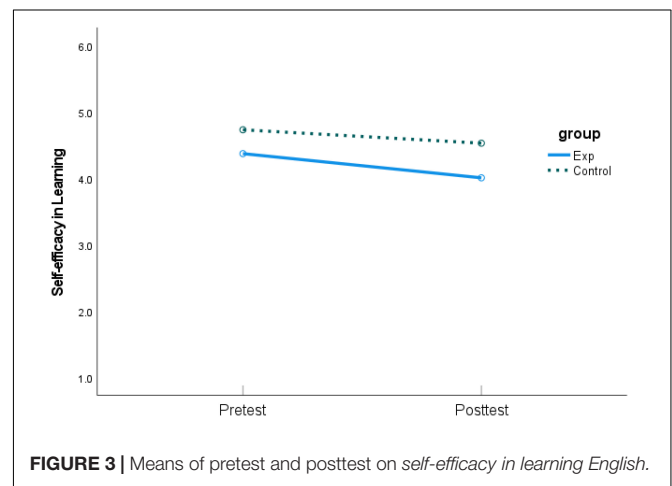
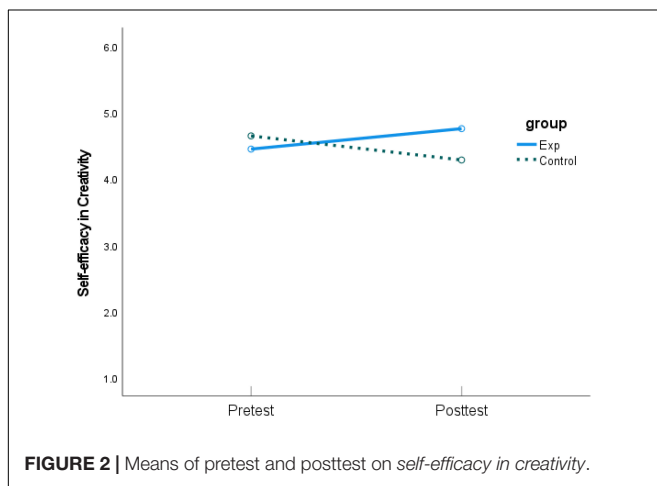
TABLE 1 | Goodness of fit in confirmatory factor analyses.

Scale	#	α	SRMR	CFI	TLI	RMSEA	χ^2	df	p
Self-efficacy in creativity	5	0.89	0.050	0.995	0.991	0.047	5.60	5	0.347
Self-efficacy in learning English	7	0.86	0.053	0.983	0.968	0.070	13.86	11	0.241

TABLE 2 | Pretest-posttest comparisons on learning outcomes.

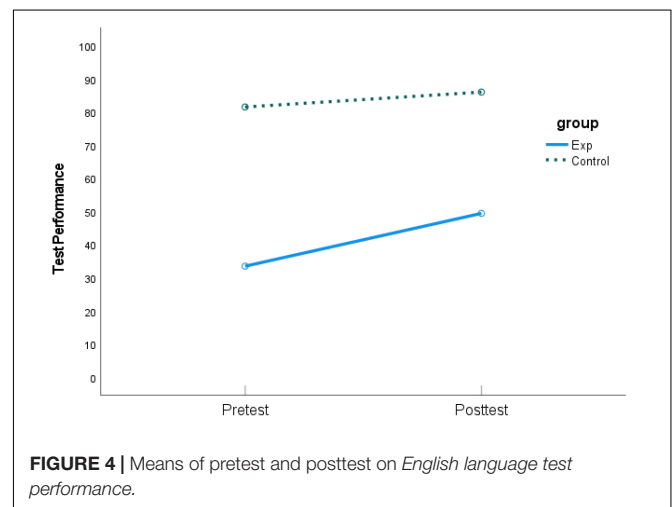
Measure		Pretest		Posttest		Mean difference		t	p
		M	SD	M	SD	M	SD		
Self-efficacy in creativity	E	4.47	1.13	4.75	0.98	0.23	1.09	0.93	0.36
	C	4.63	0.93	4.28	1.18	-0.37	0.89	-2.33*	0.03
Self-efficacy in learning English	E	4.37	1.05	4.01	1.04	-0.38	0.76	-2.23*	0.04
	C	4.71	0.68	4.53	0.84	-0.17	0.67	-1.40	0.17
English language test performance	E	33.44	13.95	49.39	14.81	15.94	9.08	7.45**	0.00
	C	81.23	7.62	86.03	6.36	4.50	8.58	2.88*	0.01

E standards for experimental group ($n = 20$); C stands for control group ($n = 31$); * is significant at 0.05 level; ** is significant at 0.01 level.



in learning English, and English language test performance, respectively, with pretest scores used as covariates to account for between-group differences before intervention. The assumption of the equality of error variances was checked via Levene's Test, and the data did not violate this assumption ($p = 0.61, 0.65, 0.11$, respectively). Moreover, the assumption of parallel lines was checked by adding an interaction term between group and pretest score (Keppel, 1991). Results showed that the interaction term was non-significant for both *self-efficacy in creativity* ($F[47,1] = 2.98, p = 0.091$) and *self-efficacy in learning English* ($F[47,1] = 0.07, p = 0.791$), but significant for *English language test performance* ($F[49,1] = 8.59, p = 0.005$). Accordingly, the interaction term was removed for the first two ANCOVA models, but kept and interpreted for the third one.

As shown in **Table 3**, for *self-efficacy in creativity*, the main effect of group was significant ($F[1, 48] = 4.30, p = 0.04$), indicating a significant difference between the posttest scores in the experimental group and the control group after controlling for pretest scores. As shown in **Table 4**, the parameter for group was 0.54 ($p = 0.04$), indicating the posttest score of *self-efficacy*



in creativity for the experimental group was 0.54 higher than that for the control group after controlling for the pretest scores, with a medium effect size ($\eta_p^2 = 0.08$) (Olejnik and Algina, 2000),

TABLE 3 | One-way ANCOVA on self-efficacy in creativity between two groups.

	Sum of Squares	df	Mean Square	F	p	η_p^2
Intercept	6.07	1	6.07	7.42	0.01*	0.13
Pretest	19.95	1	19.95	24.37	0.00**	0.34
Group	3.52	1	3.52	4.30	0.04*	0.08
Error	39.28	48	0.82			

R Squared = 0.362 (Adjusted R Squared = 0.335); * is significant at 0.05 level; ** is significant at 0.01 level.

supporting H1. The results in **Table 5** showed that the main effect of group was non-significant for *self-efficacy in learning English* ($F[1,48] = 2.45, p = 0.12$), indicating the non-significant difference between the posttest scores after controlling for pretest scores. Thus, H2 was not supported. The results in **Table 6** showed that the interaction term between group and pretest was significant for *English language test performance* ($F[49,1] = 8.59, p = 0.005$), indicating the effect of intervention varies based on different pretest scores. The main effect of group was significant for *English language test performance* ($F[1,49] = 10.50, p = 0.002$), indicating a significant intervention impact for students with average pretest scores. As shown in **Table 4**, the impact is negative ($b = -47.24$ while pretest = 69.89), not supporting H3. However, as shown in **Table 2** and **Figure 4**, both groups improved in the *English language test performance* at posttest, and students in the experimental group exhibited a larger gain in posttest scores than students in the control group. The difference in slope may be due to a ceiling effect for the control group, resulting in a narrower range of improvement. In summary, given the impact of the intervention on *English language test performance* was conditional on pretest scores, this finding remains inconclusive for H3.

DISCUSSION

This study designed a simple, relatively cost-efficient instructional intervention, i.e., the self-assessment mind maps, and examined its effect on students' self-efficacy in creativity, self-efficacy in learning English, and academic performance in English language tests. The most promising finding is that

students from the experimental group had a positive change in self-efficacy in creativity after the intervention, whereas those from the control group experienced a significant decrease over time (see **Figure 2**). The difference between the experimental and control group was statistical significance after controlling for pretest difference, supporting H1. This finding is consistent with previous studies (e.g., Wang et al., 2010; Hwang et al., 2012; Malycha and Maier, 2017) that reported a positive impact of mind mapping on students' higher-order abilities, and provides further credits to the mind mapping strategy as we focused on an understudied outcome, i.e., self-efficacy in creativity. Mind mapping as a form of visual technique enhances the processing depth of the subject matter and links diverse aspects to each other in a meaningful and constructive way (Malycha and Maier, 2017). As explained by Liu et al.'s (2014) meta-analysis of 52 studies, referring to cognitive load theory (Miller, 1956; Sweller et al., 1998), mind maps enable students to acquire knowledge easier and clearer, reduce their working load, and allow them to use higher-level schemas in an active and constructive way for the development of intellectual skills. Self-assessment mind-maps, which this study introduced in English language learning, provided personal and contextual sources for students' creative self-efficacy formulation (Gist and Mitchell, 1992) and deepened students' beliefs about their ability to engage in creative activities. It is possible that the minimum constraints on the creation process evoke divergent thinking and unleash creativity. In addition, the flexibility and autonomy granted by the creation process, along with the absence of summative consequences in its product, cultivate a sense of control in students, thus improving their self-efficacy. With a stronger sense of self-efficacy in creativity, students are more likely to attribute their success in creative activities to the personal efforts they exerted.

The increase of experimental group students' self-efficacy in creativity can also be explained by their performances in the mind maps. Firstly, the artistic elements increased in their mind maps. At the beginning of the intervention, all students used words exclusively to express their ideas. However, starting from the 3rd week, students had increasingly mixed text, symbols, and pictures in their mind maps. Past studies showed that the use of artistic elements in mind maps, such as combining text and picture, was related to a higher level of originality

TABLE 4 | Summary of parameters of one-way ANCOVA on three outcome variables.

	Parameter	B	Standard error	t	p	η_p^2
Self-efficacy in creativity	Intercept	1.35	0.61	2.20	0.03*	0.09
	Pretest	0.63	0.13	4.94	0.00**	0.34
	Group	0.54	0.26	2.07	0.04*	0.08
Self-efficacy in learning English	Intercept	1.19	0.55	2.17	0.03*	0.09
	Pretest	0.71	0.11	6.27	0.00**	0.45
	Group	-0.31	0.20	-1.57	0.12	0.05
English language test performance	Intercept	69.89	13.99	5.00	0.00**	0.89
	Pretest	0.20	0.17	1.16	0.25	0.45
	Group	-47.24	14.58	-3.24	0.00**	0.33
	Group*Pretest	0.60	0.21	2.93	0.01*	0.18

* is significant at 0.05 level; ** is significant at 0.01 level.

TABLE 5 | One-way ANCOVA on self-efficacy in learning English between two groups.

	Sum of squares	df	Mean square	F	p	η_p^2
Intercept	1.75	1	1.75	3.91	0.05	0.08
Pretest	17.61	1	17.61	39.30	0.00*	0.45
Group	1.10	1	1.10	2.45	0.12	0.05
Error	21.50	48	0.45			

*R Squared = 0.496 (Adjusted R Squared = 0.476); * is significant at 0.05 level.*

TABLE 6 | One-way ANCOVA on English language test performance between two groups.

	Sum of squares	df	Mean square	F	p	η_p^2
Intercept	2059.34	1	2059.34	40.26	0.00**	0.89
Pretest	1207.42	1	1207.42	23.61	0.00**	0.45
Group	536.91	1	536.91	10.50	0.00**	0.33
Group*Pretest	439.62	1	439.62	8.59	0.01*	0.18
Error	2506.31	49	51.15			

*R Squared = 0.888 (Adjusted R Squared = 0.881); ** is significant at 0.01 level.*

and creativity (Mento et al., 1999; Dong et al., 2021). The use of various colors, pictures, or words in mind maps not only facilitate thinking and analyzing, but also enhance originality and creativity among children (Wang et al., 2010; Dong et al., 2021). Secondly, the connections between knowledge points in mind maps were becoming increasingly complex with time. In the beginning, students only wrote words or sentences around the first-level concepts (e.g., what have you learnt today? What confuses you?). When students were more familiar with the mind maps, they tended to demonstrate their understanding of the idea hierarchy. For example, for the learning theme “mini writing,” some students proposed “interview” as the first-level concept under which they further proposed “interviewer/interviewee,” or “questioning/answer,” as the second-level concept. In this sense, mind mapping appears as a better strategy to facilitate a more precise understanding of the idea hierarchy and knowledge network (Leeds et al., 2019). With this strategy, students were more likely to generate more profound and unique responses and develop their critical thinking skills (Long and Carlson, 2011).

However, the impact of mind mapping on students’ self-efficacy in learning English and academic performance in English language tests were not significant. The results showed that students in both groups had improved their English language test performances from pretest to posttest. The magnitude of change of students from the experimental groups was larger than that of students from the control group. The experimental group benefited to a great extent from self-assessment mind maps to reach a marginally satisfactory level of academic performance (M_{exp} increased from 33.44 to 49.39). However, the between-group difference was not statistically significant, not supporting H2. Students’ self-efficacy in learning English from both groups decreased from pretest to posttest, not supporting H3.

As reminded by Liu et al.’s (2014) meta-analysis, the effectiveness of mind mapping varied across contexts, and the positive impact was not guaranteed. There are three viable

explanations for the non-significant results in self-efficacy in learning English and academic performance in English language tests. Firstly, in most studies using mind maps, teachers were intensively engaged in the design and implementation of the mind maps. Often they provided feedback to students’ self-assessment as demonstrated in the mind maps and used the generated insights for subsequent instruction. For the current study, students were required to perform “self-reflection” and “feedback-seeking” (i.e., identify their strengths and weaknesses in the lesson and identify additional resources for help and feedback). Since we did not ask the teacher to review the mind maps or provide feedback to students’ self-assessment for the sake of minimizing teacher workload, there was no monitoring system to ensure that students’ roles were fulfilled as expected. Teachers’ involvement and feedback in this regard could be deemed useful in enhancing student learning (Miller and Geraci, 2011). Though the approach to minimize teacher workload makes our intervention more likely to be sustainable, this is probably with a price of reduced impact on student learning. Secondly, most studies (e.g., Lan et al., 2015; Fu et al., 2019) showing the significant effect of mind mapping on learning the English language shared one common feature: they used tests specifically designed for the studies and focused on the targeted teaching content. The English language pretest and posttest scores used in this study were collected from regular school-based assessments, instead of specifically designed tests. The unfocused tests may blur the real impact of the mind mapping strategy. Thirdly, the intervention period in this study was relatively short (i.e., 8 weeks). As reported in Liu et al.’s (2014) meta-analysis, the time students are exposed to the mind mapping is important in determining the effectiveness of the mind mapping strategy. Mind mapping interventions lasting for 3–6 months were substantially more effective than those lasting for only 1–2 months. This was because the link between mind mapping interventions and observable learning improvements might not be direct, but mediated by other factors. A likely mechanism is that the intervention invokes motivational predictors, such as self-efficacy, which are inner drives of student learning. The inner drives have to result in high-quality behavioral engagement in learning and the use of adaptive learning strategies which, in turn, lead to learning improvements (Skinner, 2016). Each link in this chain takes time.

Implications and Future Directions

The current study aimed to design a simple and relatively cost-effective instructional intervention and test its effectiveness in improving students’ academic performance, self-efficacy in creativity and learning in the English learning context. The results identified a desirable pattern: students using self-assessment mind maps had larger positive changes on self-efficacy in creativity (with statistical significance) and academic performance. Note that many factors have the potential to enhance the intervention effect, such as teacher assessment literacy (Wu et al., 2021a), teacher feedback (Yang et al., 2021), and school support (Yan, 2021). Since this intervention was intentionally designed with a minimum requirement of teacher workload, those factors have not been manipulated in this study.

Given the promising finding, the intervention is worthwhile to further trials in classrooms. If future studies could duplicate similar results of this study, it will provide further credentials to the self-assessment mind map as a sustainable intervention. It could be reasonable to expect a more significant impact if future studies use more teacher input, such as feedback on the mind maps, or a longer intervention period.

Despite the theoretical benefits of the self-assessment mind map strategy, appropriate design and implementation are crucial to bringing its benefits into practice. One of our observations was that it is crucial but challenging to maintain students' interest in completing the mind maps. The quality of students' mind maps decreased, as indicated by the number of words and the complexity of drawings in the mind maps, when approaching the end of the intervention. Even though we designed two different mind map templates, students lost their freshness after three or four attempts. Teachers need to consider this issue in designing and using self-assessment mind maps in future. The mind maps should be attractive to students taking into account various factors, such as the subject areas, learning topics, and student characteristics.

Another relevant direction is to apply the mind mapping strategy with the support of digital technologies. Scholars (e.g., Liu et al., 2014; Hazaymeh and Alomery, 2022) suggested that applying mind mapping using software or an application led to more learning gains. It is likely because digital technologies make mind mapping an interactive fun-filled activity that enhances students' motivation and satisfaction (Rosba et al., 2021). Another advantage of digital mind mapping is that it facilitates collaborative work in small groups (Wang, 2019) so that the idea exchange and brainstorming among group members can further stimulate students' creativity. Also, collaborative mind mapping is likely to be more effective in enhancing students' academic performance and self-efficacy (Zheng et al., 2020).

Limitations

This study has its limitations mainly related to the sample size and characteristics. Firstly, although the two groups were randomly assigned to conditions, students were not randomly assigned to groups. It turned out that there were substantial differences in the baseline performances between the two groups on the English language test. The non-equal baseline performances might influence the intervention effect and, therefore, the interpretation of the results should be cautious. Secondly, the sample size for each group was small, which reduced the statistical power to detect significant differences. Future studies need to consider applying randomized controlled trials design with larger sample sizes.

CONCLUSION

As a response to the call for sustainable interventions for developing higher-order abilities, this study presents a simple,

relatively cost-effective instructional intervention, i.e., self-assessment mind maps, and examines its effect in a naturalistic learning environment. This intervention synergizes the principles of mind mapping and self-assessment and requires minimum teacher workload. The results supported Hypothesis 1, i.e., self-assessment mind maps enhanced students' self-efficacy in creativity. It is possible that self-assessment mind maps, on the one hand, developed a sense of control in students by offering flexibility and autonomy in the creation process. On the other hand, it provided personal and contextual scaffolds for the formulation of students' self-efficacy in creativity. However, the intervention did not improve students' self-efficacy and academic performance in English learning, not supporting Hypotheses 2 and 3. The non-significant results may be attributed to the absence of teacher feedback to students' mind maps, the lack of a specifically designed test focusing on the targeted teaching content, and the short intervention period. We urge future studies to test this intervention further using the randomized controlled trials design with larger sample sizes. With the limitations in mind, the findings of this study shed light on designing sustainable instructional strategies for empowerment in creativity.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Human Research Ethics Committee, The Education University of Hong Kong. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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SUPPLEMENTARY MATERIAL

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The Design and Development of the Internet-Based System for Testing and Analyzing the Psychological and Physiological Responses During Creative Learning

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An Internet-based system for testing and analyzing psychological and physiological responses during creative learning was developed using virtual instruments based on microcomputer interfaces and network communication technologies. The system can be used to study and evaluate innovative learning processes and performance at the psychological and physiological levels. This paper presents the design, implementation, and application of the system.

Keywords: creative learning, psychological and physiological information, virtual instrumentation, data collecting, galvanic skin response, cognitive

INTRODUCTION

Creative learning is becoming increasingly important in contextual education and twenty first century skills; creativity is one of the skills that keep individuals abreast of current, rapidly evolving technologies and functions as one of the priority skills.

The existing literature shows that the effect of stress on creative learning performance is an inverted U-shaped (curved) relationship. This suggests that a certain level of stress helps learners maintain focus on creative learning tasks through arousal. A review of previous research on the relationship between stress and creativity confirms the existence of negative, positive, and curvilinear relationships between the two. Cognitive, affective, and behavioral engagement are important processes for creativity (Drazin et al., 1999), and moderate levels of activation lead to maximum creativity (Byron et al., 2010).

There has been consistent research on the effect of stress on creative learning task performance, but previous studies have not reached a majority consensus on this relationship. Some studies insist that stress has a positive effect on creative learning task performance; however, others even suggest opposite results or even a curvilinear relationship (Jamal, 1984, 1990). Sometimes, these contradictory results arise from a focus on different types of stress (e.g., challenge stress and hindrance stress) or the difficulty level of the task.

An alternative account of the relationship between stressors and creativity has been proposed by some researchers (Avey et al., 2012), namely, that the relationship between stress and creativity is curvilinear (Yerkes and Dodson, 1908). Activation theory (Gardner, 1986) suggests that stress can improve performance to some extent, but too much activation can limit performance, especially for complex tasks such as creative tasks. Individuals are likely to be most creative at moderate levels of activation. Moderate levels of activation increase task engagement and lead to optimal

use of cognitive resources by reducing negative affect (Gardner, 1986; Baer and Oldham, 2006). Conversely, too little or too much activation may bring about a lack of engagement and cognitive interference that may interfere with performance on cognitively demanding tasks. Given that cognitive, emotional, and behavioral engagement is an important process for creativity (Drazin et al., 1999), moderate activation leads to maximum creativity (Byron et al., 2010). Furthermore, most studies on challenge stress have analyzed subjects' perceived levels of stress, but physiological approaches have not been widely tried.

Stress in creative learning can be measured both psychologically and physically. Psychological assessment of stress responses can be measured and assessed in terms of perceptual, behavioral, and physical responses. The assessment of perceived responses to stressors involves subjective estimates and perceptions. Self-reported questionnaires have been the most commonly used tool to measure stress (Cohen, 1988). For a long time, research and evaluation of learners' stress, emotions, and academic performance during creative learning still mostly use questionnaires and expert scoring, and there are still large gaps in the collection and evaluation of student information, ignoring information on emotions, mental activity, and changes in attention during creative learning, resulting in a lack of objective evidence that is difficult to control and quantify. The physiological response to stress has two components: a physiological response indicating central-autonomic activity and a biochemical response involving changes in the endocrine and immune systems (Rosch, 1997).

Stress induces changes in autonomic physiological function (Van de Kar and Blair, 1999). GSR is a measure of skin electrical resistance. The transient increase in skin conductivity is proportional to sweat secretion (Darrow, 1964). Thus, whenever a person is stressed, sweat gland activity is activated and increases skin conductivity. Since sweat glands are also under the control of the SNS, skin conductivity functions as an indicator of sympathetic activation due to stress response.

Many attempts have been made to detect human psychological and physiological states by employing various physiological sensors (Andreassi, 2007; Enderle and Bronzino, 2012). Brain waves (or electroencephalogram; EEG) and heart rate variability (HRV) have been frequently introduced to assess human psychophysiological states, while other bioelectrical signals, such as skin temperature (Nozawa and Uchida, 2009) and skin conductivity (or electrical skin activity; EDA) (Healey and Picard, 2005), have recently been included in the list of physiological measurements.

According to modern cognitive psychology and psychophysiology, by observing and measuring various physiological responses of learners during creative learning, information on emotional responses, attentional changes, and cognitive processing during creative learning can be captured and used as objective evidence for creative learning research. GSR is a variation of skin electrical resistance. It is determined by passing a weak current through the skin and measuring the change in current or by measuring the current generated by the body itself. GSR has been reported to be associated with emotion, attention and stress (Mohan et al., 2011). The relationship

between GSR and attitudes, empathy and social interactions, especially with small groups, has been shown in Prokasy and Raskin (1973). In this study, using the latest achievements in modern medicine and physiology, through microcomputer interfaces and network communication technologies as well as virtual instrumentation, we will develop and design an Internet-based psychophysiological response testing and analysis system for creative learning, which will be used to record various physiological data and real-time performance of student participants during creative learning in real time. By analyzing these signals, this system can be used to investigate the relationship between different stress levels and performance on different creative learning tasks.

This paper focuses on the design of the system, its hardware and software and their respective implementations.

THE DESIGN OF THE HARDWARE IN THE SYSTEM

The system mainly consists of three parts: creative learning environment subsystem, physiological signal acquisition and processing subsystem, and synchronous recording subsystem, which can be arranged according to the requirements of creative learning activities carried out and the conditions of the laboratory, as shown in **Figure 1**.

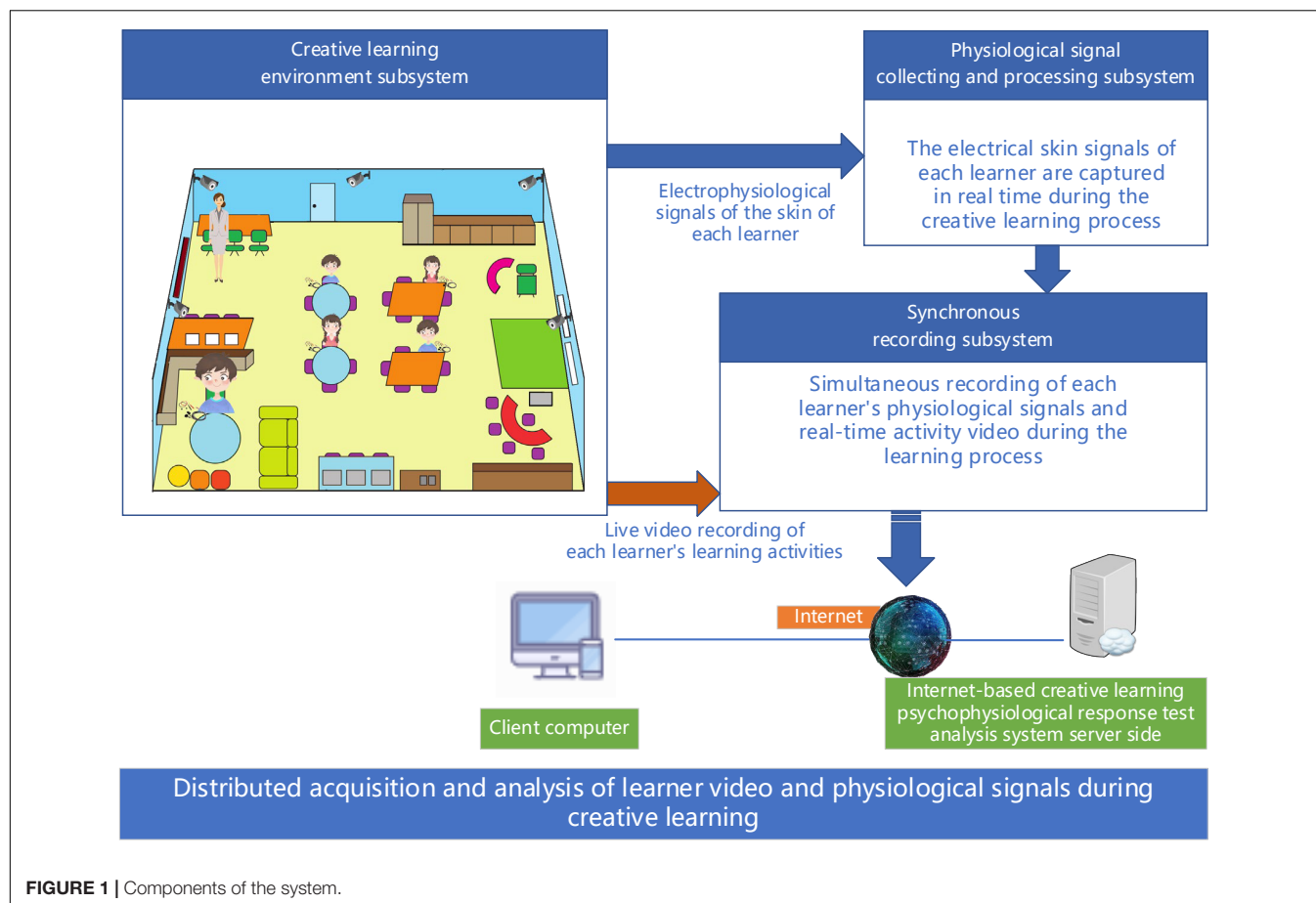
Creative Learning Environment Subsystem

This subsystem is the main creative learning environment, including all kinds of hardware and software needed to carry out creative learning activities. The learning environment should support students whether they are working in small groups, pairs, or individually. High tables, low tables, round, and square tables—a variety is preferable. Anything hung in the classroom should be meaningful and support learning. Each space in the Creative Learning Environment sub-system should be carefully designed and organized to create a creative learning environment in which students can engage in creative learning and complete creative learning tasks.

Learners wear electrical skin sensors on their fingers (as shown in **Figure 2**), and as they complete creative learning tasks, their electrophysiological skin signals are transmitted to the physiological signal acquisition and processing subsystem. At the same time, a video recording of each learner's creative learning process is synchronized by a camera and sent to the synchronized recording subsystem along with the learner's skin electrophysiological signals.

Physiological Signal Collecting and Processing Subsystem

The subsystem consists of software and hardware components. It is used to implement the analog-to-digital conversion of physiological signals, and to display, store, analyze and process these physiological signals. The software part is used for the collection, storage, analysis, and processing of the physiological



signals (as shown in **Figure 3**). The hardware part of the subsystem consists of a collector, a multimedia computer and a printer. The UA301 data collector is used for the analog-to-digital conversion of physiological signals such as electrical skin responses. The multimedia computer installs software for

collecting, analyzing and displaying physiological signals during the learner's creative learning process. The printer is used to print the results of the analysis and processing.

Synchronous Recording Subsystem

This subsystem mainly includes video monitors, video recorders, etc., which are used to record the creative learning process, various physiological signals of students and students' expressions in real time and synchronously. **Figure 4** shows a learner's creative learning process, psychophysiological response signals, and facial expressions recorded by the synchronous recording subsystem during a creative learning session.

THE SOFTWARE DESIGN AND IMPLEMENTATION IN THE SYSTEM

The system is developed by means of virtual instrumentation technology, with LabVIEW2019 as developing tool on Windows (Ehsani, 2016; Shalgar and Bindu, 2022).

Introduction to the Virtual Instrumentation and Its Developing Tools

Virtual instrumentation integrates computer hardware resources with instrumental hardware via software, resulting in the

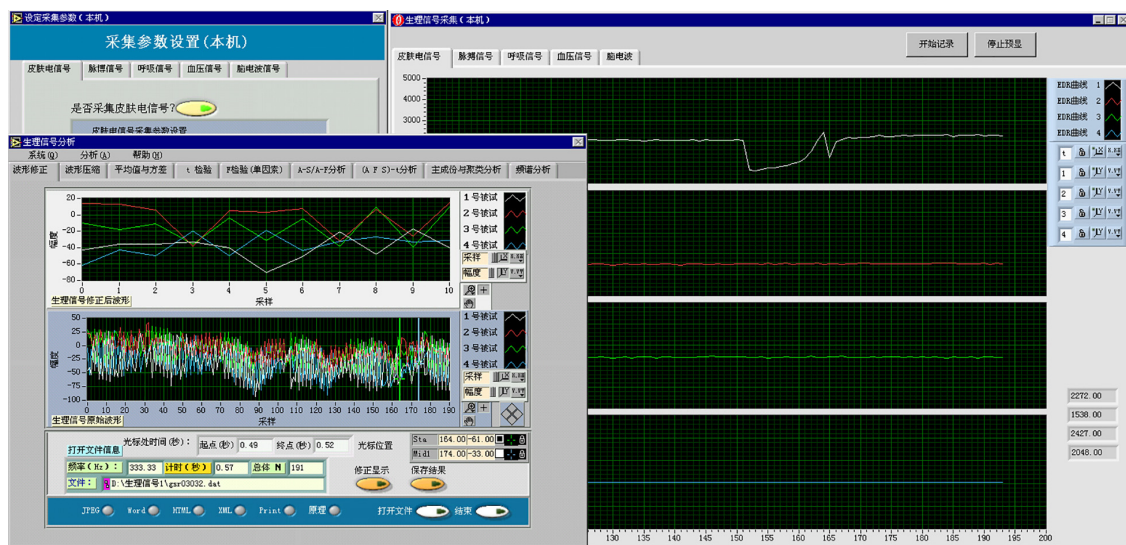


FIGURE 3 | Physiological signal acquisition and processing program (software runtime interface).

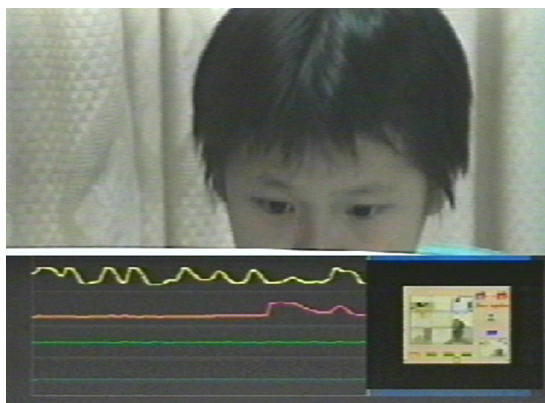


FIGURE 4 | A simultaneous recording of a learner's creative learning process, psychophysiological response signals, and facial expressions.

incorporation of the powerful computing and processing capabilities of the computer with the measuring and controlling capabilities of the instrumental hardware, thus greatly reducing the cost and volume of the instrumental hardware, and achieving data display, storage and analysis via software. Users can operate the computer with user-friendly graphic interfaces to collect, analyze, judge, display, and store the tested indexes. In the virtual instrumentation system, any user can easily alter, add or delete the functions and scopes of the system by modifying the software.

Among numerous virtual instruments developing software, LabVIEW by NI Company is a kind of graphic programming software designed for data collection, instrumental control, data processing, and data displaying. Compared with other software-developing environment, it possesses such obvious advantages as high developing efficiency, graphic programming, fast-generating models, modularized design, numerous graphic

user interfaces, embedded database and toolbox, open structure, and good expandability.

Functional Module Design of the Software

The system involves seven functional modules: testing configuration, physiological signal collecting, distributed physiological signal collecting, physiological signal redisplaying, physiological signal analyzing and processing, report generating and printing, help, as shown in **Figure 5**.

The Module for Testing Configuration

This module mainly achieves the testing configuration before collecting physiological signals, and generates the testing configuration report.

User can create a testing configuration file with the help of the guide and generate the file in Word format, including test number, test name, test purpose, parameters to collect, experimental object, path to store the physiological signal recording file, experimenter, testing date, and remarks.

User can collect data according to the default parameters, or collect data by opening existing configuration file.

The Module for Physiological Signal Collection

The module is used to real-time collect, synchronously display and real-time record physiological signals.

According to the settings in the testing configuration file, the physiological signals from the sensing system will go through the simulative-digital transformation with UA301 data collector. With the module, physiological signals can be collected, synchronously displayed, and stored in a hard disk if needed for further analysis.

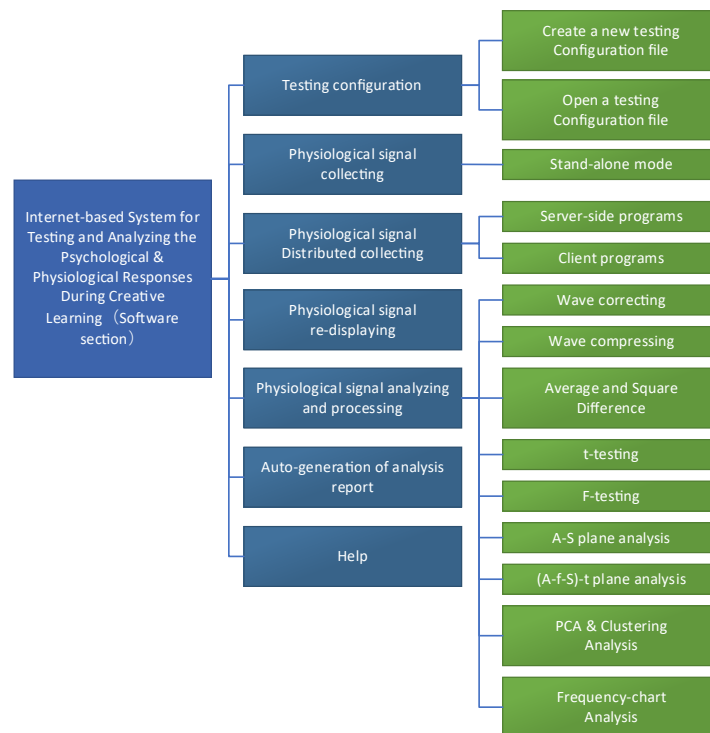


FIGURE 5 | Functional modules of the software.

The Module for Distributed Physiological Signal Collection

Adopting C/S mode, the module achieves the distributed remote collection of the Internet-based physiological signals with Data Socket protocol developed by NI Company.

Client end can define collecting parameters of the Server end (type of the physiological signals, collecting channel, sampling frequency and the amplifying times for the sampled signals), and the location to store the physiological signals of the Client end and the Server end, finally achieving the distributed remote collecting of the physiological signals via network.

The Module for Physiological Signal Re-displaying

The module is used to re-display the stored physiological signal recording files to analyze waves of physiological signals afterward, in combination with the synchronously recorded video contents. User can modify the displaying speed to fast re-display, slow re-display, or normally re-display (i.e., at the speed of signal collecting).

The Module for Analyzing Physiological Signals

The module mainly provides various means to analyze and process physiological signals, including wave correcting, wave compressing, average and square difference, *t*-testing, *F*-testing, A-S plane analysis, (A-f-S)-t plane analysis, Principal Component Analysis (PCA) and Clustering Analysis, Frequency-chart Analysis.

The Module for Generating and Printing Reports

The module is integrated with the above five modules to generate analysis reports in various formats such as Word or Excel and to store the analyzed results such as waves or tables in different formats or directly print the resulted various graphs, tables, and/or waves or to store each object on the screen in different graphic formats according to user's requirements.

The Module for Help

The module is also integrated with the above modules, and required helps are available anytime.

The Implementation of the Software

The following section will introduce the implementation process of the software by illustrating the server end of the module for distributed physiological signal collection.

The properly collection of physiological signals is the prerequisite to conduct the application study of physiological indexes and determines the subsequent analysis of these signals, therefore, the proper collection of physiological signals is the key to the system. The integration of virtual instruments with network technology to form the distributed networked the virtual instrument system is one direction of the virtual instrument system development. There are mainly two basic models to create Internet-based distributed remote virtual intelligent testing system: C/S model and B/S model. This system mainly adopts C/S model to achieve Internet-based distributed remote collecting and monitoring of physiological signals.

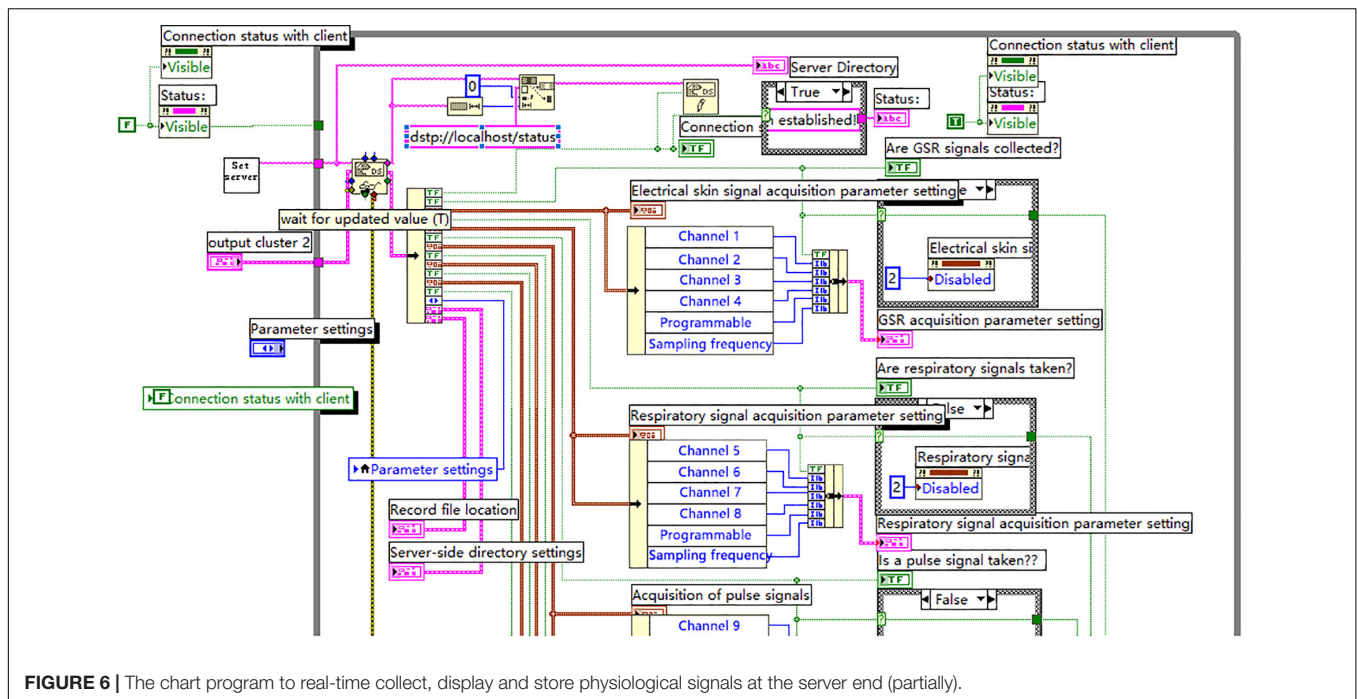


FIGURE 6 | The chart program to real-time collect, display and store physiological signals at the server end (partially).

Description of the Function

The distributed physiological signal collecting and monitoring in the system is mainly for the remote computer to collect and monitor physiological signals at the server end via the network. The client end defines parameters for the server end to remotely collect physiological signals which can be stored in the server end or the local client end, or it simply monitors the waves of physiological signals being collected at the server end.

Flow Chart of the Program (Omitted)

Implementation of the Programming

The system adopts DataSocket of LabVIEW to achieve the Internet-based distributed remote collection of the physiological signals.

DataSocket (DS) provides a single interface which can be used by various programming languages and multiple types of data communication. There are two functions in LabVIEW to receive and distribute data: DataSocket Read and DataSocket Write. The program to distribute data automatically transforms user's data into byte flow transferring on the network via DataSocket Write, while the data-receiving program reverts the byte flow into its original data type via DataSocket Read.

① The Program Design for the Server End

DS function adopts DSTP (DataSocket Transfer Protocol) developed by NI to communicate with DS server. In order to start the remote collection of physiological signals, it's necessary to first determine the address of DS server, such as `dstp://192.168.7.89/daqset`, where `daqset` is data label used to determine the address of specific data item on DS server. In practical application, the address at the server end must be identical with the address where the Client needs to access so

as to establish connection to achieve the remote collection and monitoring of physiological signals.

When the communication between the collecting program at the server end and DS server is established, the Client can begin to define the parameters for physiological signal collection at the server end. At this point the Client sends data to the Server via the function of DataSocket Write, while the server captures the data for parameter setting from the Client via the function of DataSocket Read.

② The Program Chart for the Server End

Figure 6 partly shows the program to real-time collect, display and store physiological signals. In the program, the secondary VI, i.e., SetServer, is designed to start DS server in order to establish the communication between the collection programs for the physiological signals at the server end with DS server.

CONCLUSION

It has been shown that stress negatively affects creativity by reducing the demand for cognitive resources that are not available for creative thinking, and that people adopt simpler cognitive strategies that may undermine creativity (Byron et al., 2010). Some theories suggest that stress is positively related to creativity. Stress leads to creative thinking and motivates people to find solutions to problems (Nicol and Long, 1996; Anderson et al., 2004). If individuals are exposed to stress, they may use problem-solving strategies, which can increase creativity (Bunce and West, 1994). Stress can positively influence creativity by requiring creative solutions and providing cognitive stimulation and motivational stimulation for creative thinking (Deary, 1996; Anderson et al., 2004). Some researchers have

proposed an alternative scenario for the relationship between stress and creativity (Avey et al., 2012), in which stress is curvilinearly related to creativity (Yerkes and Dodson, 1908). Activation theory (Gardner, 1986) assumes that stress can increase performance up to a certain threshold, but too much activation can limit performance, especially for complex tasks, such as creative tasks. Individuals are likely to be most creative at moderate levels of activation. Moderate levels of activation increase task engagement and optimize the use of cognitive resources by reducing negative effects (Gardner, 1986; Baer and Oldham, 2006). Conversely, too little or too much activation may lead to lack of engagement and cognitive interference that may interfere with performance on cognitively demanding tasks. Given that cognitive, emotional, and behavioral engagement are important processes for creativity (Drazin et al., 1999), moderate activation leads to maximum creativity (Byron et al., 2010). The system developed in this study is capable of dynamically acquiring and analyzing psychophysiological data of students during creative learning, while measuring cognitive, behavioral, psychological, and physiological indicators of learners during the creative learning process. Extending the study of creative learning processes and performance to the physiological level and providing advanced support environments, measurement tools, and analysis methods, it breaks through the limitations of creative learning research in collecting information on learners' cognitive, psychological, and emotional responses only through questionnaires and

self-assessments. Using this system, the impact of learners' psychophysiological responses to creative learning tasks during creative learning can be studied, for example it is used to study the changes in students' psychophysiological states during the process of solving real-life inferior problems, and to provide teachers with assistance in designing interventions that can effectively enhance students' real-life problem-solving and creative skills.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The individual(s) provided their written informed consent for the publication of any identifiable images or data presented in this article.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Knowledge Sharing Types as Predictors of Job Performance Mediated by Problem-Solving Self-Efficacy in the Information System Integration Service Industry

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Knowledge sharing is an essential approach to creative problem solving in technology firms, but few studies have considered the information system integration service industry. To address this gap, drawing on the micro-ecology theory, we developed a research model to explore the mediating role of four types of knowledge sharing (i.e., automatic response, rational reflection, ridiculed reflection, and stolen reflection) in the relationship between problem solving self-efficacy (PSSE) and IT workers' job performance. Data were collected from 307 System Integration IT workers by using the snowball sampling method via a Google questionnaire. Structural equation modeling was used to test the hypotheses of the relationships between the variables. The results showed that PSSE can positively predict four knowledge sharing types; except for stolen reflection, the others can positively predict job performance. The implication of this study is that automatic response systems and rational reflection systems in knowledge sharing can enhance job performance, supported by PSSE. It is hoped that managers can generate System Integration workers' rational reflection to effectively evoke knowledge sharing.

Keywords: problem solving self-efficacy, knowledge sharing, job performance, information technology, self-monitoring theory, system thinking, micro ecological system

INTRODUCTION

In the information industry, knowledge sharing has become an essential approach to efficiently solving technical problems (Tamjidyamcholo et al., 2013; Whitelock-Wainwright et al., 2020). According to the social exchange theory (Blau, 1964), knowledge sharing in an organization cannot only result in finding solutions efficiently, but can also lead to a cooperative tendencies. With cooperation among team members, knowledge sharing can be facilitated (Coun et al., 2019). In line with this, how to promote knowledge sharing in a team or organization to enhance employees' performance has been studied, and a positive relationship has been found between them (e.g., Tseng and Huang, 2011; Swanson et al., 2020). Employees are required to manage knowledge flows in order to find a balance between cooperative knowledge sharing and competitive knowledge protection (Gast et al., 2019). It has been found that individual job performance is

influenced by reflection upon knowledge sharing and knowledge protection (Oliveira et al., 2019). Job performance is linked with employees' ability to achieve assigned works (June and Mahmood, 2011), that can promote the competitiveness of an information technology corporation (Pavithra and Deepak, in press). However, few studies have focused on how different types of knowledge sharing affect employees' job performance in the information technology (IT) domain; thus, the present study focused on exploring the role of knowledge sharing in job performance.

In mental processes and output, Kahneman (2011) proposed "think fast and slow" as dual cognitive process systems: the automatic response system and the reflective thinking system. Moreover, Hong et al. (2012) applied the eight trigrams (BaGua) to explain reflective thinking in rational or logical reasoning as the Li trigram in the Chinese Yi-Ching ideology, and indicated that the Kan trigram is on the other side of reflective thinking in emotional reasoning. That is, Hong et al. (2004) divided reflection into rational reflection and affective reflection. Furthermore, according to the *I'm OK, You're OK* theory (Harris, 2004), there are two factors which influence knowledge sharing: opportunistic and self-interested thinking (Estrada et al., 2016). Jiang et al. (2015) explained that people with an opportunistic tendency worry that their ideas will not be accepted or will be ridiculed during knowledge sharing. On the other hand, people with a self-interested tendency want to prevent their ideas from being stolen. Considering this, ridiculed reflection and stolen reflection can be included in the four types of knowledge sharing. However, Scheibehenne and von Helversen (2015) pointed out that knowledge sharing is a kind of multi-attribute decision. Some studies have focused on the factors that affect knowledge sharing, for example, leadership style (Chaudhary et al., 2021), leadership competency (Swanson et al., 2020), and organizational culture (Venkatesh et al., 2022). However, few studies have taken the four types of knowledge sharing as perspectives of organizational practice; thus, the present study extended from Kahneman's (2011) types of system thinking to develop four processes when individuals are involved in knowledge sharing: automatic response, rational reflection, ridiculed reflection, and stolen reflection.

In line with social exchange theory (SET) (Blau, 1964; Bronfenbrenner, 1979) introduced a micro ecological system for discussing the person-process-content relationship. Individuals sharing ideas with others can improve their performance. In the information system integration service, based on the person-process-content model, employees' problem-solving efficacy when facing a high degree of competition to solve problems in time (Cui, 2017) can prevent them from sharing or promote them to share their knowledge. Technological change increases the number of non-routine jobs and exception tasks which require more problem-solving in information technology related occupations (Reijnders and de Vries, 2018). Software engineers need to be involved in the co-alignment of processes, routines, and practices to manage product, service, and software integration with smart solutions (Huikkola et al., 2021), particularly in the information system integration service industry. Furthermore, to address the problem related to lack

of engineers' mindset of sharing knowledge in service-driven culture, this study initiated taking the engineers' perspective of knowledge sharing to predict job performance. However, few studies have studied knowledge sharing types (Ritala et al., 2015). Drawing on SET and the micro-ecology model, the aim of this study was therefore to examine how employees' problem-solving self-efficacy (PSSE), the four types of knowledge sharing, perceived knowledge sharing values, and job performance are all correlated within the information system integration service.

THEORETICAL BACKGROUND

Problem Solving Self-Efficacy

Practically speaking, the fact that self-efficacy may have a positive effect on problem-solving efficacy has crucial implications for our understanding of the optimal ability and confidence belief in a task (Tierney and Farmer, 2004). This belief can be termed as problem solving self-efficacy (PSSE) in a special task. One's ability and willingness to adopt strategies to monitor, adjust, and reflect upon the problem-solving process can partially influence one's problem-solving efficacy (Caldas et al., 2016). In line with this, one's PSSE related to information integrating jobs can be defined as one's confidence in and ability to solve IT problems by monitoring, adjusting, and reflecting on problem solving in that service (Whitelock-Wainwright et al., 2020).

According to the theory of social cognitive learning, PSSE can be enhanced, but it can also be inhibited (Newman et al., 2018). Cervone and Peake's (1986) study showed that participants were led to overestimate or underestimate their self-efficacy for a special task by being provided with an irrelevant anchor. Efficacy beliefs can be easily biased as, when one faces a problem-solving task, it is difficult to correctly assess one's abilities and skills, and the effort that is necessary to successfully carry out the task (Oh, 2020). That is, self-efficacy in problem solving is subject to that problem or phenomenon (Lau et al., 2019). Individuals have a tendency to inaccurately assess their competence, and tend to be overconfident (Carter and Dunning, 2008; Molden and Higgins, 2012). It is thus likely that when a new problem-solving task is considered as being important for one's future work self, one's future self-efficacy judgments will be affected by that belief (Oh, 2020). Accordingly, given the problem-solving tasks related to software functions that IT workers focus on, the role that PSSE plays was explored in this study.

Knowledge Sharing

The knowledge sharing process is perceived to be related to sharing individual, team, and organizational knowledge. Knowledge sharing can bring significant benefits to employees and organizations due to its potential and actual advantages (Lin, 2007). In an organization, employees share knowledge with each other through storing their experiences in knowledge databases, which can lead to the improvement of their organization's efficiency (Lin, 2006; Al Qeisi and Al Zagheer, 2015). Knowledge sharing promotes employees' cooperation and teamwork through exchanging problem-solving experience and new ideas to improve the organization's learning capacity

(Dyer and Nobeoka, 2000; Cummings, 2014; Obrenovic et al., 2021). Regarding the influence of organizational factors on knowledge sharing, Ellahi and Mushtaq (2011) identified several factors that have an influence on knowledge-sharing behavior, namely mutual trust among staff, perceived usefulness and perceived value, job tasks, and appropriate technologies. The personality trait of conscientiousness, attitude of eagerness, and subjective norms were also found to have a positive impact on tacit knowledge sharing behavior (Obrenovic et al., 2021). According to Bock et al. (2005), four major factors that affect individuals' attitudes toward knowledge sharing are anticipated extrinsic reward, anticipated reciprocal response, sense of self-interest, and fairness. For example, Rungsithong and Meyer (2020) found that trust is related to the effectiveness of knowledge sharing. Obrenovic et al. (2020) found that willingness to share had an impact on tacit knowledge sharing and played a mediator role between the trait of altruism and tacit knowledge sharing. Individual, organizational, and technology infrastructure are considered as factors affecting knowledge sharing behavior (Kakhki et al., 2020). Additionally, the fear of losing power due to knowledge sharing restrains young scientists (Oliveira et al., 2019), indicating that stolen reflection in knowledge sharing needs to be considered when studying types of knowledge sharing. However, few studies have considered the four types of mental processes in knowledge sharing in the information system integration service. Thus, the present study explored the levels of the four types of knowledge sharing.

Job Performance

According to Borman et al. (1994) and Sobaih et al. (2019), job performance is the extent to which one is able to successfully carry out one's job tasks considering the normal constraints of the job and using the available resources. It includes two types of performance, namely task or in-role performance, and contextual or extra-role performance. Also, it refers to the employees' ability to achieve the expectations of the organization (Darvishmotevali and Ali, 2020). Borman and Motowidlo (1993) further proposed dividing job performance into task performance and contextual performance, where task performance refers to the outcome of job performance related to completing a mission within the organization, whereas contextual performance is an extra-role behavior that is not restricted by any official rules. Indeed, the behavioral and outcome aspects of performance are linked together (Sobaih et al., 2019). In line with Borman and Motowidlo's (1993) explanation, in this study, job performance is defined as an evaluation of the individual's job results.

According to the person-environment fit theory (Muchinsky and Monahan, 1987), if a team leader can hire employees to fit the organizational culture, the team performance can be promoted (McGuire et al., 2019). Additionally, He and Brown (2013), adopting the person-job fit theory (Edwards, 1991), studied the effect of employees' competence on their job performance, and found that there was a positive correlation. As failure costs increase exponentially during product implementation, and trouble-shooting cycles shorten, job performance within the information technology industry becomes a competitive factor (Peiro et al., 2020; Whitelock-Wainwright et al., 2020). Thus, the

level of individuals' job performance in the information system integration service jobs was explored in this study.

HYPOTHESES

Research Model

This proposition was developed further with the micro-ecology theory (Bronfenbrenner, 1979) which addresses the relationship between person-process-content. The person-process-content model (Bronfenbrenner and Crouter, 1983) was derived from the idea of the maximization of change processes. Based on the person-process-context model, we described the variability in the developmental process as studied in this paper as a function of context (job performance), person (self-efficacy), and process (knowledge sharing). Thereby, we predicted that those employees who have powerful PSSE beliefs would be likely to dedicate resources to and share their knowledge in the problem-solving process, which would in turn result in problem-solving efficiency. When we apply this theory to work in the IT industry, the correlates between employees' self-efficacy, knowledge sharing attitude and job performance are conceptualized as the research model for this study (Figure 1).

Problem Solving Self-Efficacy and Knowledge Sharing

Participants usually evaluate their collaboration with partners in light of two aspects, namely the distributive fairness of the investment-reward ratio, and the procedures designed to reward contributions (Katok and Pavlov, 2013). ET has been drawn on in a number of studies to examine the multilateral relationships that are embedded in either network rational reflection or cross-organization knowledge sharing (Zhou et al., 2020). For example, it has been found that employees' attitudes toward and intention

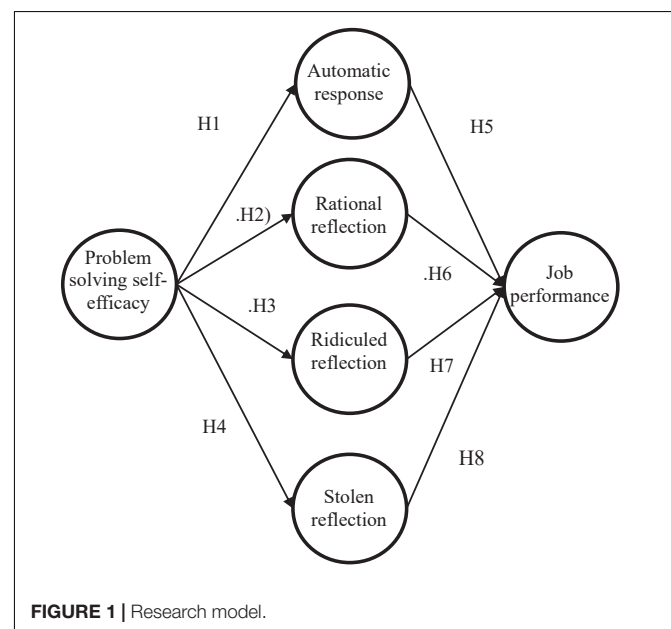


FIGURE 1 | Research model.

to engage in knowledge sharing are enhanced by self-efficacy, which provides benefits for the whole organization (Chen et al., 2012). While self-efficacy has been shown to persist over time (Pajares and Graham, 1999), individuals' judgments may change in line with changes in their perceptions of the job condition. Bandura (1986) described the connection between one's ability to control one's interactions and beliefs about one's capabilities and potential to control one's behavior (Pajares, 2002), arguing that those people who have high levels of self-efficacy tend to set themselves more challenging goals and usually work harder than those who have low levels of self-efficacy (Bandura, 1997). Some arguments arise in knowledge sharing. A previous study revealed that if employees found inequality in their knowledge sharing, they would change their attitude toward it (Hsu and Lin, 2008), but another study indicated that individual self-efficacy was more important in sharing knowledge than equity concerns (Tiedens and Linton, 2001; Bandura and Locke, 2003). However, when there is uncertainty appraisal and management is challenged in the IT industry (Brashers and Hogan, 2013), employees might not have the well-formed self-efficacy beliefs needed to be able to regulate their actions (Tamjidyamcholo et al., 2013). How employees' PSSE relates to different types of knowledge sharing was hypothesized as follows:

Hypothesis 1. PSSE is positively related to automatic response.

Hypothesis 2. PSSE is positively related to rational reflection.

Hypothesis 3. PSSE is positively related to ridiculed reflection.

Hypothesis 4. PSSE is positively related to stolen reflection.

Knowledge Sharing and Job Performance

Knowledge sharing is a vital social asset for organizations because it leads to better job performance and improves organizational success (Swanson et al., 2020). The Self-monitoring theory explains the tendency of individuals to manage their behaviors and expressions such that they reflect the surrounding environment (Snyder, 1974). When people have a high self-monitoring orientation, they will analyze the appropriate behavior and the best way to express their ideas in certain situations (Bell et al., 2000). For example, being able to sensitively react to situational clues and demands is an important issue for employees which results in different knowledge sharing behavior that affects the job performances in an organization (Oh and Kilduff, 2008). That is, promoting clues and demands in knowledge sharing can promote employees' job performance in an organization (Stollberger et al., 2019; Swanson et al., 2020). Moreover, Nassif (2019) highlighted dark personalities, stating that if people are Narcissists, they will exhibit hostility and aggressiveness when their egos come under threat, while Psychopaths have been observed to worry about making negative impressions in group communications (Rauthmann, 2012). Core behavioral adaptation related to the extent to which dark traits affect one's feeling of being worthy to share and of being

competent to work (Pratim, 2007), in particular among IT professionals (Cui, 2017), has not been explored in related studies. Thus, how different types of IT employees' knowledge sharing is related to job performance was hypothesized as follows:

Hypothesis 5. Automatic response is positively related to job performance.

Hypothesis 6. Rational reflection is positively related to job performance.

Hypothesis 7. Ridiculed reflection is positively related to job performance.

Hypothesis 8. Stolen reflection is positively related to job performance.

RESEARCH DESIGN

Research Design

A questionnaire-based survey technique was used, and snowball sampling was adopted. A questionnaire form was created in Google Docs, then a message was sent to friends who work in the sector of the information system integration service in the IT industry via Facebook, Line, and email. They were asked to mail the form to more friends working in the same field.

In consideration of the ethical issues, we assured respondents about the anonymity of their responses (Islam et al., 2020). As both independent and dependent variables were measured at the same time, the present study took some measures to avoid the issue of common method variance (Islam and Tariq, 2018). After 2 weeks of data collection, 320 responses were returned, and after deleting incomplete questionnaires, there were 307 data available to be subjected to statistical analysis.

Participants

Regarding the composition of the participants, 73 (23.8%) were females and 234 (76.2%) were males, indicating that the majority of employees in the information integrating service are males. In terms of age, 49 (16%) were between 21 and 30 years old, 112 (36.5%) were between 31 and 40 years old, and 132 (43%) were between 41 and 50 years old, indicating that employees aged between 41 and 50 constituted the major population of the current study.

Research Instruments

The questionnaire items were adapted from the previously mentioned theories and research and were obtained by using the forward-backward translation method to ensure face validity. This study used the questionnaires to collect the required data and construct the content basis for the analysis. The questionnaire applied a 5-point Likert scale as the scoring model for the subsequent analysis and presentation of the results. The questionnaire reliability and validity were examined using SPSS and AMOS.

Problem solving measurement: Previous research has indicated that there is a positive relationship between creative self-efficacy and creative problem solving in the workplace

(Amabile, 1996; Treffinger, 2000). We adapted the creative self-efficacy scale developed by Tierney and Farmer (2004) and embedded problem-solving self-efficacy in IT-oriented jobs into the items, for example, “I have confidence in solving IT problems” or “I can solve any problem in the information integrating system service.”

Knowledge sharing types of measurement: Automatic response and rational reflection were adapted from the dual process theory (Kahneman, 2011). The present study drew on the theory of *I’m OK, You’re OK* (Harris, 2004), and the opportunistic and self-interested orientations of knowledge sharing (Estrada et al., 2016) to design items related to ridiculed reflection and stolen reflection. Exemplary items in automatic response included: “If I find out someone made a mistake, I will point it out right away” and “I always express my suggestions immediately when they come to mind.” Rational reflection included: “If I have a new idea, I would think about whether it is logical before speaking out” and “If I have a new idea, I would compare that idea to others before I speak out.” Ridiculed reflection included: “If I have a new idea, I would think about whether it will be ridiculed before I speak out” and “If I have a new idea, I would consider whether it is too naïve before I speak out.” Stolen reflection included: “If I have a new idea, I would think about whether it will be stolen before I speak out” and “If I have a new idea, I would consider whether it will be taken as others’ new idea before I speak out.”

Job performance measurement: Given that our scale is job-specific, we had specific objectives for measuring IT job performance related to service work (Pitafi et al., 2018). That is, to assess employees’ job performance in a customer-oriented environment, we adapted Grote and Grote’s (1996) guide to performance appraisal to design our scale, including the items: “I think that by knowledge sharing with others, I can troubleshoot in the information integrating system sooner than before” and “I think that by knowledge sharing with others, I can solve more difficult problems.”

Data Analysis

Item Analysis

The internal validity of each item in the constructs was examined by first-order confirmatory factor analysis (CFA) with factor loading and residual values. If the factor loading of items was lower than 0.5, the item would be deleted first, then those items with higher residual value in each construct would be deleted until the threshold values met the first-order CFA (Byrne, 2010).

Table 1 indicates that after the first-order CFA, the number of items of PSSE was reduced from 6 to 4, automatic response was reduced from 6 to 4, rational reflection from 5 to 4, ridiculed reflection from 6 to 4, stolen reflection from 5 to 4, and job performance from 5 to 4.

This study evaluated the external validity of the items to determine the scope of interpretation (Cor, 2016). The value of each question responded to by all respondents was divided into the top 27% and the bottom 27%, and then a *t*-test was performed. When the *t*-value exceeds 3 ($***p < 0.001$), the external validity would be considered as reaching a significant level. **Table 1** shows the *t*-value of PSSE (17.185–22.809), automatic response (13.887–19.798), rational reflection (20.724–26.651), ridiculed reflection (18.891–29.513), stolen reflection (19.095–24.379), and job performance (19.801–28.756), indicating that all of the *t*-values were over 3, and met the threshold, which means that all of the items in this study had a degree of accuracy, and could be used to ascertain the degree of response for the different samples (Green et al., 2005).

Construct Reliability and Validity Analysis

The present study adopted Cronbach’s α to test the construct internal consistency, and composite reliability (CR) to examine the construct external consistency. Based on Hancock et al. (2018) suggestion, the values of Cronbach’s α and CR should be over 0.70. **Table 2** shows that all values in each construct were above 0.70, thus meeting the threshold.

Convergent validity analysis was analyzed by average variance extracted (AVE) and factor loading. **Table 2** shows that the values of FL and AVE in each construct were above 0.5, which meets Hancock et al.’s (2018) suggestion and indicates that the convergent validity was acceptable in this study. Construct discriminative validity was tested by comparing two values; if the Pearson coefficient absolute values were less than the values of the AVE square root, then the discriminative power of each construct can be considered acceptable (see **Table 3**).

RESULTS

Model Fit Analysis

Scholars have suggested that the recommended value of each fitting index is that the chi-square degree of freedom ratio (χ^2/df) should be less than 5 (Hancock et al., 2018), while the root mean square error of approximation (RMSEA) has to be

TABLE 1 | Item analysis.

Construct	Internal validity				External validity	
	χ^2/df	GFI	AGFI	RMSEA	FL	<i>t</i> -value
PSSE	1.835	0.994	0.970	0.052	0.690~0.837	17.185–22.809
Automatic response	3.617	0.989	0.944	0.072	0.584 ~0.783	13.887–19.798
Rational reflection	2.364	0.993	0.963	0.067	0.665 ~0.841	20.724–26.651
Ridiculed reflection	1.590	0.995	0.974	0.044	0.636 ~0.937	18.891–29.513
Stolen reflection	2.282	0.999	0.995	0.051	0.729 ~0.896	19.095–24.379
Job performance	2.283	0.992	0.960	0.065	0.614 ~0.861	19.801–28.756

TABLE 2 | Construct reliability and validity.

	<i>M</i>	<i>SD</i>	Cronbach's α	CR	FL	AVE
Threshold	–	–	> 0.7	> 0.7	> 0.5	> 0.5
PSSE	3.701	0.861	0.868	0.858	0.773	0.602
Automatic response	3.135	0.947	0.810	0.807	0.713	0.514
Rational reflection	4.194	0.691	0.831	0.831	0.741	0.553
Ridiculed reflection	3.120	0.958	0.869	0.878	0.795	0.647
Stolen reflection	2.201	0.700	0.895	0.895	0.824	0.683
Job performance	4.199	0.729	0.869	0.869	0.790	0.625

less than 0.1. It is also recommended that the goodness-of-fit index (GFI), adjusted goodness of fit index (AGFI), normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI), incremental fit index (IFI) and relative fit index (RFI) all exceed the threshold of 0.8 (Hancock et al., 2018), whereas the parsimonious normed fit index (PNFI) and parsimonious goodness of fit index (PGFI) are best to exceed 0.5 (Hancock et al., 2018). The statistical verification values of this study are $\chi^2/df = 2.012$, RMSEA = 0.058, GFI = 0.948, AGFI = 0.924, NFI = 0.902, NNFI = 0.903, CFI = 0.911, IFI = 0.914, RFI = 0.908, PNFI = 0.768, and PGFI = 0.730. All values reached the suggested index values and fitted the model well (Byrne, 2010). Besides, the result of a multivariate normality test showed that the Mardia's coefficient of multivariate kurtosis was 133.911, the critical ratio of which was 25.149.

Path Analysis

This study adopted AMOS20 to verify the paths of the research model. **Figure 2** shows that PSSE is positively related to automatic response ($\beta = 0.335$, $t = 4.921^{***}$), rational reflection ($\beta = 0.551$, $t = 7.672^{***}$) and ridiculed reflection ($\beta = 0.354$, $t = 5.414^{***}$), but is negatively related to stolen reflection ($\beta = -0.333$, $t = -5.153^{***}$). **Figure 2** also shows that rational reflection in knowledge sharing is positively related to job performance ($\beta = 0.455$, $t = 6.485^{***}$); ridiculed reflection and automatic response in knowledge sharing are positively related to job performance ($\beta = 0.184$, $t = 3.326^{**}$; $\beta = 0.180$, $t = 2.963^{**}$); however, stolen reflection in knowledge sharing is negatively related to job performance ($\beta = -0.195$, $t = 3.157^{**}$). The values of effect size (f^2) between PSSE and knowledge sharing correlate, and knowledge sharing and job performance are above the threshold. The explanative power of PSSE on automatic response is 30.4 %, on rational reflection it is 21.2%, on ridiculed reflection it is 22.5%, and on stolen reflection it is 31.1%. The explanative power of the four types of knowledge sharing on job performance is 33.3%. Those effect sizes and explanative powers are all above the threshold suggested by Byrne (2010).

DISCUSSION

Extended from the person-process-context model, we developed a research model, self-efficacy-knowledge sharing-performance, to explore the mediating role of four types of knowledge sharing in PSSE predicting IT workers' job performance. The hypotheses

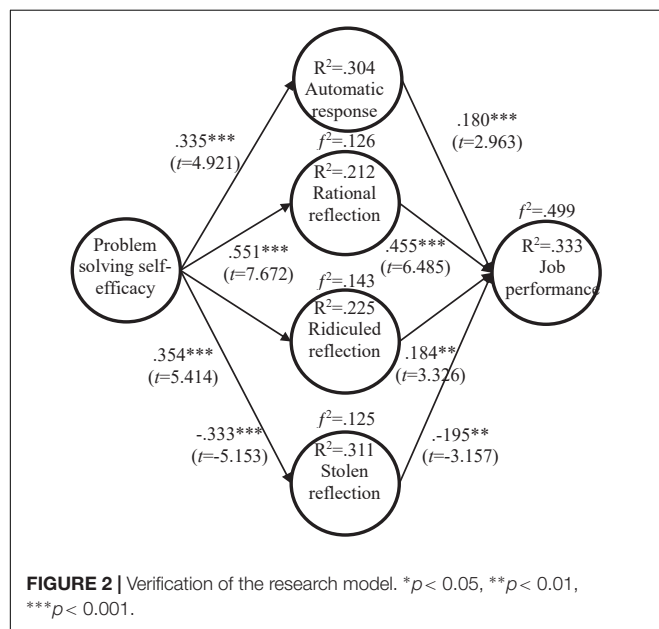
proposed in the research model were tested using AMOS, and the results are discussed as follows.

Bronfenbrenner (1979) proposed the micro ecological system to discuss the relationship between person-process-content (PPC). Bronfenbrenner and Crouter (1983) described a "person-process-context model" (PPCM) in which variability in a developmental process as studied in this paper is a function of context (job performance), person (self-efficacy), and process (knowledge sharing). According to the interaction of the PPC model, interaction between predisposing factors such as PSSE, and social behavior, such as knowledge sharing, results in specific job performance. Additionally, the self-monitoring theory explains the tendency of individuals to manage their behaviors and expressions so as to reflect the surrounding environment (Snyder, 1974). The participants' working environment was the information system integration service industry. Therefore, we took the micro-ecology model to explore how PSSE affected their knowledge sharing tendency, and the results of this study showed that H1, H2, and H3 were positively supported, but H4 was negatively supported. Our findings are supported by the study of Hoffman and Schraw (2009) which indicated that motivational beliefs, such as self-efficacy, increase problem-solving efficiency through focused effort and strategy use. Moreover, they are consistent with another previous study which revealed that if employees found inequality in knowledge sharing, it would inhibit their attitude toward sharing knowledge with team members (Chen et al., 2012). That is, if they have a strong sense of self-efficacy in problem solving when they feel that there is inequality in knowledge sharing, they will have stolen reflection compared to the other three correlates. Conclusively, PSSE is highly related to the four types of knowledge sharing, indicating that participants who have a high level of PSSE will have positive attitudes toward sharing knowledge, but they will have lower levels of stolen reflection in sharing knowledge in the information system integration service industry.

There are many studies which have aimed to understand the relationship between knowledge sharing and job performance. For example, drawing on social capital theory, Swanson et al. (2020) found that leader competencies are critical for promoting knowledge sharing and enhancing employee job performance. In another example, based on the cultural contingency model, Venkatesh (2022) revealed that knowledge providing led to better job performance. Differing from those studies, based on social exchange theory, in the present study, we developed four types of knowledge sharing tendencies and examined their prediction of job performance. Examination of H5, H6, H7, and H8 indicated that the former three hypotheses were positively supported, but H8 was negatively supported. When core behavioral adoption is related to the extent to which one feels worthy of sharing one's ideas (Pratim, 2007), the present study indicated that a prediction of rational reflection to job performance is higher than the other three types of knowledge sharing: automatic response, ridiculed reflection, and stolen reflection. Moreover, stolen reflection is negatively related to job performance. The results are consistent with some previous studies; for example, Nassif (2019) highlighted dark personality types, and found that people who are Narcissists will exhibit

TABLE 3 | Construct discriminative validity analysis.

	PSSE	Automatic response	Rational reflection	Ridiculed reflection	Stolen reflection	Job performance
PSSE	0.776					
Automatic response	0.478	0.717				
Rational reflection	0.314	0.096	0.744			
Ridiculed reflection	0.357	0.204	0.130	0.804		
Stolen reflection	0.349	0.109	−0.002	0.264	0.826	
Job performance	0.366	0.402	0.216	0.231	0.221	0.791



hostility and aggressiveness when their egos come under threat, while Psychopaths have been observed to worry about making negative impressions in group communications that hinder knowledge sharing and inhibit job performance (Rauthmann, 2012). Drawing on the protection motivation theory, Soral et al. (2022) found that dark personality traits enhance subordinates' knowledge-hiding behavior and threaten their job security. In line with the dark personality types, the results of this study indicated that employees with self-interest in knowledge sharing indicated a high level of stolen reflection that led to decreased job performance. Employees in the information system integration service industry must immediately respond, so job performance and automatic response in knowledge sharing have a positive relationship.

CONCLUSION

Knowledge sharing is an essential activity in an organization. Different types of knowledge sharing may result in different individual performances in the job, and this may influence organizational effectiveness. To understand this issue, the present study applied a micro ecological system to design four types of knowledge sharing, and applied AOM to design the research

model. Data were collected and structural equation modeling was performed in order to test the research model hypotheses, the results of which show that PSSE is positively related to three types of knowledge sharing, but not stolen reflection. These three types of knowledge sharing were also positively related to job performance, but once again not to stolen reflection.

Theoretical Implications

This research adapted a micro ecological system and the social exchange theory to develop four types of knowledge sharing. These types advance the understanding of knowledge sharing behavior in previous studies. In line with this, other types of knowledge sharing may be developed according to different organizational needs. Among the four types of knowledge sharing, rational reflection can most positively predict one's job performance. With rational reflection, the proposed ideas may be more suitable for solving job problems; thus, IT managers have to encourage their employees to practice rational reflection and thinking before take an action and to increase the effectiveness of members' knowledge sharing. Besides, IT companies need collaborative problem solving. If employees with ridiculed reflection hesitate to share their knowledge, that will hamper their job performance and their team effectiveness; thus, IT managers need to develop a friendly chatting environment to decrease the ridiculed reflection of employees.

Practical Implication

The results of this study have at least three practical implications for the field. First, this study contributes a novel, identity-centered perspective to explain four types of knowledge sharing. Specifically, we argue that the strength with which a person identifies with that aspect of PSSE will predict that person's willingness to engage in knowledge sharing. The impact of an individual's PSSE should be considered in terms of how its effects alter job performance. Second, this study provides a strong example of the importance of management approaches to avoid stolen reflection tendency in knowledge sharing. Finally, the results of this study revealed that PSSE is the antecedent of job performance mediated by knowledge sharing; thus, to enhance knowledge sharing tendency, employees with high levels of PSSE are the best choice to work in the information system integration service industry.

Limitation and Future Study

Regarding gender, most participants in this study were male because the IT industry attracts more males in Taiwan. Thus,

the present study did not analyze the difference in knowledge sharing by gender. Future studies may focus on some industries which recruit more female workers, such as bank workers, to identify any gender differences in knowledge sharing and job performance. Besides, this study was conducted on a limited sample of 307 System Integration IT workers. Thus, it is essential to expand the research samples to different IT sectors in future research.

There are many types of job categories in the information system integration service industry, for example, information security, programming, and so on. Different job attributes have different needs for knowledge sharing; thus, future studies may identify each of these subcomponents' individual impacts on knowledge sharing behavior, and may undertake a comparative study to understand the possible effects of knowledge sharing differences in different types of organizations.

Diversity researchers have long appreciated the importance of articulating effects of individual differences as an integral part of group knowledge sharing. The effect of four types of knowledge sharing: automatic response, rational reflection, ridiculed reflection, and stolen reflection should be further examined in different organizational cultures to have a greater variety of different perspectives to advance the meaning of knowledge sharing research.

To test the external validity of the questionnaire items, the present study applied *t*-tests to compare the top 27% and bottom 27% to ascertain whether the value was over 3 to ensure the external validity of each item. There are some

other statistical methods, for example, the heterotrait-monotrait ratio of correlations, for examining the external validity of questionnaire items; thus, other approaches may be applied in future studies to test the item external validity.

DATA AVAILABILITY STATEMENT

Datasets are available on request.

AUTHOR CONTRIBUTIONS

J-CH contributed to the conceptualization, validation, investigation, resources, writing—original draft, project administration, supervision, and funding acquisition. Y-FL contributed to the writing—review and editing and methodology. H-HC contributed to the software, formal analysis, and term. HN contributed to the format editing and preparing manuscript for submitting. All authors contributed to the article and approved the submitted version.

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A Study on Maker Teaching Activity Design in Senior High School General Technology Course for Creativity Cultivation

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General Technology Course (GTC) in senior high school focuses on skill training and the connection and comprehensive application of interdisciplinary knowledge, and it is a compulsory course for cultivating students' creative potential. However, GTC in domestic senior high school has low teaching efficiency and fails to cultivate students' creativity well. Fortunately, after years of theoretical and practical research in China, the Maker Education (ME), which focuses on cultivating students' innovative ability, has produced well-recognized applied research results. For this reason, this paper integrates the theories of ME into GTC. Combined the characteristics of ME and GTC, and followed the process of creation and the law of the expression of personality traits, we build a model of GTC based on ME to improve students' creativity effectively. In order to improve and optimize the designed teaching model, this study carried out three rounds of Action Research, designed the practical activities of GTC in senior high school, and revised the teaching model through action, observation and reflection continuously. Finally, this paper designed an experimental group and a control group. The experimental group adopts the recommended General Technology teaching model, and the control group adopts the traditional teaching model. Students were asked tested to take pre-test and post-test, and SPSS was used for analysis of ANCOVA and *T*-test. After analysis, the following experimental results were obtained: (1) the teaching model proposed in this paper can improve students' creativity significantly and effectively; (2) the adventurous, curiosity, imagination, challenge of students also have significant positive improvement.

Keywords: creativity, maker education, General Technology Course, senior high school, teaching model

INTRODUCTION

In West, most educators agree that Technology Education should aim to help students develop an interest in technology and the ability to address technological challenges in a conscious and innovative way (Lind et al., 2020). For example, in Sweden, Technology Education is described as a discipline that aims to develop students' technical awareness and skills so that they can become part of and act in a technology-intensive world (SWEDISH National Agency for Education [Skolverket], 2017). However, Technology Education still suffers from problems such as teachers' differing views

on what should be covered in curriculum topics (Norström, 2014) and the inability to achieve continuity between what policy documents require and the realities of practice (Doyle et al., 2019). In this case, the effect of cultivating students' creativity through Technology Education is not significant. The Technology Education in this study is the General Technology Course (GTC) currently implemented in senior high schools in China. It is a course whose goal is cultivating students' creativity through "learning by doing" and practical experience (Ministry of Education of the People's Republic of China, 2017). However, General Technology Course (GTC) teaching in China also has some problems, such as single teaching form, backward teaching content and equipment, and insufficient teaching efficiency in course, which led the course fail to cultivate students' creativity (Gu, 2014).

Creativity is considered one of the four century skills of twenty-first century. The researches on creativity have particularly flourished in recent decades (Nenad and Limin, 2017). Research shows that using maker education may be very suitable for classroom learning (Kim and Kim, 2018). Frank (1971) believes that the creative individual has the psychological characteristics of curiosity, adventurous, challenge and imagination. Surprisingly, the improvement of creativity is not a prominent issue in schools. In order to solve the problem that the General Technology Course fails to effectively cultivate students' creativity, some scholars have conducted research on this. Lv (2016) respectively proposed methods to cultivate students' creativity in GTC, such as exploring products in life, creating democratic classrooms to stimulate students' imagination, and using design activity carriers. Xiong (2016) proposed to cultivate students' innovative ability through the diversification of design projects, such as students' independent choice of project themes and reasonable arrangement of project design task time.

Noted that few scholars have carried out research on GTC teaching model for the cultivation of students' creativity. In recent years, the theory and practice of Maker Education (ME) have developed rapidly, and some excellent applied research results have emerged. The core educational value of ME is student-centered, with project practice as the carrier to cultivate students' innovative ability (Yang and Li, 2015). ME is seen as a way to enhance future capabilities (Seo and Lee, 2018). Students engage in production activities and develop a maker mindset through ME (Martin, 2015). The maker mindset is seen to be related to important competencies such as innovative ideas and actions (Kang, 2017), critical thinking, creativity, problem solving and collaboration (Kang and Yoon, 2017), etc. ME has the advantages of openness, compatibility, sharing, and practicality, which helps to cultivate students' creative ability (Yang et al., 2019). In addition, ME is closely related to the learning principle of constructivism, which also emphasizes "learning by doing" in educational theory (Kim, 2018; Yoon, 2018; Kim et al., 2020). Moreover, ME focuses on the learning process, encourages students to divide labor according to their personal interests and expertise, and turns creativity into reality through hands-on practice. Therefore, the fusion of GTC and ME to better cultivate students' creativity has great possibilities for teaching

practice. However, few scholars have carried out research on this at present. You (2017) designed a maker teaching case called the Arduino robot making in the GTC, which improved students' technical literacy. The researches about teaching model, teaching activity cases, and teaching effect on the integration of GTC and ME to cultivate creativity is relatively rare. Therefore, this paper designs a GTC teaching model based on the concept of ME for creativity cultivation. Under the guidance of the model, we design teaching activities and carry out experimental research to cultivate students' creativity effectively.

The research purposes of this study are: (1) to construct a GTC teaching model based on the concept of ME. (2) to apply this model to practice and evaluate whether it can effectively improve students' creativity.

CONSTRUCTION OF GTC TEACHING MODEL BASED ON THE CONCEPT OF ME

Four Periods of Creative Process

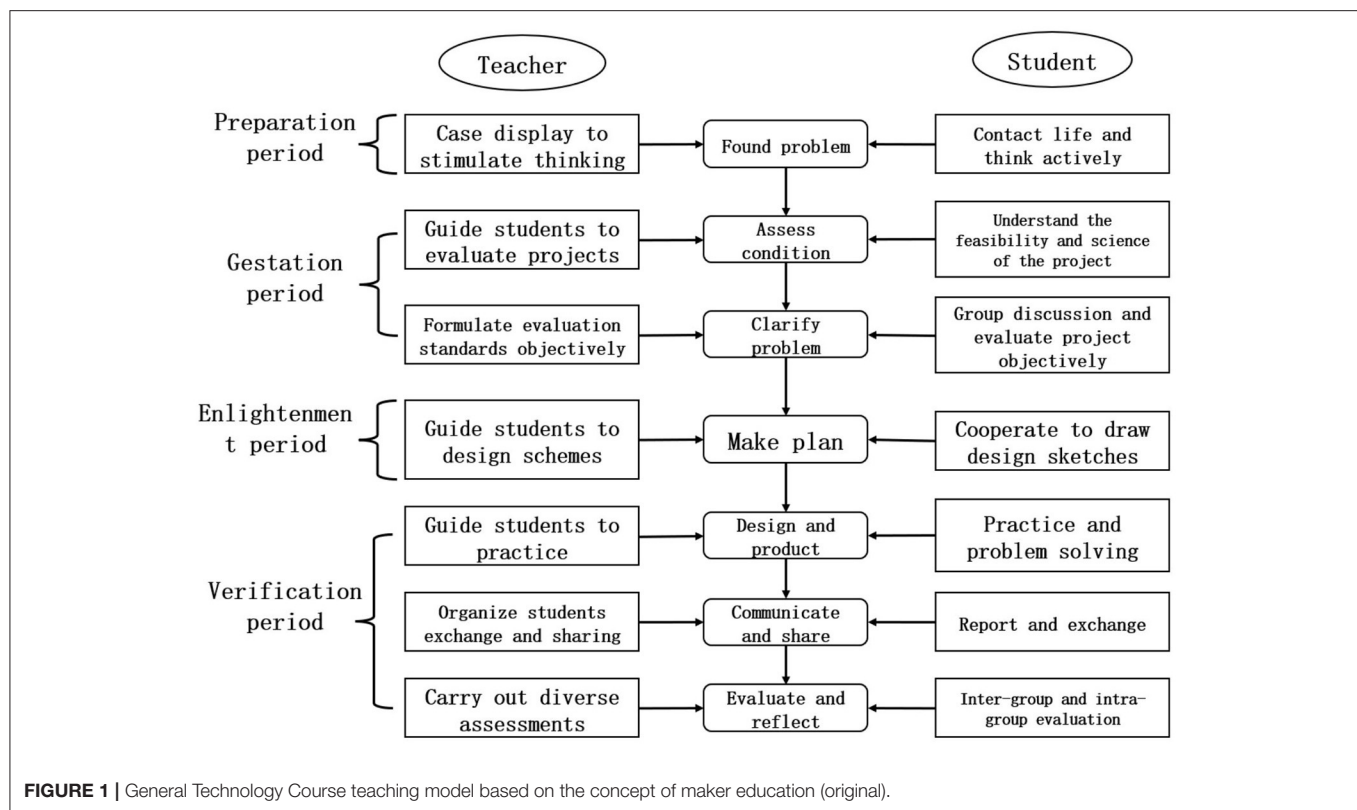
The creative process proposed by Wallas (1926) should go through four stages: preparation, gestation, enlightenment and verification. The thinking operation in the preparation period is cognitive memory, and the personality traits are studious, diligent, and maintaining attention. the creator in gestation period is bold and imaginative. In enlightenment period, the creator is enlightened by epiphany or by discovering a solution to the problem. The personality traits manifest as taking risks and accepting failure in this period. In verification period, the creation plan will be verified by facts. Therefore, according to the four periods proposed by Graham Wallas, this study divides the creative process of students in General Technology curriculum into four periods: preparation, gestation, enlightenment and verification.

Five Stages of Creative Problem Solving

Creative problem solving (CPS) model is a learning and teaching model that can effectively cultivate students' creativity. Research on creativity development shows that the most effective way to cultivate creativity is to use the CPS model (Torrance, 1972). Therefore, this study intends to introduce CPS model into the design of teaching model. Parnes (1967) proposed the five stages of CPS firstly, which divided the problem solving process into five steps: discovering facts, discovering problems, seeking ideas, seeking solutions and seeking acceptance. Stanish and Berle (1997) proposed that the creative problem solving process includes six procedures: finding confusion, collecting data, finding problems, collecting ideas, looking for countermeasures and accepting ideas. Therefore, referring to the above process, this study integrates the concept of ME into the GTC and designs the teaching process with CPS model, including seven links of "finding problems, condition evaluation, clarifying problems, formulating schemes, design and production, communication and sharing, evaluation and reflection."

Maker Education Activities

Fu (2015) proposed the "SCS Maker Teaching Method," which divides the teaching into seven steps, introduction



of sentimental stories, imitation of simple task, explanation of key points of knowledge, imitation of extended task, stimulation and guidance of innovation, collaborative task completion, and sharing of successful works. Zhu and Hu (2016) designed a design-based learning model for Maker Education, in which teachers' activities include determining projects around themes, presenting scenario and describing challenges, establishing standards and providing supports, supervising and observing timely guidance, organizing cross-border cooperation in learning, publishing results, evaluation and reflection. At present, there is no unified model for ME, but from the common characteristics of the above-mentioned model, it can be seen that ME should be based on a certain situation, let students experience learning and "learning by doing," and share the joy of the work finally. Therefore, this study refers to the maker teaching steps proposed by the above scholars, and sets the teacher's activities as "case display to stimulate thinking, guide students to evaluate projects, formulate evaluation standards objectively, guide students to design schemes, guide students to practice, organize students to exchange and share, carry out diversified assessments." According to the teacher's activities, the students' activities are set as "contact life and think actively, understand the feasibility and scientificity of the project, group discussion and evaluate project objectively, cooperate to draw design sketches, practice and solve problems, report and exchange, inter-group and intra-group evaluation."

Based on the above analysis, the paper constructs a GTC teaching model based on the concept of ME as shown in

Figure 1. This teaching model focuses on combining with students' actual life. Firstly, students discover problems in life observation. Secondly, they evaluate objective and actual conditions reasonably, and then establish the project theme, formulate a feasible design plan through group discussion, and then carry out design and production. In the process, students think actively, solve problems and communicate after completing the works. Finally, students evaluate the works of this group and other groups objectively.

ACTION RESEARCH ON GTC BASED ON ME CONCEPT

This research adopts Action Research (AR). AR is a reflective inquiry activity carried out by participants in social situations, which combines "action" and "research" in order to improve practice and rationally understand practical activities and their environment (Kemmis and McTaggart, 1982; Carr and Kemmis, 1986). AR advocates "teachers as researchers" to find and solve problems in the real educational environment. It opposes separating phenomena from situations and attaches importance to "learning by doing" in real situations. In AR, through the circular chain of "plan, action, observation, reflection," the researchers improve action constantly, so as to deepen the research and achieve the purpose of improving practice. The reason why this study adopts AR rather than experimental research in traditional education research is: in order to

implement and develop the new teaching model and method, it must be rooted in the real soil, rely on the test of teaching practice in the real situation. The paper adopt AR, and constantly find, analyze and solve problems in the real teaching environment, so as to continuously improve the teaching mode proposed in this study. In addition, the openness and dynamics of the spiral cycle process of AR “plan, action, observation, reflection” is in line with the process of repeated exploration in the design of teaching mode and the implementation of teaching scheme.

Therefore, this study selected 43 senior one students from a high school with a history of teaching general technology for many years in Guangzhou as the object of AR, and designs three rounds of General Technology Course (GTC) practice activities based on the concept of Maker Education (ME). Each round of AR aims to foster student creativity. The teaching content focuses on the integration of ME and GTC, and includes three projects, i.e., “The Production of Lamp Painting,” “The Production of Sound and Light Alarm System” and “The Production of Laserblock-based Arduino.”

The teaching practice is scheduled for the first semester of the academic year 2021–2022. The specific period is from September 6 to December 31, 2021. The total number of hours is 16. The first round of AR was conducted from September 6 to September 30, 2021, for four class periods, one 45-mins class period per week. The first round of AR adopted the original teaching model shown in **Figure 1**, and conducted the first round project “The Production of Lamp Painting,” which corresponds to the content of the compulsory 1 “General Process of Technical Design” chapter in GTC, to examine and analyze the effectiveness of the teaching model in fostering students’ creativity, as well as what problems exist. The second round of AR was conducted from October 11 to November 12, 2021, and consisted of five class periods. The instructional content was the second round project “The Production of Sound and Light Alarm System,” which corresponded to the content of the compulsory 2 “Process and Design” and “System and Design” chapters. The goal of this round of AR was to put the second round of the generic technology-based Maker teaching model into new AR practice, to observe and analyze the effectiveness of the improved second round teaching model in this round of teaching AR, and what problems existed. The third round of AR was held from November 15 to December 31, 2021, and consisted of seven class periods. The teaching content was the third round project “The Production of Laserblock-based Arduino,” which corresponded to the compulsory 2 “Structure and Design” chapter. The modified generic technology-based creator teaching model after the problems identified in the second round of AR practice was put into the third round of AR practice to observe and analyze the pedagogical effects of the improved third round model obtained in this round of teaching AR.

In each round of AR, it is necessary to obtain information such as students’ learning attitude, enthusiasm and completion of classroom tasks through classroom observation, next reflect on the existing problems of the current round of teaching model, then put forward improvement measures to optimize this round of teaching mode, and finally put the improved new teaching mode into the next round of AR. Due to the space limitation

of the article, this paper only gives the detailed teaching activity design of the third round of AR (as shown in **Table 1**).

After three rounds of AR, after reflecting on the existing problems, the following modifications were made to the teaching model: (1) In “Discover Problem,” a new system was introduced. “Zhixin Online Teaching Evaluation System” (Zhixin System) is developed by the team of a teacher in Guangzhou No.6 Middle School for teaching management and evaluation. The introduction of Zhixin System hopes to correct the learning behaviors of students in the first round of AR, such as not bringing books to class but bringing snacks and drinks. (2) In “Explicit Conditions,” the case of previous student projects is introduced to guide students to evaluate projects. Showing actual cases close to students’ learning tasks is conducive to further stimulating their curiosity in learning and improving the feasibility of students’ projects. (3) In “Identify Questions,” teachers will show the project evaluation standards, and then teachers and students formulate the standards for this project activity jointly. Allowing students to achieve scientific evaluation according to evaluation criteria is good to improve the feasibility of the project. (4) A new activity “Knowledge and Skills Learning” is added to allow students to learn the relevant knowledge and skills, such as open source software and hardware. When formulating a design plan, they can specifically describe the functions of the works in the plan. It is also helpful to make a clearly task division in the group. In addition, teachers have added the activity of “making micro-lectures” to make the content of knowledge and skills involved in the project into micro-lectures for students to learn. (5) In “Make Plan,” group work is added. Students divide the project tasks reasonably according to the respective strengths of the members of the group, so that everyone in the group has something to do and enhance the cohesion of the group. Introduce thinking tools to assist students in drawing design sketches. In addition, increase student self-assessment, so that students can learn self-assessment and reflection. (6) In “Design and Product,” the timely feedback of Zhixin System is introduced. Using the “class record” function of Zhixin System, teachers can add or subtract points and give feedback to students in real time, which may improve students’ enthusiasm for learning. (7) In “Communicate and Share,” students participate in the formulation of work evaluation standards to enhance recognition of the standards and participation in the classroom. (8) In “Evaluate and Reflect,” use Zhixin System to add students’ personal evaluation. Students can be bold to make objective evaluations of others’ works, which may cultivate their sense of adventure. At the same time, teacher can quickly collect students’ evaluation opinions, and calculate the evaluation scores of each group timely.

It can be seen that after three rounds of AR, the original teaching model introduced new technologies (such as open-source software and hardware), new systems (such as Zhixin Online Teaching Evaluation System, referred to as “Zhixin System”), and added new teaching activities (such as, knowledge and skills learning). We observed and found that students’ performance in the class and learning performance were relatively positive. At the same time, through modification and

TABLE 1 | The teaching activities of the third round of action research.

Teaching process		Teacher activity	Student activity	Purpose of design
Preparation period	Found problem	The videos of “Laserblock-based Arduino Production” made by previous students are selected for display to introduce the learning content and goals of this project. Question: According to the Arduino function modules you have learned, what kind of comprehensive project with structure do you want to design?	Students watch the video and think based on learning objectives and content proposed by the teacher.	To link the content learned and mobilize the divergent thinking of students.
	Assess condition	The teacher asks the evaluation points of relevant projects made by previous students, and analyze the scientificity and feasibility of the design themes proposed by students.	Students think about the main points of project evaluation, and evaluate design problems reasonably and objectively in combination with evaluation criteria.	To improve students' enthusiasm for active thinking, and enhance students' recognition of the evaluation standards formulated later.
Gestation period	Clarify problem	The teacher guides students to jointly formulate project evaluation standards and comprehensively evaluate design issues.	Through group discussions, students can objectively judge the project conditions and determine the design theme according to the evaluation criteria.	To enhance students' awareness of the feasibility of designing problems.
	Knowledge and skills learning	The teacher designs a technical experiment that affect structural stability and strength factors, and guides students to think about the basic ideas and methods of structural design.	Technology test exploration.	Let students learn the basic knowledge module to lay the foundation for the subsequent program design and production.
	Make plan	The teacher and students formulate program forms jointly and program evaluation standards, and use the Zhixin System to feedback program evaluation results.	Students draw the project design flow chart and try to summarize the elements of the design scheme and the key points of the scheme evaluation.	To enhance students' learning subject awareness.
Verification period	Design and product	The teacher give timely guidance to students with learning difficulties, and issue the previous knowledge and skills micro-courses and common problem-handling micro-courses.	Students carry out practice according to the division of labor in the plan, actively think about problems encountered in the process of practice, and find ways to solve problems.	To cultivate students' creativity and hands-on ability
	Communicate and share	The teacher and students work together to formulate evaluation criteria for works. Teacher organizes students to demonstrate project works.	Students try to summarize the evaluation dimensions of the works, and the group takes the stage to display the lamp painting works.	To enhance students' recognition of evaluation criteria
	Evaluate and reflect	The teacher organizes students to evaluate their works in groups, and guides students to reflect on the evaluation criteria.	Students objectively evaluate the work of this group and other group works according to the evaluation criteria	To enable students to improve their creativity through self-reflection

improvement, a relatively complete GTC teaching model based on the concept of ME has been obtained (as shown in **Figure 2**).

The teaching model divides the teaching process into seven steps: Discover Problems, Explicit Conditions, Identify Questions, Knowledge and Skills Learning, Make Plan, Design and Product, Communicate and Share and Evaluate and Reflect. Combining the four periods of preparation, gestation, enlightenment and verification proposed by Wallas (1926) in the creation process, each step is divided into a specific period, and different teaching activities are carried out according to the characteristics of students and the concept of Maker Education. In “discover Problems,” the teacher stimulates students’

brainstorming and active thinking through case presentations, and introduces new systems to assist teaching. In “Explicit Conditions,” teacher shows case projects from previous years, and guides students to think about the feasibility and scientificity of those projects. In “Identify Questions,” students make objective group evaluations of previous projects through group discussions. On this basis, the teacher and students jointly develop project evaluation standards. In “Knowledge and Skills Learning,” the teacher prepares relevant micro-lectures before class for students to learn. In addition, teacher should prepare more forms of teaching materials, and educate students to learn to solve problems and learn knowledge by themselves. In

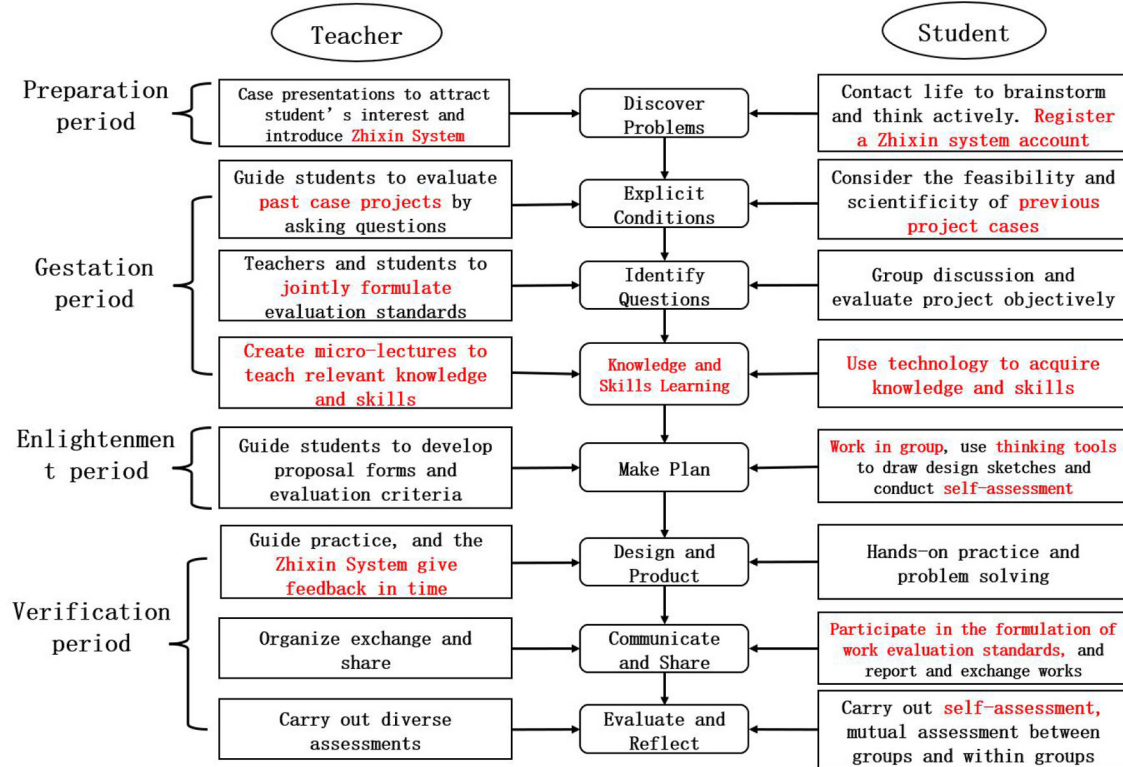


FIGURE 2 | General technology course teaching model based on the concept of maker education (after action research).

“Make Plan,” teachers guides students to carry out activities and conduct self-assessment. Through group cooperation, students are good at drawing design sketches by using mind map tools. In “Design and Product,” students practice according to the developed plan. The teacher is informed of the students’ situation in a timely manner and give feedback on Zhixin System. In “Communicate and Share,” teacher and students jointly formulate the evaluation criteria for works, and students report and exchange their works. In “Evaluate and Reflect,” teacher organizes multiple evaluations, such as mutual evaluation within the group, mutual evaluation between groups, individual self-evaluation, and teacher evaluation.

ANALYSIS OF THE APPLICATION EFFECT OF GTC TEACHING MODEL BASED ON THE CONCEPT OF ME

Experimental Procedure

The GTC teaching model based on the concept of ME has been improved through AR. In order to verify the effect of this teaching model on improvement of students’ creativity, this study adopts the quasi experimental research method. In this study, some freshmen in a senior high school in Guangzhou, China was selected to set up an experimental group (23 males and 20 females) and a control group (20 males and 17

females), and then we carry out a five-month teaching practice process to explore the effect of the recommended teaching mode. The experimental hypotheses designed in the paper are that: (1) the teaching activities designed under the guidance of the general technology-based creative teaching model can effectively improve students’ creativity; (2) the teaching of general technology under the traditional teaching model is not effective in enhancing students’ creativity. The adopted independent variable is the teaching activities guided by the general-purpose technology-based creator teaching model. The dependent variable used is students’ creativity (based on the Williams Creativity Tendency Test). The control variables used are the same level of creativity of the students in the experimental class and the control class before the experiment, and the same teacher in both the experimental and control classes.

A pre-test was carried out before the experiment, and no significant difference was found between the two groups ($Sig = 0.064 > 0.05$). When the experiment was carried out, the experimental group adopted the GTC teaching model based on the concept of ME, and the control group adopted the traditional teaching model. After the experiment, the students in the experimental group and the control group were get a post-test of creativity. Finally, the collected data are analyzed by SPSS.

Regarding the test of students’ creativity level, the scale used in this study is the well-known Williams Creativity Tendency Test, i.e., the *Williams Prefer Measurement (WPM) Forms* (Williams,

TABLE 2 | Summary of ANCOVA on students' creativity.

Post-test level	Experimental group (SD)	Control group (SD)	F
Adventurous	27.446 (0.106)	25.401 (0.114)	171.981**
Curiosity	36.029 (0.156)	33.290 (0.168)	141.191**
Imagination	30.691 (0.164)	28.089 (0.177)	113.165**
Challenge	31.072 (0.155)	28.565 (0.168)	116.885**
Total items	125.254 (0.331)	115.327 (0.358)	405.301**

** $p < 0.01$.

1993). The scale, which has good reliability and validity, was originally developed by Williams. In 1999, Taiwanese scholars Lin and Wang (1999) re-tested the reliability and validity of the scale in primary and secondary schools in Taiwan, and the re-test results showed that the scale had good reliability and validity. It has been widely used by researchers in various industries as a creativity test scale in various learning contents for primary, secondary and university students. Therefore, in order to demonstrate fairness and objectivity, we used the accepted WPM forms instead of other methods to verify the validity of our findings. The WPM forms includes all four dimensions that we are measuring. The scale consists of 50 questions, each of which can be selected from three options: "completely agree" (3 points), "partially agree" (2 points), and "completely disagree" (1 point). The scale includes four dimensions: adventurous, curiosity, imagination, and challenge. After the weighted calculation, the total score of the individual test can be obtained. The higher the individual's total score, the higher the level of creativity. After test, the coefficient of internal consistency and validity of structure for the perception survey of all participating students was acceptable with Cronbach's alpha equal to 0.915, KMO equal to 0.950. Therefore, we conclude that the perception survey was valid and reliable.

Data Analysis

The data analysis process includes: in order to verify the teaching model proposed in the research, firstly, data were analyzed by using analysis of covariance (ANCOVA) to determine any significant differences between the experimental and control groups by post-test scores with the previous test as a covariate. Secondly, data were analyzed by using Paired sample *T*-test to determine any significant differences between pre-test and post-test in experimental group or control group. The assumptions of ANCOVA were first checked to ensure that they were met in the analysis of covariance for these studies. Tests of the assumptions for ANCOVA and inferential statistical analyses were carried out using SPSS (Statistical Package for Social Sciences version 26.0). The results show no interaction between covariates and independent variables ($F = 2.621$, $p = 0.110 > 0.05$).

ANCOVA Between Experimental and Control Groups

Table 2 shows the results of ANCOVA and descriptive data analysis on students' creativity post-test scores. It is statistically

TABLE 3 | Paired sample *T*-test for each dimension before and after the test.

		N	Mean	Sig.
Experimental group	Creativity in pre-test	43	112.16	0.000**
	Creativity in post-test	43	124.91	
	Adventurous in pre-test	43	25.00	0.000**
	Adventurous in post-test	43	27.49	
	Curiosity in pre-test	43	32.56	0.000**
	Curiosity in post-test	43	36.35	
	Imagination in pre-test	43	26.65	0.000**
	Imagination in post-test	43	30.30	
Control group	Challenge in pre-test	43	27.95	0.000**
	Challenge in post-test	43	30.77	
	Creativity in pre-test	37	117.59	0.011*
	Creativity in post-test	37	118.05	
	Adventurous in pre-test	37	25.70	0.160
	Adventurous in post-test	37	25.76	
	Curiosity in pre-test	37	33.73	0.096
	Curiosity in post-test	37	33.86	
	Imagination in pre-test	37	29.00	0.044*
	Imagination in post-test	37	29.11	
	Challenge in pre-test	37	29.16	0.083
	Challenge in post-test	37	29.32	

* $p < 0.05$; ** $p < 0.01$.

indicated that the course taught using the GTC Teaching Model Based on the Concept of ME scored significantly higher than those taught using the traditional teaching method ($F = 405.301$, $p < 0.00$) (total items). Additionally, significantly higher achievement scores for the experimental group were also found at the Adventurous ($F = 171.981$, $p < 0.00$), Curiosity ($F = 141.191$, $p < 0.00$), Imagination ($F = 113.165$, $p < 0.00$), and Challenge ($F = 116.885$, $p < 0.00$). This shows that the GTC teaching model based on the concept of ME has significantly improved the creativity of students, including four dimensions of adventure, curiosity, imagination, and challenge.

Paired Sample *T*-Test Before and After Experiment

Based on SPSS (version 26), a paired sample *T*-test was performed on the pre-test and post-test of the experimental group and control group. The values obtained after the analysis are shown in Table 3. The results showed that there was an extremely significant difference between the pre-test and post-test of creativity in the experimental group. There was a significant difference in the control group. In the four dimensions of adventure, curiosity, imagination, and challenge, the experimental group also had extremely significant differences before and after the test, while the control group only had significant differences in imagination. This proves that traditional GTC can improve students' creativity, focusing on the improvement of imagination. By incorporating ME concepts and activities into GTC, students' creativity has been greatly improved. And the four dimensions of students' sense of adventure, curiosity, imagination and

challenge have also been extremely significantly improved. This shows that the GTC teaching model based on the concept of ME is more conducive to the cultivation of students' creativity.

CONCLUSIONS AND DISCUSSIONS

This research firstly integrates the theory of ME into GTC, and constructs the GTC teaching model based on the concept of ME. Secondly, through three rounds of AR, the teaching model is optimized. Finally, the quasi-experimental research method was used to apply the teaching model to teaching, which verified the feasibility and effectiveness of it. It found that the teaching model has greatly improved the creativity of students, and increased their sense of adventure, curiosity, imagination, and challenge greatly. The main reasons are as follows:

- (1) **Adventure:** The implementation of the GTC teaching model based on the concept of ME has created a "learner-centered" learning environment. The ME practice project encourages teachers to implement problem-based teaching, requires students to break the passive learning model under the traditional teaching system, and cultivates the ability to accept new knowledge and explore (Kai-Han et al., 2019).
- (2) **Curiosity:** The implementation of the ME model has brought new technologies and new systems to students, such as open-source software and hardware and Zhixin System, as well as knowledge and technologies outside the major, driving students' curiosity (Kai-Han et al., 2019).
- (3) **Imagination:** We have developed some projects to hone students' innovative thinking, such as brainstorming. In the third round of AR, thinking tools are introduced for design sketching, such as "Mind Map" and "Concept Map." These are all conducive to the divergent and convergent thinking of students and the main part of imagination cultivation (Moorman et al., 2017).
- (4) **Challenge:** The GTC in this study integrates multi-disciplinary content, including open-source software and hardware knowledge, programming knowledge and mathematics knowledge. New knowledge, new technologies, and new teaching model may impose cognitive load on students (Shadiev et al., 2019), thereby creating challenges for students. In general, under the support of the ME concept, students go through preparation, gestation, enlightenment, and the verification period in the teaching, and continue to design, produce, share, and communicate with their works, which improves their creativity. Some scholars have pointed out that creating meaningful products or social outcomes is the most effective learning experience (Kang and Yoon, 2017; Yoon, 2018). ME structures and systems knowledge and experiences as learners generate deliverables and share experiences (Kim et al., 2022). Thus, it is the integration of ME into GTC to create valuable products and share them through exchanges, which will help students master knowledge and improve creativity better.

APPLICATIONS AND PERSPECTIVES

Practical application value of this research:

- (1) Through three rounds of teaching AR, the Maker teaching mode based on the general technology can be used in General Technology curriculum teaching practice of cultivating students' creativity.
- (2) Maker teaching model based on general technology built in the paper can effectively improve students' creativity, cultivate the students' creative potential. The experimental results show that experimental class students not only master the basic knowledge and skills of general technology, master the general process and method of technical design, but will be trying to find a way to solve problems on their own when they encounter problems, which means that integrating the concept of ME into the General Technology curriculum has a great effect on the cultivation of creativity including adventure, curiosity, imagination and challenge.
- (3) The proposed Maker teaching model has certain application value to promote cultivating students' creativity in General Technology curriculum in the practice of teaching activities. Teachers should pay attention to the implementation of all aspects of GTC in daily teaching to enhance creativity.

However, due to factors such as time, space and resources, this study still has some shortcomings. Future research could focus on the following points:

- (1) This study did not analyze the effect of the recommended creative teaching model for developing learners' creativity on the gender of male and female students. There is some variability in the creativity of boys and girls. It is necessary for a deeper study on the impact of boys and girls, which is a direction for future research.
- (2) The general technology-based creative practice activities are relatively single. Due to the heavy academic burden of high school students and the limited time for extracurricular learning, the authors only designed the Arduino creator practice activities based on universal technology in this study. Because of the single practice activity, the persuasive power that the universal technology-based Maker teaching model can effectively enhance students' creativity is not enough. In the next study, other generic technology-based Maker teaching activities are added, and the generic technology-based maker teaching model is further improved in more practical activities.
- (3) Creativity results were only tested using a single scale and lacked a complete test of all aspects of creativity in the paper. In the follow-up research, theoretical tests and practical operation tests should be added to the test of students' creativity. The creativity test scale should be improved to reflect the creative personality traits of adventure, curiosity, imagination and challenge on the basis of the Williams Creativity Tendency Test for the specific content of practical activities, so that the creativity test scale can be more relevant

and convincing. Furthermore, enriching creativity testing methods and diversifying creativity evaluation methods make the research results more reasonable.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

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AUTHOR CONTRIBUTIONS

HW was responsible for thesis architecture design, theoretical design, implementation plan design, and thesis writing. YY was responsible for the implementation of three rounds of action research teaching activities and data collection. XL was responsible for classroom design and classroom observation and recording. ZL was responsible for diagram design and data processing, as well as thesis revision. YL was responsible for the investigation of relevant research status at home and abroad, including the research status of general technology teaching, maker education, and creativity cultivation. All authors contributed to the article and approved the submitted version.

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The Effectiveness of Inquiry and Practice During Project Design Courses at a Technology University

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Among the many teaching methods, inquiry-based teaching is considered to be an effective way for students to learn and solve problems on their own. However, most of the research related to inquiry-based teaching and learning has concentrated mainly on K-12 education, while few to no studies have focused on the application of inquiry-based teaching and learning in project design courses at university level. Therefore, in order to expand the understanding of the application effect of inquiry-based teaching at university level, this study adopted the quasi-experimental design method, and through the purposive sampling method, 20 students from the Department of Fashion Design at a University of Science and Technology were invited to participate in this study. During the 9-month period, teaching experiments were carried out using two inquiry models, QC/ADEAC and QD/ODEAC. First, when participants were thinking of a creative topic, they followed the process: Question (Q), Collection/Analysis (C/A), Discussion (D), Explanation (E), Amendment (A), and Confirmation (C) in the course. During the production process, the participants were allowed to improve on their work through the process of Question (Q), Doing/Observation (D/O), Discussion (D), Explanation (E), Amendment (A), and Confirmation (C). The teacher became a true guide, so that the participants could explore and work out how to improve their designs through independent inquiry and practice. In this study, questionnaires were administered to participants at five important stages of the design project: "theme development," "color development," "first Work," "second Work," and "third Work." The results of the five surveys showed that the participants' curriculum interest, curriculum value perception, and curriculum confidence in the inquiry program all increased.

Keywords: curriculum confidence, curriculum interest, curriculum value perception, fashion design, inquiry and practice, inquiry-based learning, project design, time series analysis

INTRODUCTION

In project design, students use a design and planning process to investigate a core problem, and learning occurs when students engage in a largely self-directed process that involves finding, coordinating, and selecting a functional solution to the problem (Hong et al., 2012). This is because students must be involved in the in-depth problem-solving process, which triggers progressive inquiry learning through the practical experience of solving contradictory problems (Muukkonen et al., 2005). In inquiry-based learning, the teacher's role is to guide students, help them practice

critical thinking, enhance their higher-level thinking and problem-solving skills, guide them to understand scientific concepts, and enhance their knowledge of the role of science process skills and their motivation to learn (Tseng et al., 2013).

Therefore, inquiry-based learning is considered an active learning method that has been shown to be beneficial for developing students' inquiry skills, and for improving their academic performance, engagement, and motivation (Kori, 2021). At the same time, inquiry-based learning helps learners develop the ability to work in complex and unpredictable environments, enabling them to become more critical thinkers and active learners (Suarez et al., 2018). Despite the benefits of using inquiry-based learning, it is still relatively uncommon for higher education institutions to use it compared to other educational levels (Kori, 2021).

Inquiry-based learning can best occur through project implementation (Wilhelm et al., 2008). Another concept that can be integrated with inquiry-based learning is topic-based learning (Kori, 2021). When people encounter a new topic, they try to understand it while also participating in it and looking back at what they know or need to know about the project in order to complete the topic (Hong et al., 2011). In topic-oriented learning, learners are usually more concerned with the final product, and the learning process follows more steps (Kori, 2021).

The purpose of inquiry-based learning is to engage students in the real process of scientific evidence, explicitly from a pedagogical perspective, by dividing the complex scientific process into small but logically connected units of learning, thereby drawing students' attention to the important details of scientific thinking (Pedaste et al., 2015). The main goal of classroom-based inquiry learning is to allow students to design their own experiments, collect data from the experiments, interpret the results, justify the conclusions with the results, and communicate the results of the experiments to others (Teig et al., 2018). In other words, inquiry-based learning is an approach that allows students to conduct their own scientific experiments to construct knowledge, rather than acquiring new knowledge directly from the teacher's lecture process (Jerrim et al., 2020), which shows that inquiry-based learning is a student-centered teaching method with many scientific evidence-based steps. However, the literature does not precisely define how inquiry-based learning is implemented, and learning models take many forms; inquiry-based learning is also related to other different learning strategies that include many modern teaching practices (Cairns and Areepattamannil, 2019).

Analysis of the literature on inquiry-based learning revealed that it is associated with many different learning and teaching strategies, including many teaching methods and types that are relevant to modern teaching practices, and for which different models and step-by-step processes can be found (Cairns and Areepattamannil, 2019; Kori, 2021). For example, a typical implementation of inquiry-based learning is through a semester-long course project (Mountrakis and Triantakoustantis, 2012). Project-based learning is a closely related application of inquiry-based learning in which students must complete research projects, and past experience in teaching project-based learning has taught instructors two things. First, students cannot be left

alone, but need active support and regular feedback; second, students need a clear structure and curriculum to orient their learning methods and tasks (Mieg, 2019).

This echoes Murphy et al.'s (2021) view that inquiry-based learning is defined in a variety of ways, but is often interspersed with terms such as hands-on activities, student-centered practices, and problem-based or topic-based learning. It is clear that project-based inquiry-based learning can help students define their learning methods and tasks, and engage in inquiry-based learning in a progressive manner. Therefore, this study adopted an inquiry-based learning approach based on the project. According to Tretter and Jones (2003), the implementation of inquiry-based learning can take different forms depending on classroom conditions. In essence, inquiry-based learning is the application of laboratory work to classroom learning. Therefore, in this study, we developed inquiry models applicable to project design in project design courses based on a circular model, and further explored the learning effects of their use.

Learning is motivating, and the more students believe they have learned, the higher their interest in participating in learning activities (Bulunuz et al., 2012). Thus, interest has many positive effects on learning processes and outcomes (Krapp, 2002), this is thought that interest may have an inspirational effect in guiding students to choose certain goals or in helping them to pursue them (Hui and Bao, 2013). Therefore, interest in learning is also considered as a motivation for learning (Ye et al., 2020), and a strong interest in learning activities is considered as an essential condition for learning (Hong et al., 2017). Dewey suggests that stimulating learners' interest is a better way to teach than forcing learners to take learning seriously (Chen et al., 2016). In addition, affective factors also influence students' motivation and effectiveness (Sara and Maria, 2013; Baars et al., 2017; Eckerlein et al., 2019), so understanding students' interest in inquiry-based learning courses will help to understand their motivation to learn, so this study considers interest in courses (affective factors) as one of the variables to be explored.

Perceived value refers to how important, interesting, and enjoyable students perceive an activity, as well as a subject or terminology (Mills and Moulton, 2017), so superficial learning strategies occur when students' perceived value of the curriculum is low (Floyd et al., 2009), and students' choice of learning environment may be influenced by students' perceptions of learning comfort (Clayton et al., 2018). Students' choice of learning environment may be influenced by the perceived value of the curriculum in terms of comfort (Clayton et al., 2018). Therefore, it is considered necessary to take into account students' perceived value when modifying the teaching process, since an increase in perceived value will increase students' propensity to continue learning (Dlačić et al., 2014).

Inquiry-based learning is considered a meaningful approach to learning, but it is more important to understand students' ideas about their interest in the curriculum and values, which are concepts or beliefs that are cognitive reflections of universal human needs (Schwartz, 1994), and values are ideas, principles, and rules that guide people's lives and that people accept, prefer, and consider important for judging and evaluating actions

(Knafo and Schwartz, 2004). Therefore, understanding students' perceived value of the inquiry-based learning curriculum will help to understand their recognition of the curriculum, so this study considers curriculum value (cognitive factors) as one of the variables to be explored.

Furthermore, self-confidence is a person's belief that he or she can succeed in the context of a particular task (Perry, 2011), and is considered an important component in the context of learner-centered learning and curriculum reform (MacLellan, 2014). Therefore, students' confidence in completing academic tasks can be a key factor in understanding student achievement behaviors and academic outcomes (Liem et al., 2008). This may allow students to believe in their own abilities, not to give up easily even when they encounter problems, to complete all tasks independently, and to gain the greatest sense of achievement (Safitri and Widjajanti, 2019). Whereas confidence may decrease depending on the content, topic, or situation being discussed (Perry, 2011). Students' self-confidence can be maximized through cognitive approaches (Liyadipita, 2021). Therefore, understanding students' self-confidence in the inquiry-based learning curriculum will help to understand their beliefs about their ability to participate in the curriculum, so this study includes self-confidence in the curriculum (cognitive factors) as one of the variables to be investigated.

Based on the above, the results of this study will help faculties in design departments understand how to effectively implement inquiry-based teaching methods in their courses. At the same time a time-series analysis questionnaire was also used to understand how learners' cognitive and affective perceptions changed during the implementation of this innovative teaching method. Based on the aforementioned research purposes, the research questions for this study are as follows:

Research Question 1: What are the application processes of "QC/ADEAC inquiry model" and "QD/ODEAC inquiry model" in the project design course?

Research Question 2: How effective is the application of inquiry teaching method in the project design course of University of Science and Technology?

LITERATURE REVIEW

Inquiry-Based Learning

Inquiry generally refers to a range of educational approaches with some key common features, including a curriculum that actively considers students' interests, and students asking questions and conducting authentic, discipline-based, or interdisciplinary individual or group extension units (Borovay et al., 2019). During the investigation phase, students identify issues related to the problem by designing the investigation, conducting experiments, and interpreting and evaluating the results (Teig et al., 2018). Interpretation involves thinking, feeling, and reacting in ways that are both cognitive and emotional, providing a way to determine how individuals experience the world and make sense of those experiences (Hong et al., 2011). Therefore, this is another important process of inquiry in addition to exploring the problem.

Hong et al. (2019) found different descriptions of the inquiry models presented by different researchers using various terms to mark very similar stages. However, it is important to design an inquiry model that can be simplified to actually be conceptually independent. Inquiry-based learning is often organized into inquiry phases that together form an inquiry cycle (Pedaste et al., 2015). After Hong et al. (2021) reviewed all of the inquiry-based learning stages, they concluded that different inquiry models are applicable to different types of learning content. For example, Yang et al. (2021) proposed the QODE model based on an online inquiry-based learning approach which includes Questions (Q), Observation (O), Doing (D), and Explanation (E), and other processes. Fan and Ye (2022) proposed the QC/ADEAC model based on an online inquiry-based learning approach which includes Questions (Q), Collection/Analysis (C/A), Discussion (D), Explanation (E), Amendment (A), and Confirmation (C). Hong et al. (2019) proposed a POQE model based on the characteristics of the course platform, including Prediction (P), Observation (O), Quiz (Q), Explanation (E), and other processes. In addition, Hong et al. (2020) also proposed a PD/OQ/DE/T model based on a generic inquiry-based learning approach which consists of a Prediction (P)—Doing/Observation (D/O)—Question/Discussion (Q/D)—Explanation/Transfer (E/T) process. The investigation model developed in this research will be based on the above-mentioned investigation model.

Curriculum Interest

Interest has been conceptualized as the mental state of engaging with specific types of objects, events, or ideas over time (Hidi and Renninger, 2006) and as the person-object relationship that leads to engagement or re-engagement, and on topics related to abstraction and knowledge-based learning. Learner interest has been identified as a key indicator that facilitates motivational processes (Schrader et al., 2021). The necessary condition for learning is that students develop a strong interest in the learning activity (Hong et al., 2017). Therefore, whether students have a strong interest in the inquiry and hands-on curriculum is one of the indicators of successful teaching of the new curriculum approach. Based on this concept, this study examined students' perceived interest in the curriculum when they participated in inquiry-based learning.

Curriculum Value Perception

Value assessment is the subjective value students place on a learning activity, outcome, or domain (Pekrun et al., 2011). Therefore, students' evaluation is an important variable in promoting learning (Özgüngör, 2010), so when modifying the teaching process, tertiary institutions need to consider students' perceived value, and an increase in perceived value also increases the propensity to continue learning (Dlačić et al., 2014). Therefore, for the inquiry and practice courses that belong to innovative teaching, understanding the value of the course as perceived by students will help to expand the understanding of the benefits of the course. Students' perceptions of the value of the curriculum when they participate in inquiry-based learning were measured based on this concept.

Curriculum Confidence

Confidence is an individual's belief in his or her own ability to predict future performance (Hong et al., 2017). Maclellan (2014) suggested that confidence is a component of each individual's self-expression that plays a role in a range of performance indicators and is related to the impression, content, or situation of an individual's competence in a particular domain. Confidence is an emotional construct which implies that a person who knows what to do and how to do it believes that he/she can accomplish tasks and maintain positive outcome expectations (Stajkovic, 2006). Therefore, participants' confidence in inquiry and practical work will affect their success in inquiry-based learning. Therefore, based on this concept, this study examined students' perceptions of their confidence in participating in inquiry-based learning in the curriculum.

RESEARCH DESIGN

Method

For ethical or budget reasons, random assignment in teaching practice is usually not feasible, and when randomized experiments are not feasible, a quasi-experimental design approach can be used instead to evaluate the experimental effects (Kim and Steiner, 2016). In the quasi-experimental design, the one-group time-series analysis of the single-group quasi-experimental design has multiple measurement time points in the whole experimental process. The researcher inserted an experimental treatment at one of these time points to observe changes in the subjects at each time point, which is thought to be particularly applicable to evaluating ongoing instructional programs in schools (Johnson, 1986). In addition, the single-group quasi-experimental design does not reduce its validity compared to the two-group design (Yin, 2003). Thus, the use of single-group quasi-experimental design in teaching experiments is an effective research method to help solve the problem of having too few participants or not being able to implement traditional experimental designs. Therefore, this study adopted the quasi-experimental design method of a single group, and the teaching experiment lasted for 9 months. In order to understand the cognitive and emotional state of participating in the inquiry-based learning course, this study adopted the self-report method of the participants filling out questionnaires, to see their perceptions of the inquiry-based learning curriculum during the 9-month teaching experiment.

Teaching Model

The creative design process can be described as an iterative and cyclical process in which the different stages—conceptualization, experimentation, reflection, and revision—are mixed and repeated, and through which students find design ideas and develop these ideas until the desired design creation is realized (Seitamaa-Hakkarainen et al., 2001). The creative design process is similar in many ways to a step-by-step inquiry-based process. Therefore, this study explores the development of the model by combining the creative design steps proposed by Seitamaa-Hakkarainen and the following related literature.

Hong et al. (2019, 2020), Yang et al. (2021), and Fan and Ye (2022) proposed inquiry processes echo Tretter and Jones' (2003) and Murphy et al.'s (2021) suggestion that inquiry-based experiences present different steps and approaches depending on classroom conditions. However, what remains unchanged is that in the inquiry-based learning method, the teacher always plays the role of supporting learning, while students actively build their knowledge base through the process of searching for information, asking questions, and finding answers; the inquiry-based learning process therefore also includes the process of collecting and analyzing data (Chu et al., 2011). Aditomo et al. (2013) argued that inquiry-based learning is knowledge construction driven by questions, which means that students must conduct some kind of investigation in order to solve the problem, and this concept is the basis of the analysis step. The analysis step is crucial for project design, so this process step was included in the investigation model developed in this study.

In addition, Xenofontos et al. (2020) indicated that the core components of the inquiry cycle are carefully choreographed because the stages and steps have interrelated concepts. Hsiao et al. (2017) also proposed an inquiry model design based on a circular inquiry model that could help students construct knowledge through repetitive steps. Therefore, in this study, the design of the inquiry history was based on the cyclic inquiry model. In addition, the QODE inquiry model of Yang et al. (2021) and the QC/ADEAC inquiry model for thematic development in design departments of Fan and Ye (2022) were used as the basis for the development of the inquiry model. This study combined the above concepts and was guided by three experts with backgrounds in both technical and vocational education and design education to develop the “QD/ODEAC inquiry model” for practical application and verify the two models. In addition, since the QC/ADEAC and QD/ODEAC model of inquiry, the former focuses on design ideas while the latter focuses on practical work, and the implementation steps are slightly different, meanwhile this study applied both of them.

The steps of the “QC/ADEAC inquiry model” applied to the development of the topic include: Question (Q)—students explore what direction they want to design and create based on the theme of the graduation exhibition; Collection/Analysis (C/A)—students perform data collection and analysis based on the relationship between the creative questions and the theme of the graduation exhibition; Discussion (D)—students explain and discuss their ideas with the instructor based on the results of their data analysis; Explanation (E)—the instructor explains the analysis errors or imperfections of the problem in the results of the student inquiries, that is, the relevant design principles implied in the development; Amendment (A)—students reanalyze the errors or imperfections according to the feedback from the instructor; Confirmation (C)—after students have made corrections, they confirm to the instructor that the corrections are correct, as shown in **Figure 1**.

The QD/ODEAC inquiry model for practical work consists of: Question (Q)—students explore what process they would like to use based on their own design direction; Doing/Observation (D/O)—students conduct practical work on different craft techniques and observe whether the best effect is presented by

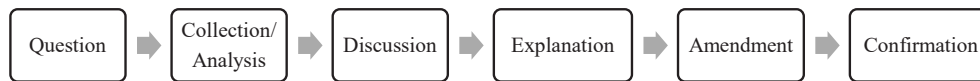


FIGURE 1 | The QC/ADEAC inquiry model.

the technique they want to use; Discussion (D)—students and the instructor discuss the results of their practical work and observations; Explanation (E)—the instructor provides feedback on the rationality of the design based on the content of the students' explanations and suggests ways to improve the quality of the work; Amendment (A)—students rework their works based on feedback from the instructor to address errors or imperfections; Confirmation (C)—students correct the work and confirm to the instructor that the corrections are correct, as shown in **Figure 2**.

Teaching Implementation

While executing project design, students may find and solve many problems. In this approach to learning, students are usually asked to complete a task and must investigate and explore the causes behind the problem themselves to produce a complete design. Therefore, at the beginning of the semester, the study first announced the concept of this inquiry-based learning curriculum (i.e., students are the main actors of independent knowledge inquiry and teachers are the supporting actors of knowledge absorption) according to the principle that students were free to choose to participate in this study's inquiry-based learning design project curriculum, which was designed to motivate more students to join by gaining a sense of commitment from students and teachers. In addition, the study also addressed the issue of attendance and teaching practices by keeping the number of participants within a manageable range.

The project design program was designed to guide students in the production of fashion accessories such as bags, shoes, and boots for their graduation exhibitions. During the summer and fall semesters, 36 weeks (9 months), the researcher conducts inquiry and practical courses in the project design program at the school where the teacher teaches, with two 100-min sessions per week.

This course mainly used the QC/ADEAC and QD/ODEAC inquiry models to guide students through the complete project design process from theme, inspiration (including developing imagery and color schemes to match the theme), personal creativity and style (including drawing design drafts, developing plates, finding suitable materials, making models, and finished products), and presentation (displaying exhibition boards, design drafts, models and finished products).

Participants

The participants in this study were 20 students from the Department of Fashion Design at a University of Science and Technology in southern Taiwan, including four male and 16 female students. In this study, the gender imbalance is due to the fact that the majority of students in fashion design majors in Chinese communities are female.

Measurement

This study collected data through a questionnaire, which was adapted from previous research instruments, and was subjected to a two-round content validity review by three experts with expertise in inquiry-based learning to confirm the integrity of the questionnaire content and the comprehensibility of the text. The Likert 5-point scale (1–5 for *strongly disagree* to *strongly agree*) was used to measure students' perceived curriculum interest, value, and confidence in participating in the course through inquiry and practice.

Curriculum Interest

This study modified Hong et al.'s (2014) interest scale with nine items to measure participants' perceived interest in an inquiry-based and hands-on thematic design course. An example item is: "I find this way of teaching very interesting." The Cronbach's alpha value for this scale was 0.81, the CR value was 0.85, the factor loading values ranged from 0.67 to 0.98, and the AVE value was 0.66.

Curriculum Value Perception

This study referred to and modified Nguyen et al.'s (2021) activity value scale with five items to measure participants' perceptions of the value of the curriculum based on inquiry and hands-on design of the project. An example item is: "Attending this course has enhanced my ability to expand my thinking and inferencing." The Cronbach's alpha value for this scale was 0.83, the CR value was 0.88, the factor loading values ranged from 0.76 to 0.80, and the AVE value was 0.61.

Curriculum Confidence

This study revised Hong et al.'s (2017) inquiry-based learning confidence enhancement scale with six items to measure participants' perceived confidence in the curriculum of the topic design after participating in inquiry-based and hands-on work.



FIGURE 2 | The QD/ODEAC inquiry model.

An example item is: “Designing projects through inquiry-based learning has given me more confidence in understanding the content of the projects.” The Cronbach’s α value for this scale was 0.97, the CR value was 0.98, the factor loading values ranged from 0.95 to 0.96, and the AVE value was 0.91.

RESULTS

Reliability Analysis

In this study, the internal consistency of the scale was confirmed by Cronbach’s α . Hair et al. (2019) suggested that Cronbach’s α should be higher than 0.70 to meet the acceptable standard. The Cronbach’s α values in this study ranged from 0.94 to 0.98, which met the recommended standard, as shown in **Table 1**.

Time Series Analysis

A time-series analysis was used to examine the learners’ affective performance in theme development (first survey; course month 2.5), color development (second survey; course month 3.5), first piece of work (third survey; course month 5.5), second piece of work (fourth survey; course month 7), and third piece of work (fifth survey; course month 9). In all five surveys, the participants’

perceptions of the three dimensions remained above 4 (satisfied), which means that they maintained positive feelings toward the course throughout the 9 months. The fifth survey on learners’ perceived interest in the course increased by 0.31 on average compared to the first survey; the fifth survey on perceived value of the course increased by 0.21 on average compared to the first survey; and the fifth survey on perceived confidence in the course increased by 0.20 on average compared to the first survey, as shown in **Figure 3**.

Project Design Template

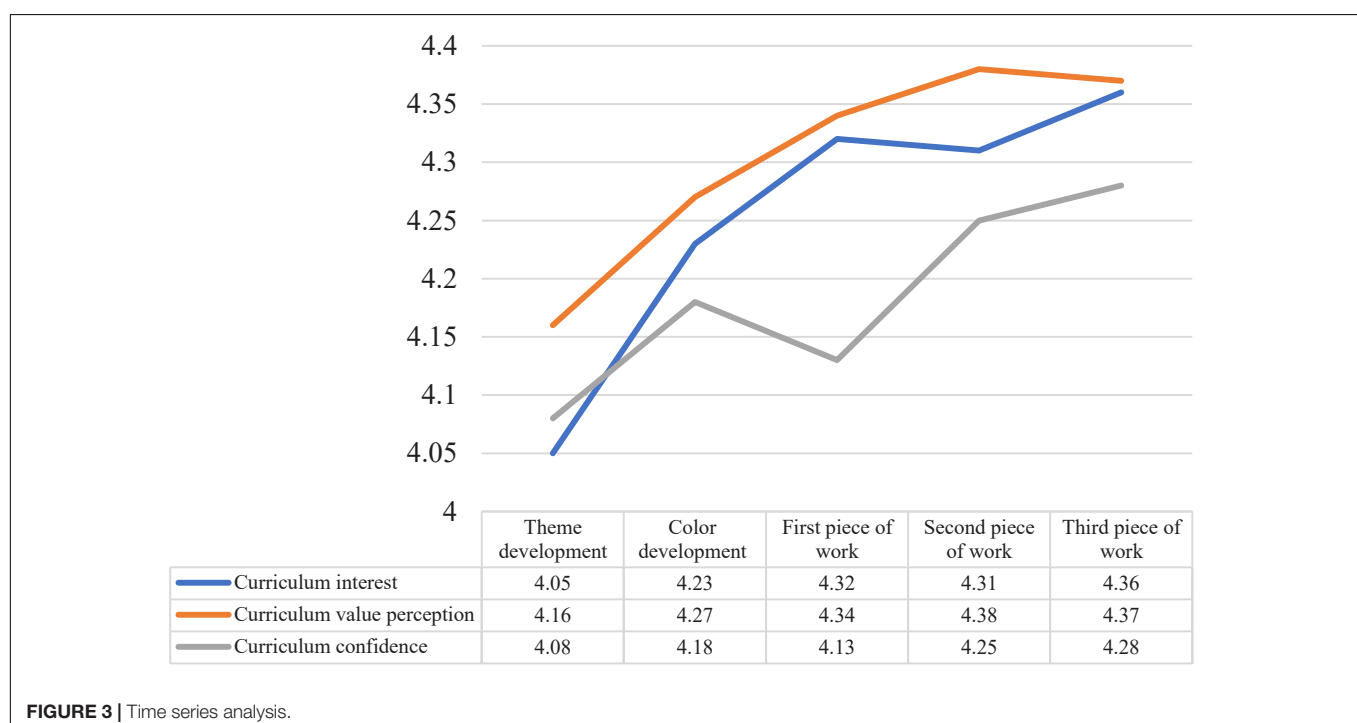
The project was designed in five stages. The QC/ADEAC inquiry model was used in the two stages of “theme development” and “color development.” The QD/ODEAC inquiry model was used in these three phases of the implementation of “first piece of work,” “second piece of work” and “third piece of work.” However, due to the limitation of space, only one student (hereinafter referred to as Student A) is listed as an example in this study. In addition, due to space limitation, this study only used theme development to demonstrate the QC/ADEAC inquiry model and did not repeat the color development example.

Theme Development of the QC/ADEAC Inquiry Model

In the first 10 weeks of the first phase of this study, the QC/ADEAC inquiry model was used to develop student themes in six stages. In the first stage, “Question,” students were given a design creation question and were asked to confirm their design theme at the end of the sixth stage, “Confirmation.” In this study, the QC/ADEAC inquiry model of the students in this course was summarized and analyzed step by step.

TABLE 1 | Reliability analysis.

Constructs	<i>M</i>	<i>SD</i>	Cronbach’s α
Curriculum interest	4.36	0.66	0.97
Curriculum value perception	4.37	0.64	0.94
Curriculum confidence	4.28	0.72	0.98

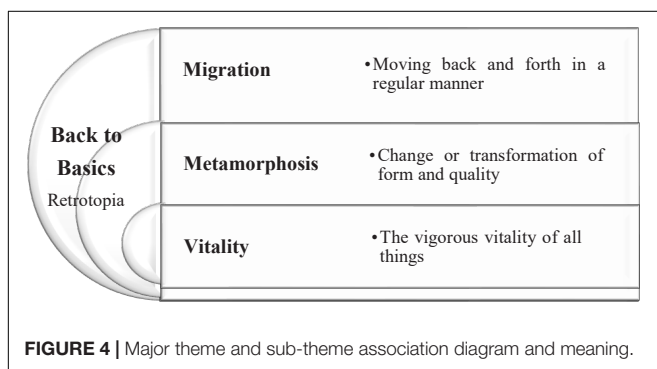


Question

After the first 3 weeks of course development and student voting, the major theme of the graduation exhibition was determined as “Back to Basics, BB,” and the three sub-themes were “Migration, MGN,” “Metamorphosis, MTPH,” and “Vitality, VTL,” with **Figure 4** as its association map and meaning. In the first step of inquiry-based teaching, “Question” refers to “How should students develop their own creative themes based on the major theme?” The first step of the inquiry-based instruction is “How should students develop their own creative themes based on the major theme?”

Collection/Analysis

In order to develop a personal theme that fits the major theme and the three sub-themes of the Graduation Exhibition for the Class of 2022, students first collected data online using documentary analysis, searched for inspiration, conducted idea searching and idea generation, and then explored their personal themes by using



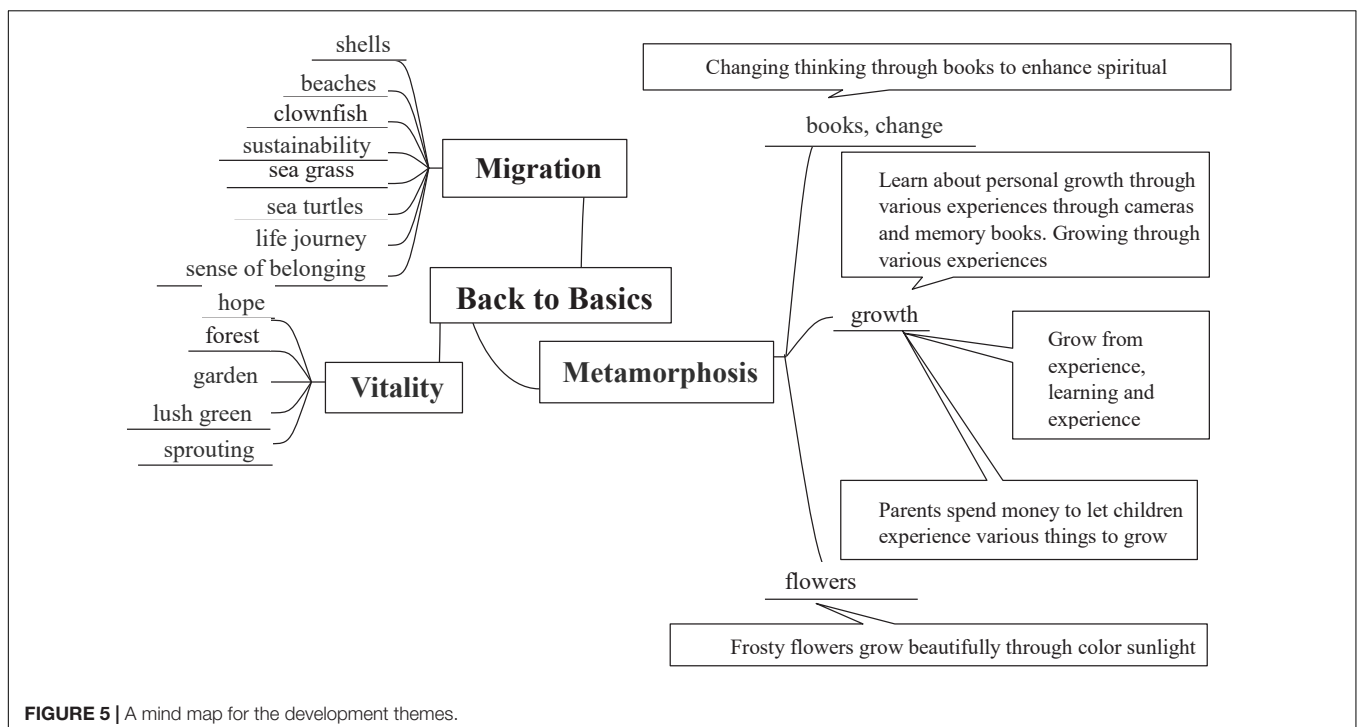
the mind mapping method, using “key words” and “radioactive structures” to draw a mind map by hand. The XMind 8 Update 9 software was used to create a mind map of the development of Student A’s theme, which can be seen in **Figure 5**.

Discussion

Student A used the data from the “Collection/Analysis” to develop a mind map of her theme, analyze the relevant literature (including text and graphics). The researcher asked Student A to present the collected data. Student A was asked to think about how to organize and summarize these materials. She was then asked to re-examine her thematic developmental mind map, from which she found the most data representing the sub-theme of “metamorphosis” and wanted to “combine it with the image of frosty flowers melting in winter to show the different characteristics of human beings after growing up.” In this stage of the inquiry process, Student A continued to analyze and interpret the data and wrote down her initial decision actions based on the key words needed for the development of her theme.

Explanation

At the end of each week, students were asked to write a report on the “project design inquiry and practical course learning record report” designed by the institute and upload it to the university’s online platform. The researcher reviewed Student A’s learning record after the previous lesson and found that she wrote down the key words required for the development of the theme “growth, change, books, flowers,” and initially developed the theme “frost * bloom.” The flowchart and related words, phrases, and sentences are shown in **Figure 6**.



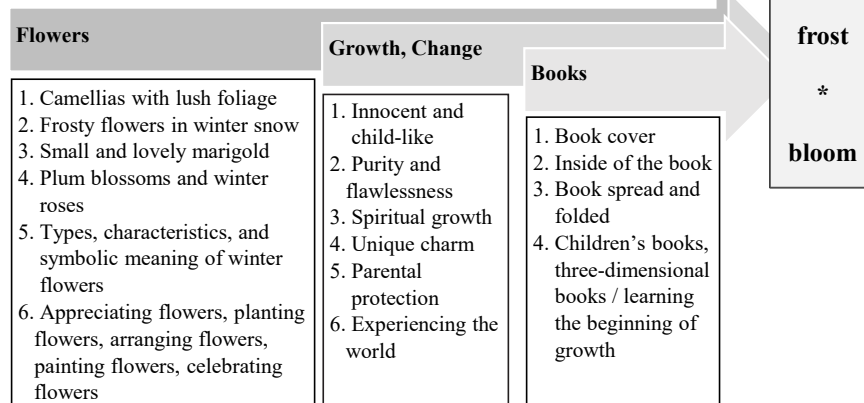


FIGURE 6 | Flow chart for the development of student A's initial theme.

Amendment

Student A used “Winter Flowers,” the most popular theme in the previous phase of development, as a concept revision theme and hand-drew a fishbone diagram to develop a thematic network focusing on winter flowers. I We used the XMind 8 Update 9 software to draw the fishbone diagram of student A's correction theme, as shown in **Figure 7**. We found that the student focused the thematic development on the concept of “winter flowers.” Therefore, it was recommended that she explore and develop the theme directly from this.

Confirmation

The researcher reviewed Student A's “project design inquiry and practical course learning record report” on the theme of exploring and revising the content related to “winter flowers,” which mentioned that:

“Through the gradual receding of the frost and snow that covers the plum blossoms in late winter and early spring after being nourished by sunlight, we compare the process of human growth and metamorphosis, and transform it into a creative inspiration for our works.”

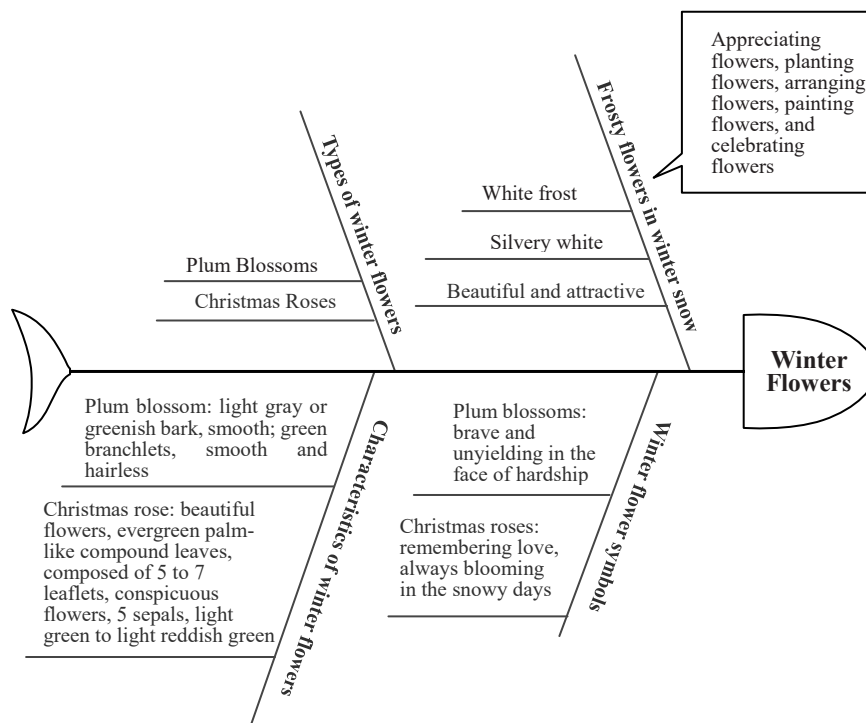


FIGURE 7 | Student A's correction theme of the fishbone diagram.

Student A also took the symbolic meaning and shape of plum blossoms and presented her bag creation in a way that “the emotion is in the scene,” using both flat and three-dimensional compositions to create a “late winter and early spring, when the sunlight penetrates the sky, and the frost and snow recede as the weather warms up, and the flowers gradually reveal their colors.” As a result, student A decided on the theme of “Winter Flowers.” In addition, after deciding on this theme in week 10, Student A continued to search for imagery, develop a color scheme, and draw a design based on the theme, all following the “QC/ADEAC inquiry model.”

The QD/ODEAC Inquiry Model of Work Production

In the first 18 weeks, Student A developed their themes in the “QC/ADEAC inquiry model” and decided on the theme of their graduation exhibition, “Winter Flowers,” then searched for imagery, developed color schemes, drew designs, and finalized the project. In the following 18 weeks, the first work, the second work, and the third work were developed in the “QD/ODEAC inquiry model” based on the finalized design, and the three works for the solo exhibition were finalized. The following is a step-by-step analysis of the development and production of Student A’s first work using the “QD/ODEAC inquiry model.”

Question

Student A confirmed the theme of her graduation exhibition as “Winter Flowers,” and the imagery of the theme was interpreted as “The flowers in the late winter gradually bloom with their own unique colors under the nourishment of warm light, just as people change their thinking through learning, knowledge brought by education and books, experience and physical transformation, and reveal their different qualities.” The first step of the “QD/ODEAC inquiry model,” “Question,” is “How can I integrate the concept of book opening and closing into bag design and production?” The first step in the QD/ODEAC inquiry model was “How can I integrate the concept of book opening and closing into bag design and production?”

Doing/Observation

At this stage, student A first drew the design, during the drawing process, and were required to refer to different data and paper models or prototype production, and compare their characteristics with the combination of the results, in order to confirm the most suitable design or production results. In addition, student A used the Adobe Illustrator vector graphics software to simulate the first piece of artwork based on the final draft of the design of “Winter Flowers,” as shown in **Table 2**.

The mock-up process must consider the bag opening structure, function, material, hardware, manufacturing method,

and so on, and constantly observe and compare the various considerations that bag professionals will make before producing the finished product.

Discussion

Student A used Adobe Illustrator vector graphics software to simulate the first piece of work, in order to consider all aspects of the design before it is produced by bag professionals. Student A discussed with the researcher from design to pattern making, the physical properties of leather and other materials in relation to pattern making, the correlation between the thickness of leather and pattern making, the comprehensive analysis of processing techniques, the correlation between hand stitching or sewing stitches and needle adjustment, the choice of machine, and the correlation between the structure of leather parts and the type of sewing machine.

The researcher asked student A to define the width, depth, and height of the bag according to the design, and to think about the structure of the pattern before making the layout. It took a long time to make the plates, and the teacher kept checking and giving appropriate suggestions during the process. Student A mainly used the computer to open the plates and output each plate, and then tried to make paper molds with white newsprint. In this process student A repeated the cycle of “open plates→make paper molds→correct the plates→correct the paper molds” and kept observing and comparing whether the paper molds made for the bag corresponded to the design draft and had the function of opening and closing like a book. **Table 3** shows the paper bag mold for Student A’s “Winter Flowers.”

Explanation

Student A completed the paper model of the bag in the previous stage, and the exhibition plate and paper model were examined for the first time. The judges gave the following suggestions.

“The shape is original, the structure is quite creative, the material is not yet defined and the structure is reasonable.”

The process of exploring the design to the pattern and paper mold in the previous stage helped Student A choose the thickness and type of leather, hardware, and other sub-materials, and then confirm the processing technology of this bag. In the “project design inquiry and practical course learning record report” feedback, the student noted:

TABLE 2 | Student A’s final draft design, “winter flowers.”








Item	Front view	Side view	Overhead view	After closing
Design draft				

TABLE 3 | Student A’s “winter flowers” paper bag mold.

Front view	Side view	Overhead view
		
Size: Width (W.) × Depth (D.) × Height (H.) = 21 cm × 68 cm × 35 cm Strap Drop = 20 cm.		

“Because the teacher’s advice gave me a direction to look in, I also discovered many materials that I hadn’t used before, and the material cost a lot of money.”

Amendment

Student A first encountered many difficulties in the development of the plate, for example, the original manual development, but could not accurately produce the book opening and closing functions, and because of the complex structure of the bag, changed to a computer development plate. Next, she chose cowhide as the main material to make the front and back pieces of the bag, but because cowhide is not easy to shape, it could not create the effect of a book opening and closing, and so she changed to using washed kraft paper.

Student A gave the following feedback in the “project design inquiry and practice course learning record report”:

“The production process was difficult, but fortunately I didn’t give up, because I didn’t need to consider the inside when making the paper mold, and I added the inside to the finished product, so I thought a lot about “how to make the inside” during the process.”

After completing the first product and going through the third review, Student A discussed with the instructor to revise the product in response to the reviewers’ suggestions.

Confirmation

Student A’s finished product is shown in **Table 4**. In addition, she wrote down her creation experience in the “project design inquiry and practical course learning record report”:

“The work was created by observing the surrounding things. Due to the complex layout, it was mainly carried out in the way of computer printing. When making the work, I encountered difficulties again and again, and the process of solving them one by one constantly improved the details. Various bag-making techniques were used to make the work appear.”

Examples of the Work

In this project, each student was asked to design a series of three pieces of artwork based on the major theme of the graduation exhibition, and they were judged by internal and external design experts. Twenty students who participated in this inquiry-based teaching program passed the review. In project design, students need to apply higher order cognition, a neurodevelopmental function consisting of a complex set of thinking skills including concept acquisition, systematic decision making, evaluative thinking, brainstorming (including creativity), and rule use (Levine, 2009), in order to produce creative work. In addition,

teachers who encourage active discussion among students during lessons can enhance students’ higher levels of cognition (Dubey and Dubey, 2017). The students in this study used verbal and non-verbal language to describe or reflect on concepts, choose appropriate strategies and think flexibly to solve problems in the design process, and generate ideas through brainstorming to complete their personal work. Therefore, in this study, these works, which were reviewed and approved by internal and external experts, were considered as a cognitive expression of inquiry-based learning. A sample of related works is shown in **Table 5**.

Discussion




Research Question 1: What Are the Application Processes of “QC/ADEAC Inquiry Model” and “QD/ODEAC Inquiry Model” in the Project Design Course?

Pedaste et al. (2015) suggested that from a pedagogical perspective, complex scientific processes that are divided into subtler and logically connected steps can guide and draw students’ attention to important features of scientific thinking. Therefore, the step-by-step inquiry model can help students to conduct an in-depth scientific inquiry. In addition, because design creation requires continuous experimentation to find the best and most appropriate effect, the design process also involves repetition. Thus, in this study, the QC/ADEAC inquiry model and the QD/ODEAC inquiry model were designed for

TABLE 5 | Examples of the work.

No.	Front view	Side view
1		
2		
3		
4		
5		
6		

TABLE 4 | The first finished product of “winter flowers” by student A.

Front view	Side view	Overhead view
		

Size: Width (W.) × Depth (D.) × Height (H.) = 21 cm × 68 cm × 35 cm Strap Drop = 20 cm.

the two major stages of thematic development and practical work of thematic design, which are effective in the “inquiry-based” design creation process. The two models adopted in this study were also consistent with Cairns’ (2019) argument that the active, more self-directed, and student-centered nature of inquiry-based learning allows students to be participants in knowledge generation rather than being passive recipients of knowledge. It also implicitly engages students in the scientific investigative skills that are prerequisites of equipment use, data generation and processing, and reasoning (Cairns, 2019). In summary, this study identified a model of inquiry that is applicable to each project design phase at a University of Science and Technology.

Research Question 2: How Effective Is the Application of Inquiry Teaching Method in the Project Design Course of University of Science and Technology?

Inquiry teaching can produce positive cognitive and affective outcomes (Borovay et al., 2019). Therefore, in this study, questionnaires were administered to participants at five important stages of the design project: “theme development,” “color development,” “first Work,” “second Work,” and “third Work.” The results of the five surveys showed that the participants’ curriculum interest, curriculum value perception, and curriculum confidence in the inquiry program all increased. In the last survey, the participants’ perceptions of curriculum interest, value, and confidence in inquiry were all greater than 4.0, which mean that the participants recognized the positive learning benefits of the inquiry model in the project design curriculum.

This is in line with previous literature such as Hong et al. (2017), who stated that a necessary condition for learning requires a strong interest in the learning activity. When the brain makes a connection between the activity that elicits interest and positive feelings, this makes us want to repeat the behavior (Bressler et al., 2021). However, interest can, over time, engage specific types of objects, events, or mental states of ideas (Hidi and Renninger, 2006). A great interest in learning can contribute to success in a variety of domains (Zheng, 2021).

Mansour (2015) noted that the value of inquiry-based learning for student learning and engagement in science classrooms is increasingly recognized. Value assessment is considered to be the subjective value that students place on a learning activity, outcome, or domain (Pekrun et al., 2011), so when learners perceive a higher level of value, it indicates a higher level of recognition of the curriculum activity. The results of this study showed a high level of perceived curriculum value, which means that participants recognize the project based on the inquiry and practical model.

Moreover, confidence is considered as various beliefs of someone that recognizes his/her ability and competence in a particular academic subject (Sheldrake, 2016). Therefore, confidence should be considered as a student’s quality in which the student believes that he/she has the confidence to successfully complete different activities inside and outside the classroom

in order to achieve the learning objectives. Confidence then affects the success of students’ learning process and outcomes (Kapur, 2008).

In addition, this study pointed out the influences of confidence in the learning process, which refers to how students’ learning changes when they experience high or low confidence (Akbari and Sahibzada, 2020). As shown in **Figure 3**, the participants in this study had consistently high levels of confidence in the inquiry and practical project design course.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Although problem-based learning and topic-based learning are often used in the design field at universities of technology, the concept of “inquiry-based” is less commonly mentioned and few studies have been conducted on it. The development of an inquiry-based approach to the design field will facilitate the implementation of inquiry-based teaching in this field. Therefore, this study developed and verified the inquiry models based on the concept of cyclic inquiry learning. When students made memory or comprehension errors in the project design, they could use this approach to provide immediate feedback which helped them to correct themselves. The development of an inquiry teaching model applicable to the design field is also one of the contributions of this study. On the other hand, the results of the analysis showed that the students were positive about this learning model and it helped them to improve their confidence in inquiry. It also indicated that they had a deeper understanding of the QDEAC science concepts and knowledge, and gradually improved their learning effectiveness in project design (design creation) through the inquiry-based activities they participated in.

Newton and Tonelli (2020) suggested that inquiry based on a practical curriculum is a way for students to find their own answers, correct misconceptions from mistakes, and then share what went wrong and how to improve. While inquiry-based learning is the ideal learning principle for higher education, it depends on students’ motivation and independence to achieve self-constructed knowledge. Therefore, in order to maximize students’ knowledge inquiry, the instructor played the role of a facilitator throughout the 9-month teaching period to help students construct their own knowledge.

During the implementation of this study, we found that the “QC/ADEAC inquiry model” for theme development and the “QD/ODEAC inquiry model” for artwork production can develop students’ abilities of “problem identification,” “planning and research,” “argumentation and modeling,” and “presentation and sharing.” For example, in the “Question” and “Collection/Analysis” stages of theme development, students developed their own theme for their graduation exhibitions based on the major theme, and had to observe social phenomena, collect information on popular trends, and so on. Through the process of collecting information, reading, and discussing, students

proposed appropriate design inquiry questions and came up with their own ideas for their graduation exhibition themes.

In the “Question” and “Doing/Observation” stage of the work production, students used the Adobe Illustrator vector graphics software to simulate their first work by considering the bag opening structure, function, material, hardware, production method, and so on, and constantly observed and compared the various considerations that bag professionals make before producing the finished product. The students were able to observe and compare the various considerations that bag professionals make before they produce the finished product, which cultivated the students’ ability to “find problems.”

In the “Collection/Analysis” stage of theme development, students used the appropriate tool of mind mapping to draw up a personal theme development plan, collect data continuously, design an appropriate recording format and record each idea in detail, and to plan appropriate methods, materials, and processes according to the questions raised by the teacher. In the “Doing/Observation” stage, students were required to work on different techniques and observe whether the best results were achieved by the techniques they wanted to use. In the “Discussion,” “Explanation,” and “Amendment” stages of theme development, students analyzed and interpreted data, created a flow chart of theme development based on the collated data, collected data systematically with a fishbone diagram, examined the most appropriate conditions, proposed conclusions or solutions based on them, and finally developed and established their own graduation theme. In the “Discussion,” “Explanation,” and “Amendment” stages, students used the Adobe Illustrator vector graphics software to simulate their first work, develop a layout, make a paper model, and finally complete the final product.

During the “Discussion,” “Explanation,” “Amendment,” and “Confirmation” stages of theme development and production, students presented their inquiry results in a structured manner, used various resources to share information with others, used symbols or models to present their inquiry process and results, and used oral, written, and multimedia expressions appropriately to present their inquiry process and results. In the process, they collaborated and discussed with their peers, listened to others’ reports, provided specific comments to evaluate their peers’ inquiry processes, results, or models, and proposed reasonable improvement plans. In addition, in the fifth stage, “Amendment,” and the sixth stage, “Confirmation,” students proposed ideas or models based on the selected questions, evaluated and judged various types of information, and critically examined their applications.

Recommendations

Summarizing the above findings and conclusions, this study recommends the following.

The Instructor Needs to Adopt a Variety of Strategies to Enhance Learners’ Ability to Deconstruct the Problem

Inquiry-based learning is defined as instruction that presents students with a specific challenge, through which they can learn

to acquire a great deal of information, record their personal learning, and explore the problem by setting up a path to find a solution. However, when students encounter problems during the implementation process, they must have the basic knowledge, concepts, and abilities to overcome and complete the tasks. Although much information is available through the Internet, instructors need to adopt a variety of strategies to enhance learners’ problem-solving abilities, and to enable them to learn how to harness and apply the knowledge.

The Future Research Target Can Be Extended Downward and Expanded to Different Education Levels

The circular inquiry learning method was effective in terms of helping the design students in this study improve the completeness of their project designs, and the students affirmed that this learning mode helped them to improve their confidence in inquiry. Therefore, the “QC/ADEAC inquiry model” and “QD/ODEAC inquiry model” can be used as an effective teaching tool, and it is suggested that the future research targets can be extended and expanded to different educational levels, in addition to the university students in this study.

Limitations and Further Study

Because the teaching experiment of this study was conducted for 9 months, only highly motivated participants were invited to participate in this study in order to avoid sample attrition, which led to the problem of a small number of participants. Therefore, in future studies, the number of participants can be significantly increased to verify whether the concepts proposed in this study can be supported and inferred to different professional project designs.

Inquiry-based learning has been shown to be an effective way to increase students’ motivation in STEM subjects and increase their understanding of science concepts. Nevertheless, teachers do not often use inquiry-based learning in the classroom due to different (perceived) barriers (Silm et al., 2017). Despite researchers’ positive belief in inquiry-based learning, teachers tend to be less willing to implement inquiry-based learning in their courses, and claim that the implementation of inquiry-based learning is fraught with difficulties (Ramnarain and Hlatswayo, 2018). Therefore, future research could be conducted with higher education teachers to examine their perceptions and difficulties related to the implementation of inquiry-based learning courses in order to suggest specific teaching strategies for improvement.

In addition, inquiry-based learning and hands-on work are often combined with STEAM education concepts, which are considered to be more conducive to enhancing learners’ creative expression and hands-on skills. In the field of design, the concept of STEAM is also gaining importance. Therefore, exploring different types of STEAM education approaches will help to expand the understanding of the benefits of curriculum and instruction in design education. For example, the “C” in C-STEAM education is an abbreviation for culture, a goal-oriented concept that focuses on cultural transmission as the main educational goal (Huo et al., 2020). C-STEAM, with its strong traditional cultural characteristics, is considered to be

conducive to the implementation of localized interdisciplinary education, and culture is an important part of design education. However, there is still limited understanding of the effects of different STEAM approaches applied in design education. Therefore, this study suggests that in future research, different STEAM methods can be combined with inquiry and practical work to compare their effects.

In addition, Xenofontos et al. (2020) suggested that appropriate instruction provided by the teacher during inquiry-based learning improved student learning outcomes more than uninstructed or minimally instructed inquiry-based learning for the same course material. However, the number of instructional sessions was not considered in this study, so it is not possible to understand the effect of different instructional intensities on student learning outcomes in the inquiry models presented in this study. Therefore, the effect of instructional intensity on inquiry-based learning can be investigated through multiple experimental group designs in subsequent studies. This study only explored the students' inquiry and practical experiences, but did not use the students' practical work as a basis for evaluation. Therefore, it is expected that future research will establish and develop a set of criteria for assessing students' work, and allow teachers and students to complete them, so that a more comprehensive multiple assessment of students' learning effectiveness can be implemented in the future, and besides, as seen in the previous literature, the implementation of inquiry-based learning can be combined with the use of educational

technologies (e.g., apps, websites) in different ways. However, in this study, other educational technologies were not integrated, so the effects of technology-assisted inquiry-based learning on students' cognition, emotions, knowledge, and skills can be explored in the future.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

J-YF and J-HY: concept and design and drafting of the manuscript, acquisition of data, and statistical analysis. J-YF: critical revision of the manuscript. Both authors contributed to the article and approved the submitted version.

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Exploring the Effects of Argument Map-Supported Online Group Debate Activities on College Students' Critical Thinking

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Debate has been warranted as a meaningful activity to promote students' higher-level thinking, such as critical thinking. However, traditional debate activities which are typically carried out in the physical classroom may meet some obstructions of limited time and space, which would result in the phenomenon that many participants act as silent watchers rather than mind exchangers. Moreover, it is hard to make a visualized record about the whole process and contents of the traditional debate activity. The current study aimed to explore the effects of argument map (AM)-supported online group debate activities on college students' critical thinking, including their depth and phases of critical thinking, and the relationship between students' depth of critical thinking and their number of speeches. In the study, an innovative argumentation construction way was designed. All students enrolled in a course could have a chance to attend the AM-supported online group debate activities and the whole process and outcomes of online group debate could be visualized by AM. At the same time, the effectiveness of the innovative activities was evaluated by content analysis of AM. A total of 42 sophomores in the undergraduate course named "Learning Sciences and Technology" were recruited to attend online group debate activities assisted by a web-based visualization tool named "ZJU Yuque" in 5 weeks. Newman's framework about the depth of critical thinking and Murthy's instrument of critical thinking phases were employed as guidelines. We found that 42 students' overall depth of critical thinking was gradually improved in an obvious way during the five online debate activities. The most frequent phases for students in the first and second team in online group debate activities include Understand→Understand (U→U), Recognize→Understand (R→U), and Understand→Evaluate (U→E). However, students' creating behaviors were not significantly generated. Teachers' real-time feedback was helpful for students' improvements of high-level thinking skills and their preparation for the next debate activity. Students' interviews found that students highly valued such online group debate activities because every student could have a chance to express their thoughts and they had enough time to prepare debate contents. Based on the findings, some implications were proposed for the better design and implementation of online group debate activities.

Keywords: depth of critical thinking, phases of critical thinking, argument map (AM), number of speeches, college students

INTRODUCTION

Critical thinking refers to the “purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as an explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based” (Facione, 1990). In this media-enriched age, people are confronted with all kinds of information produced by various professional or non-professional producers. Critical thinking skills become more and more important in social contexts where adequate decision-making and problem-solving behaviors are needed (Ku, 2009).

Critical thinking was closely related to the creative thinking (Siburian et al., 2019). Therefore, promoting students’ critical thinking skills is an essential goal of school education (Wang et al., 2007). However, many college students often discussed issues without using sufficient evidence, their critical thinking skills still need to be improved (Rodriguez et al., 2016). Such a phenomenon implicates that traditional lecture was not an effective way to cultivate students’ critical thinking skills (Ahmad et al., 2019).

Such instructional activities as dialogue, free questioning, debate, self-assessed homework, problem-based learning, and collaborative group work were proven efficient in improving learners’ depth of critical thinking (Omelicheva and Avdeyeva, 2008; Carroll et al., 2009; Şendağ and Ferhan, 2009; Fung and Howe, 2014). Among them, the debate is a commonly used method, especially in social science-related courses in universities. The debate is a formal discussion on a particular matter in a public meeting or legislative assembly, in which opposing arguments are put forward, and it usually ends with a vote (Hanna et al., 2014). The debate was proven to positively impact students’ critical thinking, collaboration, engagement, and communication skills (Omelicheva and Avdeyeva, 2008; Hartin et al., 2017; Mitchell, 2019).

Argumentation is the main activity in the process of debate (Clark and Sampson, 2008), it asks debaters make assertions, conclusions, or rebuttals with supportive evidence (Zohar and Nemet, 2002), which could practice their critical thinking skills (Kuhn et al., 2004; Alvarez-Ortiz, 2007). However, in traditional face-to-face debate carried out in the physical classroom, only very few students were selected as debaters to engage in arguments. In contrast, most students only act as audiences without chances to express their thoughts about the topic. This problem was more serious in university courses on a large scale.

Some efforts have been made to ensure that all students can participate in debates. For example, students were asked to write down their arguments, allowing them to present their opinions with more sentences than just the propositions (Monk, 2001; Harrell, 2004). However, the massive amounts of written arguments made it difficult for debaters to assimilate and understand the “gist” of arguments (Kintsch and van Dijk, 1978; Harrell, 2005). Therefore, some measures should be taken to organize those written arguments more logically and clearly. Additionally, it is rare for the instructor to evaluate the debaters’ depth of critical thinking by analyzing their

written content on argument, or to explore its relationship with debaters’ participation level, participation level usually measured by debaters’ number of speeches.

To deal with such issues, the aim of this study was to design an argument map (AM)-supported online group debate activity in an undergraduate course, in which all students could attend the debate by constructing an argument map in an online learning platform. Debaters’ critical thinking was objectively evaluated by analyzing the content they wrote in AM. Before introducing the main contents of the study, the literature review was presented.

LITERATURE REVIEW

Argument Map and Debaters’ Critical Thinking

An argument map is a visual representation of argumentation; in an AM, claims and evidences were represented by a diagram comprising of “colorful boxes and arrows” and indicates a claim and claim-evidence relationship, colorful boxes indicate the status of basic claims, such as claims, reasons, rebuttals, they are represented by different colors. The arrows reveal the evidence-based relationships between basic claims (van Gelder, 2002; Dwyer, 2011). An AM has some apparent advantages. Firstly, it makes a record about argumentation, and this provides debaters with sufficient time to think and communicate (Klein, 1999). Secondly, it demonstrates argumentation through dual modalities (visual-spatial/diagrammatic and verbal/propositional) to facilitate students’ deeper encoding of argumentation; the deeper encoding of argumentation could practice students’ critical thinking skills (van Gelder, 2003). Thirdly, AM presents information in a hierarchical manner. The hierarchically organized information was proven to promote learning and memory (Dwyer et al., 2012). Practically, although AM was usually constructed in the traditional form by using manuscript and pencil (Alvarez-Ortiz, 2007; Butchart et al., 2009; Dwyer et al., 2011), it has some shortcomings, for example, the inconvenience to edit or change, especially when the map size is large.

To deal with such shortcomings, computer-based AM was proposed as a better argumentation development (van Gelder, 2000). Constructed asynchronously in an online environment, computer-based AM not only provides students sufficient time to explore further information and think deeply (Dracup, 2012), but also allows them to add or delete content freely. Empirical studies have indicated the positive relationship between computer-based AM and students’ critical thinking (Alvarez-Ortiz, 2007; Butchart et al., 2009; Carrington et al., 2011; Harrell, 2011; Eftekhari et al., 2016). For example, Eftekhari et al. (2016) compared the effects of three kinds of instruction (argument mapping instruction *via* Rational software, argument mapping *via* manuscript and pencil, and traditional instruction without AM) on students’ critical thinking. Result demonstrated that students showed the highest level of critical thinking when they constructed AM through Rational software.

Whether constructed in a traditional or computer-based environment, AM focuses on the inferential structure of argumentation and require all argumentation with “boundaries” (Davies, 2011). In another word, AM emphasizes not only evidences, but also the relationship among those evidences. When constructing AM, the Toulmin model is frequently used to ensure the rigorousness and comprehensiveness of argumentation (Toulmin, 1958). The mode has six parts, such as claim, data, warrant, backing, rebuttal, and qualifier. However, the model focuses on “Monolog argumentation” (Schwarz and Baker, 2016), that is, the argumentation is the product of individual thought, ignoring the influence of human interaction. Therefore, the rebuttals, which are considered as the high level of argumentation (Osborne et al., 2004), are often generated by the person who has already made the claim, data, warrant, backing, and qualifier. While in fact, when rebuttals were proposed by those with opposing views, it is supposed to be more efficient in improving students’ depth of critical thinking. However, rarely studies have explored this.

Debaters’ Number of Speeches and Their Critical Thinking in Argument Map

Generally speaking, when students construct AM, their number of speeches is an important reference to reflect the engagement. The more the number of their speeches, the larger size the argument map. According to the fact that mapping (Eftekhari and Sotoudehnama, 2018) and software (Carrington et al., 2011) could improve learners’ meaningful engagement, computer-based AM, which is usually featured as constructing maps by software, potentials in enhancing students’ active engagement. When students engaged in constructing the correct AM, they were required to select the grounds correctly, make the relationship among premises clearly and conclude completely. All these were beneficial to students’ depth of critical thinking. Dwyer et al. (2010) pointed out that for students skilled in verbal and spatial reasoning; they were likely to engage themselves in reading arguments to practice their critical thinking. Additionally, van Gelder et al. (2004) found that learners’ critical thinking performance and their AM practice hours were significantly correlated in a computer-supported learning environment.

However, some studies found no difference between students’ critical thinking and their engagement (Dwyer et al., 2012), in which the engagement was measured by the number of argument maps students completed. The possible reason may be that students could not reasonably assimilate a large number of argumentation in a short period of time (Dwyer et al., 2010, 2013). In Dwyer’s (2011) study, when the recall was tested, students in smaller argumentation groups outperformed those in larger argumentation groups. It becomes even worse when the topics were not attractive to students. The unattractive topics took students’ more time to assimilate information. Whether the larger size of the maps, the higher depth of students’ critical thinking. Such question still needs to be further explored. And usually,

the size of AM could be quantified as the number of debaters’ speeches.

Evaluation of Debaters’ Critical Thinking in Computer-Based Argument Map

Many previous studies have used the survey to evaluate students’ depth of critical thinking in computer-based AM (Dwyer et al., 2012; Eftekhari et al., 2016; Gargouri and Naatus, 2017). For example, Dwyer et al. (2012) utilized a survey to collect data about the effectiveness of AM on enhancing students’ depth of critical thinking; the AM was constructed in the platform of Rationale. Although results indicated that computer-based AM was efficient in promoting students’ critical thinking by quantitative gains, it is sometimes quite subjective due to the influence of uncertain factors in filling the survey. Open-ended items encouraging students to think multi-directionally and creatively were more adaptable to measure high-level skills (Akay et al., 2006; Bahar et al., 2012). Content analysis was appropriate to analyze the contents students responded in open-ended items.

Content analysis is an objective evaluation method; it usually codes students’ oral or written contents based on the specific theories or frameworks. For example, in the study of Rapanta and Walton (2016), content analysis was used to assess students’ weaknesses in reasoning; 1,230 units of argumentative discourses in AM were coded, the AM was constructed in Rational software, results indicated that weakness usually happened when students constructed rebuttals, or proposed reasons to support a possible counter-argument.

In addition to theories, some frameworks are also frequently used to code students’ oral or written contents. For example, in critical thinking-related studies, Newman’s depth of critical thinking framework (Newman et al., 1995) or Murphy’s phases of critical thinking framework (Murphy, 2004) were frequently utilized. According to Newman’s framework, the depth of critical thinking is indicated by a value, which is between -1 and 1 . The larger the value, the higher the depth of critical thinking. According to Murphy’s framework, the phases of critical thinking were divided into five phases, such as recognize, understand, analyze, evaluate, and create. Some previous studies have evaluated learners’ depth of critical thinking by using content analysis based on these frameworks. For example, in order to compare the effects of different interaction strategies on secondary students’ depth of critical thinking, students’ writing reflections were analyzed based on Newman’s framework (Wang and Woo, 2010). Students’ reflections were coded at sentence level. Results demonstrated that when students wrote thoughts individually, they got the highest depth of critical thinking of 0.83 . For computer-based AM, however, few studies have applied the frameworks of Newman or Murphy to evaluate debater’s depth and phases of critical thinking.

Literature review has indicated that AM could be adopted to present the structure of argumentation in a clear form. Computer-based AM could provide more participants the opportunities to engage in argumentation activities. However, in previous studies, AM was usually drawn by students in a team holding the same view. Few studies explored the effects

TABLE 1 | Debate topics in the five weeks (from the 3rd to the 7th week).

Week	Course content	Debate topics	
		Pros	Cons
3	Technology-supported learning	Technology narrowed educational gap among regions	Technology widened educational gap among regions
4	Technology-supported teaching	The advantages of education industrialization outweigh its disadvantages	The disadvantages of education industrialization outweigh its advantages
		Pedagogy should be an undergraduate major	Pedagogy should not be an undergraduate major
5	Methodology in learning science studies	More should be done to develop students' skills in non-continuous texts	More should be done to develop students' skills in long and continuous texts
		Preschool education should be included in compulsory education	Preschool education should not be included in compulsory education
6	Learning assessment	More general teachers are needed in primary schools	More specialist teachers are needed in primary schools
		In primary education, art education should be based on formal curriculum	In primary education, art education should be based on informal curriculum
7	Future learning	In junior high school, students of different learning levels should be taught in separate classes	In junior high school, students of different learning levels should not be taught in separate classes

of students with opposite viewpoints to draw AM together, which was supposed to facilitate rebuttals. In the study, an innovative argumentation construction way was designed. All students enrolled in a course could have chance to attend the AM-supported online group debate activities and the whole process and outcomes of online group debate could be visualized by AM. As to the effect of AM, many previous studies have proven that AM could promote students' critical thinking, which was normally evaluated by the survey. It remains unknown that whether or not students could practice their critical thinking by practicing more. In this study, the effectiveness of the innovative debate activities was evaluated by content analysis of AM.

PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

Based on the literature review, the study aims to design AM-supported online group debate activities to improve college students' critical thinking skills. In the activities, two debate teams holding the opposite viewpoints could carry out online group debate through drawing AM together. To examine the effects of the activities, not only students' depth and phases of critical thinking could be evaluated through analyzing the

contents in AM, but also the relationship between students' depth of critical thinking and the number of speeches could be explored. Specifically, the study includes the following research questions:

- Q1: In each debate, what are debaters' general depths of critical thinking and their number of speeches?
 Q2: Is debaters' depth of critical thinking significantly correlated to their number of speeches?
 Q3: What are debaters' phases of critical thinking?
 Q4: How do debaters perceive the AM-supported online group debate activities?

METHODOLOGY

Participants

The participants of this study were 42 sophomores enrolled in Zhejiang University (ZJU), China, which was founded in 1897 and is a top university in China. The 42 participants took the course named *Learning Science and Technology*. This course was a compulsory course for all sophomores majored in education. Among these 42 students, 38 were female and 4 were male. Their average age was 20. To attend the debate activities, these 42 students were randomly divided into five groups. Four groups had eight students and one group had ten students. There were two debate teams (pro and con) in each group, and each team had four or five members. Each debate team was randomly assigned the position (pro or con) of the debate in the group.

Instructional Design

The course was taught in 8 weeks of Spring Semester 2021 (from 2 March to 22 April 2021). The course was twice a week (one on Tuesday and the other on Thursday). In each lesson, students needed to take two continuous classes and each class lasted 45 min. The main contents of the course include foundation of learning science, technology-supported learning, technology-supported teaching, methodology in learning science studies, learning assessment, and future learning. Students' performance in the course was mainly assessed from these aspects: posting debate topics (10), debate activities (50), group presentation about debate activities (20), and learning reflection (20).

In the first week, the instructor gave students a general introduction about course arrangement, such as course goals, outline of course contents, course schedule, guidelines for debate, and criteria for students' performance assessment. The first 2 weeks were featured by the instructor's lecture about the basic knowledge about learning science. From the 3rd week to the 7th week, five debates were integrated into the course, and it took place on every Thursday. In the last week, students were asked to make a learning reflection.

In the first week, eight rules about the debate were presented to students: (1) all statements and responses should be expressed appropriately and respectfully; (2) information should be clear, accurate, and comprehensive; (3) rebuttal should be clear, relevant, and strong; (4) facts, statistics, and literature are needed when supporting opinions; (5) contents should be organized logically, and have reasonable and orderly arrangement; (6)

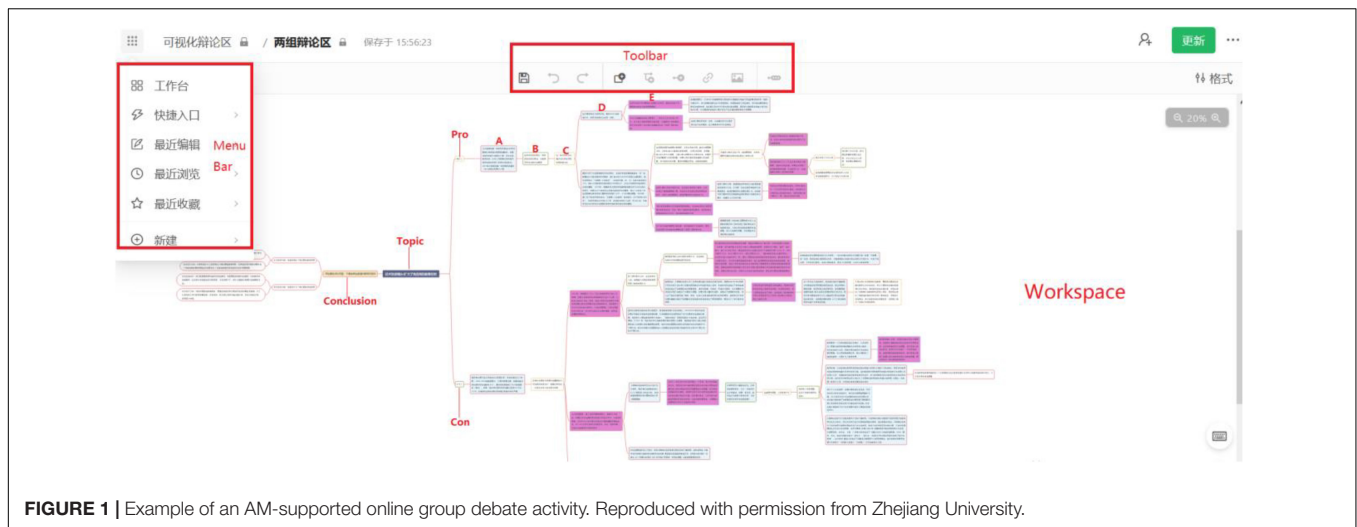


FIGURE 1 | Example of an AM-supported online group debate activity. Reproduced with permission from Zhejiang University.

debaters should understand the topic clearly, and debate under the same concept; and (7) information should be presented professionally. By learning these rules, students would better understand the key points of debate.

From the 3rd to the 7th week, on each Tuesday, the instructor lectured on a specific topic. Right after the instructor's lecture, students were encouraged to propose debate topics through an online discussion board in an online platform named "Learning in ZJU." After the debate topics were proposed, students were selected their topics through voting. The top three topics were considered as debate topics, and students chose one from the three topics. **Table 1** presented the selected debate topics in the course.

After selecting debate topics, each group consisting of one pro team (4 or 5 members) and one con team (4 or 5 members) would carry out AM-supported online debate activity through "ZJU YuQue" platform. Comparing with traditional debate activity, the activity designed in this study has obvious innovation in two dimensions. Firstly, all students could have a chance to attend the online debate activities at their own pace through "ZJU YuQue" platform. "ZJU YuQue" is an online collaboration platform that could support students to draw AM at any time. As **Figure 1** shows, the platform includes three main sections: menu bar, toolbar, and workspace. The menu bar includes such functions as providing guidance for drawing AM, creating a new AM, viewing recently edited contents, returning back to the previous page, and saving favorite contents. The toolbar could help students add rectangles with different colors. Workspace is the place where students draw their AM. Secondly, the argumentation would be carried out in a visualized way through AM, which allows both sides of a debate to put their viewpoints together and finally draw an AM together. In an AM, a rectangle could contain a speech. In order to standardize the argumentation, rules about colors used in AM were set before the activities were carried out. Burgundy represents rebuttals supported by evidence. Blue represents supplements supported by evidence. White represents rebuttals or supplements without evidence. Students could write their thoughts about argumentation in rectangles. Therefore,

students' viewpoints (the supplement and the rebuttal) and whether they are evidence-based could be easily recognized by different colors. Additionally, the recorded contents could be analyzed to evaluate students' critical thinking objectively.

Figure 1 presented an example. The selected topic was "technology could narrow/widen educational gaps among regions." The pro side thought that technology could narrow the educational gap among regions, while the con side thought that technology would widen the educational gaps among regions. A part of the argumentation was listed as following. A, B, C, D, and E in **Figure 1** presented some students' viewpoints. A, C, and D were from the pro side and B and E were from the con side.

- (A) Yunnan Luquan No. 1 Middle School, one of the 248 middle schools in poverty-stricken areas, took the synchronous classes through live video with Chengdu No. 7 Middle School, which is a school with high quality of education. This had increased enrollment in poor areas and reduced the loss of local students. In 2019, all students in one class that adopted this teaching method went to key universities.
- (B) This is peer-to-peer supporting. The limited high quality resources could not meet the needs of all schools in poor areas.
- (C) This problem can be addressed through the flexible application of technology.
- (D) The high quality resources could be one-to-many in asynchronous class, such as massive open online courses (MOOC).
- (E) Some studies have explored the effect of MOOC on students' learning. Results indicated that children from poor families showed lower participation and completion rates in MOOC.

The argumentation above demonstrated that the pro side supported their viewpoint with evidence of A. Then A was rebutted by B, which was generated by the con side without evidence. C means the rebuttals to B without evidence.

D was rebutted by the con side with evidence, and the evidence was shown as E.

Between the 3rd and the 7th week, on each Thursday, all the five groups were asked to present the main content of their AM. The final score of each debate was decided by the instructor and the teaching assistant.

In the 8th week, some students were randomly invited to share their learning reflections. After the 8th week, all students were required to submit their learning reflections to the instructor. Additionally, students' semi-structure interview was also carried out 1 week after the 8th week.

Instrument

In this study, the content analysis framework of critical thinking developed by Newman et al. (1995) was adopted to evaluate debaters' depth of critical thinking. The framework mainly contained ten indicators and its detailed information is shown in **Table 2**. According to the framework, an indicator would be marked with “+” for positive information if it meets the standard. Otherwise, it would be marked as negative information “-.” Finally, an individual's depth of critical thinking would be presented by the critical thinking ratio, which is calculated by $(X^+ - X^-)/(X^+ + X^-)$, and its range is between -1 and 1. The higher the value of the ratio, the higher students' depth

of critical thinking. For example, -1 means that all indicators of an individual's viewpoints are negative information, and it implicates that the individual has no depth of critical thinking. 1 means that all indicators of an individual's viewpoints are positive information, it implicates that the individual has a high depth of critical thinking.

Additionally, the content analysis framework of critical thinking developed by Murphy (2004) was adopted to evaluate the debaters' phases of critical thinking. According to the framework, the phases of critical thinking could be divided into five phases, namely, recognize, understand, analyze, evaluate, and create (**Table 3**).

Data Collection and Analysis

Data were collected in an innovative way. Different from the survey, which was subjective, the content of AM drawn in “ZJU YuQue” platform was the most important source of data in the study. The contents were analyzed based on the analysis unit. Each rectangle was considered as an analysis unit. Guided by Newman's depth of critical thinking framework, all analysis units were independently coded by two doctoral students majoring in educational technology.

In order to know the phases of debaters' critical thinking, the content of AMs in the first- and second-team (the depth of critical

TABLE 2 | Newman's critical thinking framework (Newman et al., 1995).

Category	Indicator and description	Category	Indicator and description
Relevance (R ±)	R+ Relevant statements R- Irrelevant statements, diversions	Ambiguities (A ±)	AC- Confused statements A+ Clear up ambiguities
Importance (I ±)	I+ Important points/issues I- Unimportant, trivial points/issues	Linking ideas, Interpretation (L ±)	A- Continue to ignore ambiguities L+ Linking facts, ideas, and notions L+ Generating new data from information collected L- Repeating information without making inferences or offering an interpretation L- Stating that one shares the ideas or opinions stated without further or adding any personal comments
Novelty (N ±)	NP+ New problem-related information NP- Repeating what has been said NI+ New ideas for discussion NI- False or trivial guidance NS+ New solutions to problems NS- Accepting the first offered solution NQ+ Welcoming new ideas NQ- Squashing, putting down new ideas NL+ Learner brings new things in NL- Dragged in by tutor	Justification (J ±)	JP+ Providing proof or examples JS+ Justifying solutions or judgments JS+ Discussing advantages and disadvantages of solution JP- Irrelevant or obscuring questions or examples JS- Offering judgments or solutions without explanations or justification JS- Offering several solutions without suggesting which is the most appropriate
Bringing outside knowledge or experience to bear on problem (O ±)	OE+ Drawing on personal OC+ Refer to course material OM+ Use relevant outside material OK+ Using previous knowledge OP+ Brought course-related problems OQ+ Welcoming outside knowledge OQ- Squashing attempts to bring experience in outside knowledge O- Sticking to prejudice or assumptions	Critical assessment (C ±)	C+ Critical assessment or evaluation of own or others' contributions C- Uncritical acceptance or unreasoned rejection CT+ Tutor prompts for critical evaluation CT- Tutor uncritically accepts
Ambiguities (A ±)	AC+ Clear, unambiguous statements	Practical utility (P ±)	P+ Relate possible solutions to familiar situations Discuss practical utility of new ideas P- Discuss in a vacuum (treat as if on Mars) Suggest impractical solutions
		Width of understanding (W ±)	W+ Extensive discussion (discuss as a whole) W- Narrow discussion (fragments or parts)

TABLE 3 | Murphy's phrases of critical thinking framework (Murphy, 2004).

Process	Descriptor	Code
Recognize	Recognizing or identifying an existent issue, dilemma, problem, etc	R
Understand	Exploring related evidence, knowledge, research, information, and perspectives	U
Analyze	Seeking in depth clarification, organizing known information, identifying unknown information, and dissecting the issue, dilemma, or problem into its fundamental components	A
Evaluate	Critiquing and judging information, knowledge, or perspectives	E
Create	Producing new knowledge, perspectives, or strategies and implementing them or acting on them	C

thinking ranks in the middle among the ten debate teams) was analyzed. The content was analyzed based on the analysis unit. Each sentence was considered as an analysis unit. Guided by Murphy's critical thinking phases framework, all analysis units were independently coded by two doctoral students majoring in educational technology. And then the codes were analyzed by the software of GSEQ (short for Generalized Sequential Querier), which is a computer program for analyzing sequential observational data.

In order to understand how students perceive AM-supported online group debate activities, the semi-structured interview was conducted and it was designed by instructor and assistant. The semi-structured interview includes three questions: (1) How do you perceive the online environment? (2) How do you perceive AM? and (3) How do you evaluate instructor's role during the debate?

RESULTS

Debaters' General Depth of Critical Thinking and Their Number of Speeches in Each Debate

As to Q1 (In each debate, what are the debaters' general depths of critical thinking and their number of speeches?), the reliability of coding was 0.77, indicating that the coding was reliable. Content analysis found that, in five debates, debaters' depths of critical thinking were 0.81, 0.85, 0.86, 0.89, and 0.90, respectively, which indicates a gradual upward trend (Table 4). Additionally, debaters' numbers of speeches from 1th to 5th debate were 212, 329, 293, 361, and 321, respectively. Totally, 1,516 speeches were generated in five debate activities.

Relationship Between Debaters' Depth of Critical Thinking and Their Number of Speeches

As to Q2 (Is debaters' depth of critical thinking significantly correlated to their number of speeches?), correlation analysis found that there was no significant correlation between debaters' depth of critical thinking and their number of speeches (Table 5). That is, debaters' depth of critical thinking was not significantly related to their number of speeches.

TABLE 4 | Debaters' depth of critical thinking and their number of speeches in five debates.

Debate	Debaters' general depth of critical thinking	Debaters' number of speeches
1	0.81	212
2	0.85	329
3	0.86	293
4	0.89	361
5	0.90	321

TABLE 5 | Correlation analysis of debaters' depth of critical thinking and number of speeches.

		Debaters' number of speeches	Debaters' depth of critical thinking
Debaters' depth of critical thinking	Pearson correlation	1	0.839
	P		0.076
	N	1516	1516
Debaters' number of speeches	Pearson correlation	0.839	1
	P	0.076	
	N	1516	1516

Debaters' Phases of Critical Thinking

As to Q3 (What is debaters' phases of critical thinking?), the content of AM was drawn by debaters from the first- and second team were analyzed as a sample. The reliability of the coding was 0.72, indicating that the coding was reliable. Table 6 presents the number of effective single sequences and the top three effective single sequences in each of the five debate activities.

As for the number of effective single sequences, it was larger in the second- and fifth debates, with the number of 141 and 137, respectively. In these two debates, the type of debate topics was "yes or no," while in the third and fourth debates, the type of debate topics was "choose one from two," the former brings a wider range of discussions, while the later limited discussion scopes, which may make the argumentation challenging to carry out. While for the first debate, although the topic type was "yes or no," students were not familiar with the AM-supported online group debate activities; therefore, the number of effective single sequences was still small.

In terms of the top three effective single sequences, it could be seen that Recognize→Understand (R→U) and Understand→Understand (U→U) ranked first and second in the first and second debate, while they ranked second and first in the last three debates, indicating that the quality of debaters' critical thinking phases was improved.

Table 7 shows all the sequences generated by debaters in the first- and second team in five debates totally. As Table 7 indicates, in the five debates, debaters in the first- and second team totally generated 552 effective single sequences. The top three effective single sequences such as Understand→Understand (U→U), Recognize→Understand (R→U), and Understand→Evaluate (U→E), with the number of 128, 93, and 50, respectively. There is no sequence to create.

TABLE 6 | Debaters' effective single sequences in the first and second team in five debates.

Debate topics	Number of effective single sequences	The top three effective single sequences (number)
1. Does technology narrow educational gap among regions?	92	R→U(18), U→U(18), R→R(13)
2. Does education industrialization outweigh its disadvantages?	141	R→U(23), U→U(22), U→A(14)
3. Which kinds of skills should students develop, non-continuous texts or long and continuous texts?	82	U→U(26), R→U(14), U→E(8)
4. Which is more needs in primary schools, general teachers or specialist teachers?	100	U→U(31), R→U(14), U→E(11)
5. In junior high school, should students of different learning levels be taught in separate classes?	137	U→U(31), R→U(24), U→E(23)

R, recognize; U, understand; A, analyze; E, evaluate; C, create.

TABLE 7 | Frequency of effective single sequences in the first and second team in five debates.

	R	U	A	E	C	Total
R	36	93	24	5	0	158
U	45	128	42	50	0	265
A	16	28	11	13	0	68
E	12	31	10	8	0	61
C	0	0	0	0	0	0
Total	109	280	87	76	0	552

R, recognize; U, understand; A, analyze; E, evaluate; C, create.

TABLE 8 | Adjust residuals of effective single sequences in the first and second team in five debates.

	R	U	A	E	C
R	0.26	0.02	0.82	<0.01	-1.00
U	0.12	0.27	0.96	<0.01	-1.00
A	0.40	0.09	0.92	0.17	-1.00
E	0.99	0.99	0.89	0.88	-1.00
C	-1.00	-1.00	-1.00	-1.00	-1.00

R, recognize; U, understand; A, analyze; E, evaluate; C, create.

Table 8 presents the adjusted residuals calculated by GSEQ. There were no significant sequences with adjusted residuals greater than 1.96. That is, among the 552 single sequences, there was no significant single sequence, indicating that although some sequences are more or fewer than other sequences, it was not statistically significant.

Debaters' Feeling About AM-Supported Online Group Debate Activities

As to Q4 (How do debaters perceive the AM-supported online group debate activities?), semi-structured interview was utilized to collect opinions from 20 interviewees. Table 9 presents the themes, codes, and code-related frequencies generated from the analysis of interview data.

TABLE 9 | Codes and frequencies of the semi-structured interview data.

Theme	Codes	Frequencies
Feeling of online environment	More time to think	16
	Engage at any time	13
	Rebut without awkwardness	10
	Take up a lot of time	10
Feeling of AM	Unable to support or rebut timely	9
	Get a clear picture of debate	20
	Topic-related support or rebuttals	16
	Evidence-based support or rebuttals	15
Feeling of instructor's role	Logical thoughts	13
	Evidence-based argumentation	16
	Recognized effort	12
	Gain argumentation skills	9
	Gain professional knowledge	9
	Rebut under the same concept	6

For the question of "How do you perceive the online environment," interviewees showed two opposite attitudes. Some students expressed their positive attitude. They reported that online environment could provide them more time to think, allow them to engage at any time and rebut without awkwardness. This indicated that AM-supported online debate not only provided all students the flexible time to engage, but also helped them to debate freely without pressure from social relationships through rebutting anonymously. As an interviewee stated, "In online environment, I needn't end in a specified time. I can add new content in a few days, which deepens my discussion and helps me better understand the topics." Such statement reflected that the time was sufficient for students to debate online. However, some students expressed the negative attitude about the online environment. They thought that the online environment extended argumentation time and let them spend too much time on the activity. Sometimes, they were unable to support or rebut timely. This implied that the appropriate debating time as well as the reminder whenever students write their speeches in the AM should be set in advance. For example, an interviewee mentioned, "I feel like that I have to argue every day, which took up a lot of time away from doing other things." Such expression suggested that the online debate was a time-consuming process.

For the question of "How do you perceive the AM," all of the 20 students expressed their positive attitudes. The reasons might be as follows. The AM helped them to get a clear picture of debate, provide topic-related supplements or rebuttals, make the evidence-based supplements or rebuttals, and organize the thoughts in a logical way. This indicates that the application of AM could not only facilitate students' evidence-based supplements and rebuttals, but also encourage them to organize these evidences logically. An interviewee stated, "The map makes the argumentation structure and content clear. The different colors represent different means, I could see what others rebut or support my side clearly," this statement

was the indication that students understand the structure of debate in a clear way.

For the question of “How do you evaluate the instructor’s role during the debate,” all the 20 students expressed their positive attitude. Students’ AM was commented and their effort was recognized by the instructor. The instructor emphasized that argumentation should be evidence-based and both teams’ argumentation should be under the same concept. Generally speaking, the instructor’s guidance helped students in gaining both argumentation skills and professional knowledge. For example, an interviewee mentioned, “Evidence-based argumentation was one of the most important words I learned from the instructor’s evaluation. That is, when making a point, we should be sure to back it up.” The sentence showed that students realized the importance of evidence in argumentation.

DISCUSSION

The aim of the study was to explore the effects of AM-supported online group debate activities on college students’ depth of critical thinking. Five AM-supported online group debate activities were designed based on the platform of “ZJU YuQue.” A total of 42 sophomores majoring in education were invited to attend the debate activities. Guided by Newman and Murphy’s framework of critical thinking, content analysis of debaters’ speeches found some interesting findings.

Firstly, in five debates, debaters’ general depth of critical thinking increased gradually. The result was in agreement with the previous studies (Carrington et al., 2011; Harrell, 2011; Eftekhari et al., 2016), which indicated a positive relationship between computer-based AM and students’ critical thinking. The possible explanation for such a positive relationship may be closely related to the innovative design in this study. (1) Online environment has such advantages as providing all students the chances to engage and letting them have sufficient time to think, write, and edit. It could also reduce the social anxiety through the anonymity function (Maurino, 2006). A similar opinion was expressed by interviewees in the interview. (2) Mapping out argumentation in a visualized way, such as AM, allows students to extract propositions, claims, and rebuttals easily (Chandler and Sweller, 1991; Pollock et al., 2002). The AM helps debaters to identify essential issues, realize their possible lacking of sufficient evidence in supporting their views, make better connections between claims and evidence, all of which were beneficial to facilitate the students’ reflection about reasoning and clarify their insights (Van Gelder, 2005; Kaeppl, 2021), and finally practice their high-level thinking skills (Kabataş, 2011). Such opinions were also verified by students’ interviews. (3) The instructor’s objective and timely feedback on the students’ presentation could help students to reflect and think deeply. In the interview, students expressed that evidence-based, a word usually emphasized by the instructor, was what impressed them most.

Secondly, debaters’ depth of critical thinking was not significantly correlated to their number of speeches. The result was consistent with Dwyer et al. (2012), in which the result

indicated that no matter debaters engaged more or less in debate, no difference was found on their critical thinking ability. However, the result was different from the opinion that students’ active participation in argumentation could promote their conceptual understanding (Nam et al., 2011; Kabataş and Çakan, 2020). The conceptual knowledge may facilitate the meaningful learning, which is considered as high quality and efficient learning with active thinking. The difference might be explained from the following perspectives. (1) In this study, students were informed that an important criterion for evaluating AM was its size and shape, the larger size was better. Although the quality of content was also important for the evaluation, they couldn’t be seen intuitively. Students may ignore the quality of argumentation, focusing on increasing their number of speeches to enlarge the map size. From this perspective, evaluation criteria for online debate are suggested to clearly communicate to debaters before debate activity. That is, both the number and the quality of speeches were considered in evaluating online debates. (2) Debate topics were proven to affect students’ critical thinking; the interesting topics motivate students to participate in argumentation (Garcia et al., 1992). In this study, topics were proposed and selected by students themselves. Although some topics were interesting, they were difficult to debate. This was verified by some students in interviews. For example, for the topic of “Should Education be an undergraduate major?,” students expressed that they could not find materials to support their argumentation. They usually used subjective feelings or experiences as evidences. Some debate topics may affect students’ motivation negatively, and therefore, affect their depth of critical thinking. In this view, the instructor may play a more important role in guiding students’ efforts into activities that require more critical thinking (Kaeppl, 2021). (3) Debate aims to refute others with evidence. Therefore, debaters’ opinions are often criticized openly, which might make them feel threatened or defensive (Walker, 2017). The “negative emotional response” may affect critical thinking in a negative way. Therefore, instructors should try to elicit students’ positive emotions when they are involved in the debate. Considering that everyone owns privacy, one efficient way was to be anonymous in online debate; no one knows who is being criticized but himself/herself.

Thirdly, through exploring debaters’ phases of critical thinking in the first- and second team in five debates, it was found that Understand→Understand (U→U), Recognize→Understand (R→U), and Understand→Evaluate (U→E) were the top three effective single sequences, indicating that the phases of debaters’ critical thinking were relatively low. This result could be explained from the following aspects: (1) Butchart et al. (2009) has proven that when students constructed their AMs online, the automatic and real-time feedback was efficient in improving their critical thinking because it provided students opportunities to evaluate and reflect on their own thinking (Dwyer et al., 2012). While in this study, although the instructor provided timely feedback to students’ presentations of debate, due to the limited time in class, it was not fully benefit to students. Therefore, showing students the process of how teachers evaluated their depth of critical thinking based on their speeches, making it as material to study in the next class would be a useful way for

students to evaluate their debate. Understanding and assessing argumentation in AM were proved to be effective in improving students' critical thinking (Carrington et al., 2011). (2) the topics were not closely related to content lectured in class. Therefore, students may be not familiar with the argumentation content, which increased the difficulty of their in-depth analysis of the topics. This was verified by some students' interview. (3) Although constructing AM in a collaborative manner facilitated students to work together, the uneven participation in groups (Kaeppel, 2021), which manifested as some students kept silent while some were responsible for map construction, may prevent students from working collaboratively or thinking deeply. In this study, this problem was also mentioned by students in interviews. From this perspective, using intelligent technology to automatically record students' procedural performance, such as their number of speeches, may be effective in promoting students to participate in debate deeply.

CONCLUSION, LIMITATIONS, AND SUGGESTIONS

Traditional AM is usually drawn by students on the same side at the fixed time, which is not good for triggering the rebuttals. At the same time, the effects of AM-supported argumentation activities are normally measured by the survey instrument. This study designed an AM-supported online group debate activity, which could allow all of the participants (both the con and the pro sides) to visually debate by drawing online AM together at a flexible pace. Students could not only support their own viewpoints, but also rebut the opposite sides in the same online AM. Students' depth and phases of critical thinking could be objectively evaluated by analyzing the contents they created in the AM.

Additionally, in order to know whether students' critical thinking skills were practiced through participating debate, the relationship between students' depth of critical thinking and the number of speeches was explored in the study. Results indicated that debaters' general depth of critical thinking was increased gradually. Understand→Understand, Recognize→Understand, and Understand→Evaluate were the top three behaviors for students in the first- and second team usually had during the argumentation. Students' critical thinking skills were not practiced by participating in the debate.

Based on the results, some enlightenments are proposed. Firstly, the debatable and lecture-related debate topics are the premises for high-quality argumentation. Secondly, drawing AM online allows all students to think and collect debate-related evidence in sufficient time, to express their ideas at their own pace, to organize the evidence in a more logical way, and to understand the structure of argumentation in a

more clearly way. Thirdly, rebutting anonymously let participants express themselves freely, for they don't have to consider the pressure from the social relationship. Fourthly, the timely and procedural feedback from the instructor facilitates students' gaining in professional knowledge as well as argumentation skills. Finally, in order to practice students' critical thinking skills through their participation in debate, an evaluation criterion that emphasizes both on the quantity and the quality of debaters' speeches is needed.

Although the study found some meaningful findings, the study has some limitations. Firstly, the study was carried out in a relatively short period. Secondly, the debate teams included different number of members (4 or 5), this might affect the debate team's overall depth of critical thinking. Thirdly, some topics were not suitable for debate; the unsuitable debate topics may also affect the debaters' depth and phases of critical thinking.

Based on the findings and the limitations of the study, some suggestions are put forward. Firstly, in AM-supported online group debate activities, to further explore debaters' depth and phases of critical thinking, and the relationship between debaters' depth of critical thinking and their number of speeches, more studies are encouraged in more courses from diverse disciplines. Secondly, the instructor may engage in the process of students proposing and choosing debate topics, ensuring that the topics were closely related to course content taught in class. Finally, considering the familiarity among team members may weaken their frequency of rebuttals, further studies may explore debaters' depth and phases of critical thinking in an anonymous way.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

XC is mainly responsible for the implementation of experiment, manuscript writing, and data coding. LW is mainly responsible for data coding. XZ is mainly responsible for manuscript writing. YL is mainly responsible for the implementation of experiment and manuscript writing. All authors contributed to the article and approved the submitted version.

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How Does Hands-On Making Attitude Predict Epistemic Curiosity and Science, Technology, Engineering, and Mathematics Career Interests? Evidence From an International Exhibition of Young Inventors

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Whether the hands-on experience of creating inventions can promote Students' interest in pursuing a science, technology, engineering, and mathematics (STEM) career has not been extensively studied. In a quantitative study, we drew on the attitude-behavior-outcome framework to explore the correlates between hands-on making attitude, epistemic curiosities, and career interest. This study targeted students who joined the selection competition for participating in the International Exhibition of Young Inventors (IEYI) in Taiwan. The objective of the invention exhibition is to encourage young students to make innovative projects by applying STEM knowledge and collaborative design. We collected 220 valid data from participants in the 2021 Taiwan IEYI selection competition and conducted a confirmatory factor analysis and structural equation modeling to test the hypotheses. Results indicated that: (1) hands-on making attitude was positively related to two types of epistemic curiosity; (2) interest-type epistemic curiosity (IEC) and deprivation-type epistemic curiosity (DEC) were positively associated with STEM career interest; additionally, DEC had a higher coefficient on STEM career interest than IEC; (3) both types of EC had a mediating role between hands-on making attitude and STEM career interest. It is expected that encouraging students to participate in invention exhibition competitions can raise both types of EC and increase their interest in pursuing STEM careers.

Keywords: STEM, epistemic curiosity, invention exhibition, hands-on making attitude, STEM career interest

INTRODUCTION

In order to ensure that young students can meet the growing demand for creativity in science, technology, engineering, and mathematics (STEM) fields, educators must help them learn to think outside the box (Hardy et al., 2017), and learn new procedural and declarative knowledge to creatively design projects (Nazzari and Kaufman, 2020). Higher levels of depth capability to learn new knowledge result in a greater impact on invention (Kok et al., 2019). Hands-on attitude and open-ended exploration are integral components of good STEM design (Wu et al., 2014; Hu et al., 2020), which implies that STEM creative exploration should play a role in activating students' curiosity (Hong et al., 2016, 2019). That is, epistemic curiosity is always accompanied by motivation to solve problems about one's surrounding environment (Buyalskaya and Camerer, 2020), indicating that project design with STEM knowledge may impact Students' entrance into the STEM career pipeline (Birenbaum et al., 2021). However, few studies have focused on exploring the correlates between hands-on making attitude, epistemic curiosity, and career interest. Thus, the present study aimed to explore their correlations.

Which factors drive creative activity? According to the Attitude-Behavior-Outcome (ABO) model, attitudes are robust predictors of appraisal of behavior and decision making (Ajzen and Fishbein, 1980; Nabi et al., 2006). Epistemic curiosity (EC) refers to one's desire to acquire new knowledge, and comprises two different types after engaging in activities. On one hand, it can arouse positive feelings of intellectual interest, which is known as Interest type EC (IEC). On the other hand, it can reduce the undesirable condition of uncertainty that is associated with being deprived of information, which is referred to as Deprived type EC (DEC). As an example, scientists perform behaviors to seek knowledge from context-specific information provided by contextual situations to alleviate the pressure from knowledge gaps that can reduce uncertainty about specific unknowns, and consequently achieve their goals. Moreover, genuine interest in a STEM career relies on individuals' major or experience, which influences their decisions to choose a career (Kim and Beier, 2020). However, few studies have investigated STEM experience in a contest involving invention model making and competitions in which Students' hands-on making attitudes activate their epistemic curiosity related to their career interest. Thus, drawing on ABO, the present study formed a research framework to explore the correlates between hands-on making attitude, IEC and DEC, and career interest. It is expected that the study results can be applied in Taiwan educational settings which focus on Confucian culture.

THEORETICAL BACKGROUND

Science, Technology, Engineering, and Mathematics Education

STEM education has become an important part of curricula in educational systems around the world (e.g., Bagiati and Evangelou, 2015; Al Salami et al., 2017;

Margot and Kettler, 2019), and in particular, has seen successful implementation in a number of Western countries including the United States and Australia (Lee et al., 2019). In a special issue on STEM education in 2019, Le et al. (2021) called for further investigation of how STEM education is implemented in Asian schools. Since then, the difficulties of implementing STEM education have received increasing attention, and there has been a search for effective educational approaches and curricula (Le et al., 2021). It has been argued that STEM narratives of progress, competition, and innovation have obscured some of the issues that students must face on a daily basis, including urgent ecological, ethical, and social justice issues (Yanez et al., 2019). Thus, an approach should be practiced with these critical principles—production pedagogy—in mind when applying STEM knowledge in a competition. In the process of producing projects, students engage in critical discussion and make alternative models which generate new perspectives on how they might “do” differently and innovatively. In line with this, a focus on “doing” to learn STEM to design products for an International Exhibition of Young Inventors (IEYI) competition was emphasized in this study.

Hands-On Making Attitude

Attitudes have been defined as an individual's cognitive preferences and behavioral predispositions toward objects, which result in either favorable or unfavorable evaluations of certain stimuli that reflect that individual's tendency (Eagly and Chaiken, 1993). This psychological tendency conveys the individual's evolution of referents (Augoustinos et al., 2014) and their resulting behavioral intentions (Ajzen, 2001). Moreover, hands-on learning has been defined as any instructional approach that involves students in actively manipulating objects so as to develop their knowledge or understanding (Hauray and Rillero, 1994). Activity-centered learning is used synonymously with hands-on making, including manipulative activities and practical activities with hands-on activities (Ateş and Eryilmaz, 2011). A previous study suggested that people's attitudes are defined as a stable trait that is formed *a priori* and is activated unconsciously in response to either the internal or external stimuli provided by an activity (Serenko and Turel, 2019). However, students have reported hindering attitudes toward doing innovative research because they may consider that innovative activities are time-consuming, and they may face difficulties completing the activities due to their lack of knowledge (AlGhamdi et al., 2014). In line with this, the role of participants' hands-on making attitudes in designing a project for IEYI was considered in this study.

Epistemic Curiosity

Loewenstein's (1994) information gap theory of curiosity was recently extended by Litman and Jimerson (2004) and Litman (2005) to include both the interest (I-type) dimension, which involves the acquisition of novel information which can generate positive feelings of interest, and the deprivation (D-type) dimension, which is related with minimizing uncertainty and eliminating undesirable states of ignorance. Epistemic curiosity is described as the individual's “desire to know” novel knowledge that shrinks the discrepancy (knowledge-gap) of the “need to

know” between known and desired information (Litman et al., 2005). Previous studies have indicated that curiosity has a central function in hands-on exploration and intellectual behavior (Murayama et al., 2019), and would directly predict positive effort beliefs and goal orientation (Grossnickle, 2016). Epistemic curiosity (EC) is a distinctive human tendency to drive cognitive inquisition. IEYI is a material- and activity-centered project-making STEM competition which emphasizes hands-on as well as minds-on activities. Hands-on making projects require students to acquire knowledge and discuss with peers and/or instructors. In making an invention, students have to co-produce knowledge which interconnects scientific and technical knowledge (Eaton et al., 2021) and in ways of practicing epistemic curiosities (Birenbaum et al., 2021). This suggests that students involved in design invention drive themselves to learn more knowledge, for example, to know how different sensors can work. Thus, the roles that both types of epistemic curiosity play in making inventions were explored in this study.

Career Interest

STEM-centered learning activities comprise both activities carried out in school and out-of-school (OOS) STEM programs (Kong et al., 2014). OOS STEM programs designed for young teenagers emerged in association with the development of the competencies and the corresponding confidence considered suitable for a STEM career (Gagnon and Sandoval, 2020). An example is a program comprising semi-structured courses which explored how students could continue to engage across a range of STEM career pathways. The results suggested that specifically focusing on STEM programs for young people could encourage them to pursue a STEM career in the future (Beier et al., 2019). Moreover, Kang et al. (2019) suggested that OOS programs may provide the necessary context for developing young people's socio-emotional and motivational skills along with their STEM career aspirations and career determinism. However, although STEM education has been found to be able to motivate students to study STEM and to pursue future STEM careers (Lee et al., 2019; Margot and Kettler, 2019), how an event such as IEYI may develop adolescent participants' career interest in STEM is still unknown. Thus, participants' career interest was explored in this study.

RESEARCH HYPOTHESES AND MODEL

Hands-On Making Attitude and Epistemic Curiosity

IEC refers to the “desire to know” know-how, and results in positive feelings of intellectual interest in and enjoyment of cognitive tasks which require effort, while DEC refers to the “need to know” in the motivation to reduce undesirable states of informational deprivation in cognitive tasks (Strobel, 2014). In hands-on making contests, project design can activate Students' curiosity to produce different kinds of artifacts (Mohr-Schroeder et al., 2014). Moreover, most people are not even aware of the existence of attitude and its implicit impact on their behavior, and so they often refer to their automatically driven actions

(Serenko, 2022). When students experience pleasure in cognitive activities, positive affect will promote high levels of curiosity, which is more conducive to problem solving and exploratory behaviors (e.g., Hong et al., 2016). Evidence supports the link between curiosity and attitude of hands-on making, underlying which is a high degree of uncertainty, novelty preference, and dynamic complexity (Jirout and Klahr, 2012). Accordingly, how hands-on making attitude related to participants' two types of epistemic curiosity when working collaboratively on STEM making and design of inventions in competition groups was hypothesized as follows:

H1: Hands-on making attitude is significantly related to IEC.

H2: Hands-on making attitude is significantly related to DEC.

Epistemic Curiosity and Science, Technology, Engineering, and Mathematics Career Interest

IEC orients individuals toward a carefree form of intellectual exploration (Lauriola et al., 2015), relates with acquiring knowledge purely for the intrinsic pleasure, and is associated with “drive to know” (Litman, 2008). In contrast, DEC reflects a state of dissatisfaction with a specific problem and is conceptualized as a “need to know” with moderately unpleasant feelings (Litman, 2008; Subaşı, 2019). It is correlated with pervasively negative emotions such as depression, anxiety, and burnout (Litman, 2008; Kashdan et al., 2020). Nevertheless, some empirical studies have indicated that DEC orients individuals to have positive relationships with performance achievement, intrinsic motivation, self-growth, stress tolerance, and perseverance to master goal orientation (Litman et al., 2010; Kashdan et al., 2018). It also influences one's career optimization and professional life (Malcom et al., 2020). However, many studies have taken epistemic curiosity as one variable, with few separately exploring whether the different types of EC (drive to know and need to know) play different roles in career interest (Tang and Salmela-Aro, 2021). Furthermore, few studies have connected epistemic curiosity to hands-on STEM activities, an important pathway to develop young Students' team competitiveness and STEM career interest (Wright and Walton, 2003; Mussel, 2013). To understand how both types of EC relate to participants' future career interest was hypothesized as follows:

H3: I-type EC is positively correlated to STEM career interest.

H4: D-type EC is positively correlated to STEM career interest.

Hands-On Making Attitude and Science, Technology, Engineering, and Mathematics Career Interest

Epistemic curiosity is driven by positive attitudes. Individuals who are placed at a high level of EC will probably be highly motivated and engaged in learning, and tend to frequently exhibit explorative behaviors in choosing scientist and inventor

careers (Birenbaum et al., 2021). Moreover, in comparison with conventional settings, the essence of the IEYI contest is the process of hands-on creation with STEM knowledge. Such a competitive environment fosters more interest and positive attitudes toward invention projects (Huang et al., 2016). Accordingly, their hands-on making attitude supports the development of their behavioral intentions, thus leading to actual career intention (Serenko, 2022). In this study, considerable attention to the Attitude-Behavior-Context (ABC) model (Guagnano et al., 1995) links to examining participants' attitudes in the specific context of invention design, in light of epistemic curiosity, which ultimately influences their career interests. However, few studies have explored whether hands-on making attitude can directly enhance Students' intention to participate in STEM careers. Hence, we proposed the following hypothesis:

H5: Hands-on making attitude is significantly related to STEM career interest mediated by two types of epistemic curiosity.

Research Model

This study employed the ABO framework, which has been widely used to understand behavior and outcomes in various settings (e.g., Hansen, 2008; Ashnai et al., 2016). The pursuit of STEM-related career interests could be the outcome regarded as career decision-making in which students evaluate the person-vocation fit of their career interest (Kim and Beier, 2020). Hence, we utilized these multiple links in our models (presented **Figure 1**) to confirm the influences of hands-on making attitudes which activated two inquisitive behaviors of Students' epistemic curiosity then predicted the outcomes of their STEM career pursuits in a real hands-on making contest.

MATERIALS AND METHODS

Research Setting

IEYI is a science and technology contest with the designated goal of providing students with the design knowledge and skills needed for their future careers, and of developing Students' core competences such as problem solving, critical thinking, and communication skills. Participants should prepare a complete description of the work and the outstanding information related to their work. Professional judges evaluate the inventions based on the principles of creativity (e.g., innovative function; innovative mechanism; application of scientific nature), marketability benefits (e.g., market demand; social contribution; appearance and exquisiteness) and operability (e.g., operation, constitutive property, and overall integration). Therefore, participating team members need to implicitly learn and use scientific knowledge, mathematical principles, and creative thinking to design their prototypes, as well as technical knowledge, engineering ability, and practical skills to create projects. Also, participants should decorate and articulate their artworks with creative forms and have intelligible expression when presenting their projects. Engaging in this task-specific

activity certainly poses cognitive challenges for youth, as they must quickly and accurately come up with solutions to turn their imaginations into concrete innovative products.

Participants and Research Procedure

This study used purposive sampling. The participants were competitors from vocational high schools in Taiwan who participated in the 2021 IEYI Taiwan Competition held on March 16, 2021, and freely signed up in teams of up to three students. The questionnaire data were filled out and collected anonymously while taking time out of the competition. Participants who did not wish to complete the questionnaire could withdraw from the study without any repercussions.

After the competition, 236 questionnaires were collected. In a preliminary review, questionnaires with missing responses or answers that were all the same were excluded; the valid questionnaires numbered 213, with an effective response rate of 91.5%. The analysis sample consisted of 128 (60.71%) males and 85 (40.4%) females.

Questionnaire

The questionnaires were designed by referring to prior studies and relevant theories to assure their face validity (Hardesty and Bearden, 2004). The original items were then translated into Chinese and were reviewed by domain experts for both accuracy and intelligibility. A 5-point Likert scale was used, where 1 = *very slightly or not at all* and 5 = *extremely*.

Hands-on making attitude (HMA): Three attitude components: affect, behavior, and cognition (knowledge and beliefs) were identified by Breckler (1984). In addition, according to the Expected value theory, attitude has evolved as an integrated framework of needs, expectations and values, and could be used as an explanation of Students' multidimensional attitudes toward hands-on making (Zhang et al., 2021). Considering that attitude definition differs depending on the culture or domain (Vogel and Wänke, 2016), the construct items of hands-on making attitude were adapted from Hong et al.'s (2021) study, which included affect and behavior and were developed to assess students' tendency to engage in hands-on problem-solving. The scale has seven items such as "I like to assemble things following the manual instructions," and "When an electrical appliance breaks down (e.g., an electric fan), I will try to repair it by myself first."

Epistemic curiosity: Two different epistemic curiosity scales were composed to assess the IEC and DEC components adapted from Litman and Spielberger (2003). Each has six items. For I-type EC, example items are, "The more complex the invention, the more I enjoy exploring its innovativeness," and "When I find a novel invention, I will explore its features and functions by browsing all kinds of information." For DEC, exemplary items are, "When I'm working on a creative project, I will continue to explore the causes of other problems that arise after one problem," and "When I encounter challenges in inventing, I will estimate and probe ways to solve them."

STEM career interest (SCI): For this scale, the Career Interest Questionnaire (CIQ) (Tyler-Wood et al., 2010) was compiled. This scale consists of seven items such as "I will enjoy a career

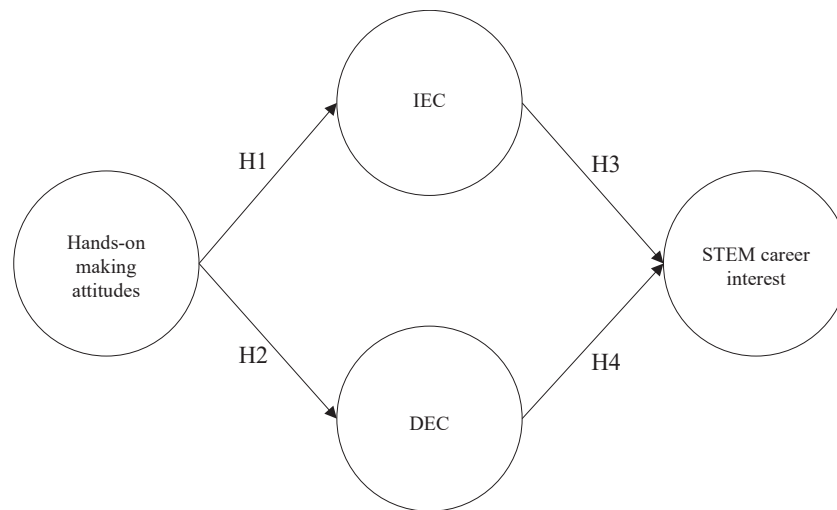


FIGURE 1 | Research model.

in science” and “When I graduate, I will specialize in the field required for a career in science or engineering.”

RESULTS

Item Analysis

In order to ensure the suitability of items in each construct, firstly, items with factor loadings less than 0.5 were deleted. Next, a first-order confirmatory factor analysis (CFA) was conducted to check the internal validity of each item through excluding items which showed the highest residuals for each construct until they reached the recommended threshold (Hair et al., 2019b). Accordingly, the χ^2/df value should remain below 5, the RMSEA is in the range of 0.05–0.10, and the expected of GFI and AGFI values should be above 0.80. As the results of executive Model Fit Statistics are shown in **Table 1**, the deletions in this study were that HMA was reduced from seven to four items, the IEC and DEC items were both reduced from six to four, and the SCI items were reduced from seven to six.

To examine the external validity of each item, we performed an independent sample *t*-test. The top 27% of the scale scores were categorized as high and the bottom 27% as low. According to Cor (2016), the resultant value should be above 3 to be considered as statistically significant. In this study, the *t*-value was higher than 13.59 ($p < 0.001^{***}$), demonstrating that the model had good discriminant and external validity, and could be used for different samples in different situations (Green and Salkind, 2004).

Reliability and Validity Analyses

Questionnaire reliability was assessed by Cronbach's α and composite reliability (CR). The Cronbach's α value should be above 0.7 (Tavakol and Dennick, 2011) and CR should exceed the 0.7 threshold (Lleo et al., 2021). As shown in **Table 2**, the Cronbach's α values above 0.83 reveal that those constructs have

good internal consistency; the CR values above 0.70 indicate that they have acceptable external consistency. Further, the convergent validity of the constructs was verified by the AVE and factor loading, where the values should exceed 0.5 (Lleo et al., 2021). **Table 2** shows that the FL and AVE of all variables were above 0.6, signifying that there is acceptable convergent validity for all constructs.

To ensure construct discriminant validity (i.e., the difference between two constructs), it is recommended that the correlation coefficient between two constructs be less than the square root of the AVE of each construct (Awang et al., 2015). As can be seen in **Table 3**, the square root of the AVE of each construct exceeded the absolute value of the correlation coefficients between constructs. Thus, the questionnaire had good construct discriminative validity.

The Structural Model Fit Analysis

In the study, we used AMOS 20.0 to analyze the model fit. As a large number of fit statistics consider different aspects of the fit, Thompson (2000) suggested that researchers should report multiple fit statistics in structural equation modeling studies. According to the absolute fit measures, the recommended values including χ^2/df should be less than 5, RMSEA should be less than 0.1, and GFI and AGFI should be greater than 0.80 (Hair et al., 2019a). As for the incremental fit measures, the fair fit indicators include NFI, TLI, CFI, IFI, and RFI which should all be larger than 0.8 (Hair et al., 2019a). In this study, $\chi^2/df = 2.995$, RMSEA = 0.096, GFI = 0.849, AGFI = 0.801, and NFI = 0.856, TLI = 0.880, CFI = 0.898, IFI = 0.899, and RFI = 0.831. All of these indicators meet the recommended criteria, demonstrating that the model has good fit.

Path Analysis

This study adopted the covariance-based structural equation model. The significance of the paths is determined by the value of each path coefficient (Hair et al., 2019b). **Figure 2** shows

TABLE 1 | Results of first-order confirmatory factor analysis—model fit measures.

Index	Threshold	Hands-on making attitude	I-type EC	D-type EC	STEM career interest
χ^2/df	<5	2.421	1.419	1.959	2.098
RMSEA	<0.10	0.081	0.044	0.066	0.071
GFI	>0.8	0.978	0.993	0.982	0.971
AGFI	>0.8	0.934	0.967	0.947	0.933
FL	>0.5	0.570~0.831	0.753~0.838	0.681~0.841	0.624~0.878
t-value	>3	15.563~22.368	17.151~22.150	16.828~17.813	14.835~18.148

TABLE 2 | Construct reliability and validity analysis ($n = 213$).

Constructs	<i>M</i>	<i>SD</i>	α	CR	FL	AVE
Hands-on making attitude	3.824	0.756	0.826	0.894	0.757	0.628
I-type EC	4.358	0.631	0.880	0.882	0.808	0.653
D-type EC	4.272	0.671	0.864	0.894	0.787	0.628
STEM career interest	4.246	0.70	0.903	0.904	0.767	0.613

the validation of the path analysis between hypotheses. H1: the influence of hands-on making attitude on I-type EC was supported with a standardized regression coefficient (SRC) of 0.541 ($t = 7.422^{***}$, $p < 0.001$); H2: the influence of hands-on making attitude on D-type EC was supported with a standardized regression coefficient (SRC) of 0.644 ($t = 8.595^{***}$, $p < 0.001$); H3: the influence of I-type EC on Students' STEM career interest was supported with a standardized regression coefficient (SRC) of 0.365 ($t = 3.427^{***}$, $p < 0.001$); H4: the influence of D-type EC on Students' STEM career interest was supported with a standardized regression coefficient (SRC) of 0.550 ($t = 3.984^{***}$, $p < 0.001$).

In the path analysis, R-squared (R^2) shows the proportion of variation in the variables explained by the effects of other variables within the model, based on the square of the multiple correlation coefficient (Byrne, 2001). Therefore, when the value of R^2 is closer to 1, the model's explanatory ability is more powerful. It has been suggested that R^2 larger than 0.67 means the model has good explanatory ability, when it is around 0.33, the model has fair explanatory ability, and when it is around 0.19, it has poor explanatory ability (Awang et al., 2015). The variance of the hands-on making attitude to I-type EC was 43.2%, and to D-type EC it was 60.1%; and for variance of hands-on making attitude, I-type EC and D-type EC to STEM career interest was 60.9%. Those variances were above the suggested threshold value of 10% (Falk and Miller, 1992), indicating that all variables had good predictive power.

The Cohen's f^2 effect size is defined as follows (Cohen, 1988): Where R^2 is the squared multiple correlation, $f^2 \geq 0.02$, $f^2 \geq 0.15$, and $f^2 \geq 0.35$ represent small, medium, and large effect sizes, respectively. These data can help determine statistical significance, but if confirmed as practically significant, it can be judged according to the verification of the effect quantity. As for the effect sizes in this study, results indicated that hands-on making attitude to I-type EC had a large effect size ($f^2 = 0.767$); hands-on making attitude to D-type EC had a large effect size ($f^2 = 1.531$); and hands-on making attitude, I-type EC, and D-type EC to STEM career interest also had a large effect size ($f^2 = 1.558$).

TABLE 3 | Construct discriminative validity analysis ($n = 213$).

Constructs	1	2	3	4
Hands-on making attitude	0.792			
I-Type EC	0.459	0.808		
D-Type EC	0.592	0.776	0.792	
STEM career interest	0.487	0.679	0.712	0.783

Bold values on the diagonal are the square roots of AVE. To establish the discriminative validity, the value should be greater than the inter-construct correlations.

Indirect Effect Analysis

The study used Bootstrapping, which means using a small initial program to load the program into the operating system to analyze the indirect effects of this model. When the indirect effects were analyzed, the interval between the two values did not include zero. According to Preacher and Hayes (2008), this shows that the model had an indirect effect. The indirect effect of hands-on attitude on STEM career interest ranged from 0.375 to 0.974. As shown in **Table 4**, this suggests that there is an indirect effect in this research model (MacKinnon, 2008). As hypothesized, higher levels of hands-on attitude were positively associated with STEM career interest, thus supporting H5. That is, hands-on attitude positively predicted STEM career intentions under the mediation of the two types of EC.

DISCUSSION

The IEYI competition activities provide a learning environment which creates an environment for youth learners to experience the objects of real-world STEM-related tools to solve problems, manipulate the real technologies within the world of work, and experience the complete action process (Hu et al., 2020). Drawing on ABO, this study chose young inventors who participated in an international youth invention exhibition as subjects. How the role of Students' hands-on making attitude as antecedent to motivate the epistemic behavior to advance STEM knowledge

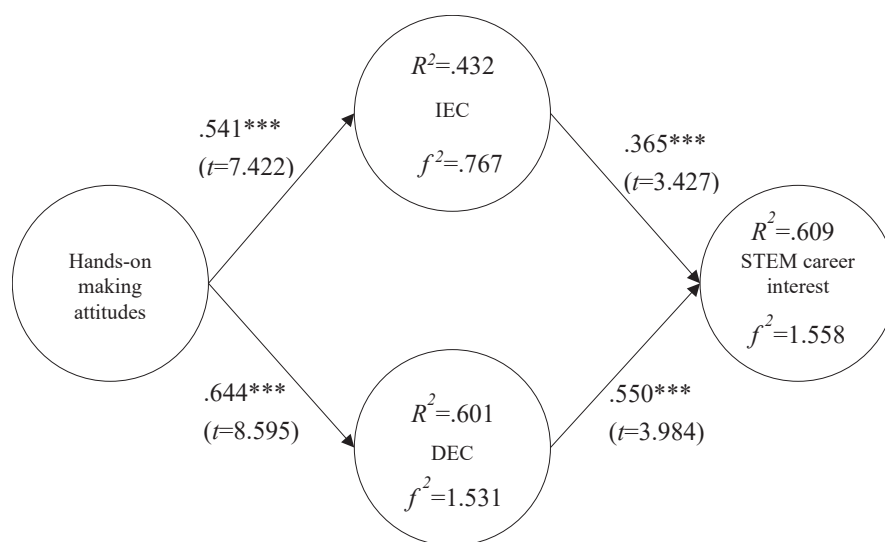


FIGURE 2 | Model fit analysis. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

TABLE 4 | Indirect effect analysis.

Construct indirect effect	Hands-on making attitude	
	β	95%CI
STEM career interest	0.627***	[0.375, 0.974]

***The mean difference is significant at the 0.001 level.

and skills for IEYI contests that explicitly predict Student's future pursuing in STEM-related career. These proposed hypotheses were verified as follows.

The existence of attitudes implicitly impacts on individuals' behavior, and individuals often refer attitude to the tendency to drive actions (Serenko, 2022). In hands-on making contests, to create functions and ensure the quality of an invention in which that Students' curiosity can be activated (Mohr-Schroeder et al., 2014). In line with this, in IEYI competitions, students need to complete their works and design excellent products to win the competition. In this process, they have to consistently improve the quality and function of their products; thereby hands-on making attitudes contribute to salient beliefs and outcome expectations (Sukhu et al., 2019). How hands-on making attitudes relate to triggering students' epistemic curiosity in project design for IEYI was hypothesized, and H1 and H2 were both positively verified. This evidence supported the link between curiosity and attitude toward hands-on making, and is consistent with a previous study which revealed a positive correlation when students were involved in making project with a high degree of uncertainty, novelty preference, and dynamic complexity (Jirout and Klahr, 2012). Moreover, the results are supported by other studies which revealed that a positive hands-on attitude contributed to the development of STEM knowledge and skills when searching for or thinking about solutions to problems (Christensen et al., 2015; Sari et al., in press).

Individuals' epistemic curiosity increases their confidence in the STEM field. We drew on the broaden-and-build psychology of working theories to better understand how optimism about one's career develops and influences one's vocational interest (Eva et al., 2020). Inquisitive curiosity captures flexibility and risk taking, and optimizes career confidence (Santilli et al., 2017). Careers have been defined as a sequence of work experiences which evolve over a person's lifetime, and as the movement of a person through time and work space (De Vos et al., 2021). Work experiences help individuals to self-evaluate their person-vocation fit, which in turn builds their personal career confidence and interest (Glosenberger et al., 2019). In line with this, how the efforts of attending IEYI with project making in relation to individuals' STEM career interest, we applied the broaden-and-build theory to explain. Accordingly, we hypothesized that the two types of EC can predict STEM career interest, and H3 and H4 were positively verified. The results are supported by a previous study; for example, the extent to which interest increases as a consequence of out-of-school program participation is a positive yet trivial probability (Lewalter et al., 2021). Taken IEYI contest as out-of-school activity in an invention-oriented STEM competition, which bring out students have to thinking outside the box in relation to practicing their epistemic curiosity in which their STEM career interests promoted.

With more students eager to participate in STEM technology competitions, a previous study directly spotlighted that Students' positive attitudes toward STEM practices during competitions can enhance their interest in making STEM projects (Ku et al., 2022). In line with this, out-of-school STEM programs were found to help boost high school STEM career aspirations (e.g., Constan and Spicer, 2015; Kitchen et al., 2018). H5 was positively supported by this research and further explains the reasons. In the process of producing projects, students make alternative models which generates their new perspectives on how they might "do" (STEM) differently (Yanez et al., 2019).

IEYI is an integrated STEM contest which provides students with experience of analyzing, designing, verifying, and practicing in hands-on actions to assemble interrelated elements into a functional whole to showcase their competencies (Kim and Kim, 2021). In line with this, hands-on making attitude, as an observed variable in Students' subjective perceptions of the value of the STEM competition, was shown to have an indirect effect on their STEM career interest. This study contributes to the STEM theory by examining an "attitude-behavior-outcome" framework of STEM hands-on making relationships and distinguishing the influence between IEC and DEC which were activated through different stimulations on Students' STEM career interest.

CONCLUSION

STEM is important because it integrates multiple disciplines, emphasizes learning by doing and experiential learning, and adopts practical skills assessment practices. The aim of STEM education is to provide a seamless gateway for students moving from school to the workplace and to contribute to the increase in Students' curiosity about the physical world (Jirout and Klahr, 2012) and innovation in their future career development. IEYI is a STEM competition which highlights Students' learning in science, engineering, mathematics, arts, and technology investigations. In summary, those participants who had more positive hands-on attitudes toward solving little problems in their daily life had higher positive predictive power for IEC and DEC, and both types of EC positively predicted students' STEM career interest.

Implications

This study was conducted during a youth invention competition, and the results showed that STEM competitions can be seen as a suitable channel for fostering creative engagement and access to knowledge objects as a way to stimulate Students' developing interest in STEM. According to Knorr Cetina (2001), "epistemic practice" exists in advanced project design, while Guile (2009) argued that "the accumulation, verification and distribution of knowledge to improve quality is becoming a constitutive feature of innovation." From this, epistemic curiosity generated from and resting on practice could foster STEM inquiry or reflection on problem solving during the invention process. When attending an invention competition, if students can maintain high levels of EC, the transition from education to work will be supported and more of the twenty-first century workforce will be willing to choose STEM careers in the future. In this case, these findings provide practical guidance as to how educators can be involved with activity-centered STEM outreach design: implicitly designate vocational exploration practices with cognitive challenges for young makers. Activating curiosity as a unique aspiration has important implications for supporting Students' development as hands-on making inventors.

Using ABO to guide this study was feasible; hands-on making attitudes as an antecedent could activate participants' epistemic curiosity in the forms of desire to know and need to know. ABO is suitable for analyzing the predictions between perceived

behavior and career decision-making after engaging in STEM activities, derived mainly from the interaction between contextual factors such as successful problem solving in the invention process (Christiansen and Tett, 2013), as a way to enhance individuals' career interest with person-vocation fit. This study suggests that the hands-on making attitude of vocational high school students involved in STEM projects should be improved to initiate their epistemic curiosity and cultivate their long-term career interest in STEM.

Limitations and Future Study

There are some limitations to the present study that should be noted. Firstly, some researchers have argued that students have already established high levels of STEM interest and positive attitudes prior to outreach program participation (Bachman et al., 2008). Future research can administer pre- and post-program surveys so as to infer the causal effect of STEM competition activities on career intentions.

The mind-sponge mechanism assumes that individuals have a mindset, or a set of core values, which serves as a benchmark for information absorption and multiple filtering (Vuong and Napier, 2015), which has a further positive influence on their thinking and behaviors (Vuong et al., 2022). In that case, when facing a problem that they cannot solve based solely on prior knowledge and skills, Students' mind-sponge regulates seeking information from external sources to arouse epistemic curiosity. Such epistemic curiosity later appears in the mindset and subsequently influences the subjective cost-benefit judgment during information absorption. Thus, future studies may focus on how the mind-sponge mechanism could be revealed more deeply from epistemic curiosity.

This study was based on an IEYI competition which involved making a product by applying STEM; we therefore put more emphasis on attitude toward career interest when students were engaged in the creative activities. The point of view is from IEYI participants' perception; however, the scheme of organizing an invention exhibition can influence the willingness of students to endeavor to practice STEM knowledge and skills. This is observed from the enrollment numbers of joining the Taiwan IEYI competition in which the value evaluated by participants affect them to decide how much they will engage in that will develop their STEM interest in that career. This perspective was not included in this study; thus, future studies can focus on the value the rationalize participants career interest.

Finally, we described students' STEM-related career interest in general, but made no differentiation between STEM career categories, such as science (Biological/Chemical investigators), engineering (e.g., ICT professionals, technicians, and construction workers), medicine (e.g., veterinarians, dosimetrists), or health (e.g., nursing), with no breakdown of Students' career interest being tracked. It is therefore suggested that future studies can adopt a more fine-grained analysis of Students' STEM-related domain-specific career interest to better understand whether there are differences according to different categories of STEM.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation

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The Impact of Knowledge Management Process and Intellectual Capital on Entrepreneurial Orientation and Innovation

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Innovation is considered to be a dominant cause for sustainable business success. Knowledge management and intellectual capital are powerful tools to promote innovation in the organization. Therefore, this study aims to explore the influence of knowledge management process and intellectual capital on innovation with the mediating effect of entrepreneurial orientation and moderating role of leader education level. Data were collected from a sample of 393 IT firms listed in the Pakistan Software Houses Association and applied a partial least squares structural educational modeling (SEM) technique. The results show that the knowledge management process and intellectual capital have a positive effect on innovation. Moreover, the study confirms that entrepreneurial orientation partially mediates the relationship between knowledge management and intellectual capital on innovation. Furthermore, the moderation effect of a leader's education was confirmed for the knowledge management-innovation relationship whereas, the moderation effect of the leader's education on intellectual capital and innovation relationship was insignificant. Recommendations for practitioners and future research directions were also discussed.

Keywords: knowledge management process, intellectual capital, entrepreneurial orientation, innovation, IT industry, Pakistan

INTRODUCTION

Globalization and growing technological changes have forced organizations to adopt more creative and innovative work patterns (Al-Jinini et al., 2019; Ruiz-Ortega et al., 2020). Individuals and organizations bring new ideas to markets frequently because they are facing competition at both domestic and international levels. Thus, for survival in such globally competitive markets, innovation has become a major challenge and is considered to be the key element for business success (Buenechea-Elberdin et al., 2017). It is pertinent to mention that innovation displays a crucial part in the development of a company and helps companies to gain a competitive advantage over their rivals (Hassan et al., 2018; Alvino et al., 2020). Flanigan et al. (2017) define knowledge

management as the process of creating, increasing, sharing, and transforming the knowledge and information of an organization. Li et al. (2019) view innovation as a vital factor for long-term business success. The innovation of a firm depends upon the current competencies and capabilities to enhance or convert the older technology into new technology (Rasheed et al., 2017). A successful and sustainable innovation process is dependent on intellectual capital and knowledge management as resource-based theory (RBT) states that organizational innovation depends upon the internal capability of a firm, such as knowledge, ability, and employees' skills, and proper management of the knowledge and intellectual capital (Cabrilo and Dahms, 2018). In the current intense competitive world, the establishment of knowledge-based resources in organizations is vital for successful organizational operations, and to knowing what information is more critical to the organizational success than what it owes (Asemokha et al., 2019).

Intellectual capital is considered the best powerful competitive weapon and a very precious asset of an individual (Iqbal et al., 2018). Intellectual capital is a major source for a company for achieving innovation in processes, products, and getting an edge of competitive advantage in the marketplace (Li and Yu, 2018). An innovation in an organization is mainly dependent on different facets of intellectual capital (Dabić et al., 2018) comprising human, organizational, and social capital. The real value of a company lies in finding the hidden brainpower (intellectual capital) which provides a competitive advantage to improve the market value and financial performance (Zhai et al., 2018). Furthermore, Naqshbandi and Jasimuddin (2018) emphasize that it is important that critical knowledge possessed by the organization should be stored in an appropriate forum for long-term innovation; furthermore, to attain a sustainable comparative advantage, the organization should also ensure creativity. Such types of knowledge strategies and policies are necessary to attain better quality knowledge management to enhance sustainable comparative innovations since there is little research connecting the intellectual capital and knowledge management with innovation, particularly in the context of a collectivistic country as these conceptions are earlier developed and tested in Latin America and Western culture (Migdadi et al., 2017; Le and Lei, 2019).

Entrepreneurial orientation is a vital source for the success of an organization. Entrepreneurial orientation is extracted into entrepreneurship; it takes all action, adopted techniques, and decision-making activities that encourage starting a new business (Tajeddini et al., 2020). Moreover, entrepreneurial orientation also boosts entrepreneurial activities. Literature evidence that there is a positive association between intellectual capital and entrepreneurial orientation (Zhai et al., 2018; Al-Jinini et al., 2019). Entrepreneurship serves as the backbone of a country since it has an essential role in improving the economy of the country (Li et al., 2020). It necessitates studying those resources, which cannot be quickly and easily imitated by revivals, such as the intellectual capital of the organization and entrepreneurial orientation. Moreover, as discussed above, an effective knowledge management process based on its inimitability leads toward sustainable competitive advantage in

the marketplace and aids differentiation up to a sustainable level and enhances innovation. Proper knowledge management enhances organizational capabilities to utilize resources of firms properly to exploit new opportunities arising in the market. Therefore, knowledge has become a significant foundation of entrepreneurial orientation that energizes the strategic orientation of a firm and enable it to adapt to environmental changes and react to trendy opportunities (Li et al., 2019).

According to McDowell et al. (2018), innovation is explained as the organizational capability to launch novel goods and services and these novel goods and services are considered as innovation because they present the capability of an organization to adjust according to market changes. In a similar pattern, Masa'deh et al. (2018) explain that entrepreneurial orientation leads to superior performance because it makes owners and managers more vigilant toward the adaptation of the latest market demands and changes, thus promoting innovation. However, few types of research within the existing body of knowledge management process and intellectual capital testified to the positive association between entrepreneurial orientation and innovation in the context of developed countries (Al-Jinini et al., 2019).

The literature-based evidence has been spotted where the relationship between grassroots innovation and entrepreneurial success was fully mediated by entrepreneurial orientation (Singh et al., 2019). So, in a Pakistani business perspective, the current study has the objective of unfolding the intervening role of entrepreneurial orientation in the relationship between intellectual capital, knowledge management, and innovation. Literature has well defined the integral role of leadership education across the organizations. It has been established that leadership success is the cause of higher education; therefore, antiquities discussed that the innovation of a firm depended upon the education level of leaders (Silva, 2014). Similarly, higher education levels of leaders may change the intensity of the relationship between intellectual capital and knowledge management with innovation as employees' abilities and organizational ability to process knowledge, leading to increased innovation (Cabrilo and Dahms, 2018). Therefore, to fill this gap, this study investigates the moderating effect of leaders' education on the relationship between knowledge management, intellectual capital, and innovation.

This study contributes to the literature on knowledge management, intellectual capital, and innovation because this is the first study that links knowledge management and intellectual capital with innovation through the mediating effect of entrepreneurial orientation and the moderating role of a leader's education in the IT (hi-Tec) sector of Pakistan. After all, prior studies explore different outcomes of intellectual capital and innovation (Han and Li, 2015; Obeidat et al., 2017), while little is known about the relationship between knowledge management and innovation (McDowell et al., 2018; Alrowwad et al., 2020). Therefore, this study is the first that explores the level of innovation in developing countries like Pakistan because Pakistan stands at a very low pace in entrepreneurship and innovation compared to its neighbor countries in Asia (Poblete and Mandakovic, 2020; Tok, 2020). It is pertinent to mention that

a prior study has been conducted in SMEs, manufacturing, and pharmaceutical sectors (McDowell et al., 2018), but the current study aims to testify to the relationship in the IT (hi-Tec) sector because the IT industry plays a crucial role in enhancing the innovation in the era of digitalization, and many prior studies call for enhancing the understating of the innovation.

Based on the above-mentioned research inputs, this study aims to identify these research gaps in the conceptualization of knowledge management process on entrepreneurial orientation and innovation with the moderating role of leaders' education. Therefore, within the developed research model, the study investigates the following research objectives:

RO1: To identify the impact of knowledge management process and intellectual capital on entrepreneurial orientation and innovation.

RO2: To assess the mediating effect of entrepreneurial orientation in the relationship between knowledge management process and intellectual capital on innovation.

RO3: To examine the moderating role of leader education in the relationship between knowledge management process and intellectual capital on entrepreneurial orientation.

The remaining part of the article is ordered as follows: Section "Theoretical Framework" discusses the theory and hypotheses of development. The methodology and data are presented in section "Materials and Methods," while empirical results are reported in section "Results," and discussion and conclusion are explained in section "Discussion and Conclusion." Theoretical and practical implications are explained in section "Implications."

THEORETICAL FRAMEWORK

Theoretical Support

The foundation of the current study was established on entrepreneurial orientation and the resource-based view (RBV). This explains how entrepreneurial efforts and organizational internal resources should be focused on because these are the center of attention in the RBV theory and concepts of entrepreneurial orientation (Bacq and Eddleston, 2016; Ziyae and Sadeghi, 2020). The RBV conceptualizes the firm as a bundle of resources and highlights the importance of resources to generate an added value to the firm (Ziyae and Sadeghi, 2020). To sustain performance over time, firms must possess or develop unique resources, i.e., resources that cannot be easily copied by other firms (intellectual capital) and proper knowledge management. The extended perspective of the RBV includes all types of resources accessed by a firm (Burvill et al., 2018), while the appropriate realization of entrepreneurial orientation is beneficial not only for the effective mobilization of resources but also coordinates the firm to interconnect stakeholders within or among the firms like governmental agencies and business partners (Nagano, 2019). The different entrepreneurial orientation dimension focuses on the attitude of enterprises

toward risk, which is the key to decision-making, research and development, and product/service launch (Korobov et al., 2017). The RBV recommends forming a resource bundle that is unique enough to create the foundation for getting a competitive advantage for a firm that is difficult to be imitated by the competitors of the firm (Pee and Kankanhalli, 2016).

Prior studies argue that companies that are increasingly developing their knowledge management processes and intellectual capital tend to improve their entrepreneurial orientation over time and eventually promote innovation in firms that are supposed to explore in this research (Al-Jinini et al., 2019; Alvino et al., 2020). Based on the discussion on RBV, the specific intentions of this research are to explore the following factors: (1) knowledge management processes to accumulate and utilize the knowledge in a time to support entrepreneurial orientation; (2) a firm's intellectual capital can appropriately cope up with different uncertainties inherited in such highly variant activities as RBV believes that the intellectual capital provides the basis for further development and enhancement of employee's capacities through continuously emphasizing on collaborative learning opportunities; (3) entrepreneurial orientation enhances the innovation capacity of a firm because it helps to identify the prevailing opportunities, firm's capacity to exploit these opportunities, and its capability to adapt these opportunities appropriately. Furthermore, Kianto et al. (2017) argue that innovation has been recognized as an important driver of economic growth and often enables organizations to provide higher quality products and services at lower prices; and (4) the role of a leader's education level in exercising entrepreneurial orientation to exploit innovation infirm.

Hypothesis Development

Linking the Knowledge Management and Innovation

Regional economic growth and innovation knowledge are considered as basic inputs. In local and international markets, knowledge is an integral resource to improve competitiveness (Teixeira et al., 2019). According to Payal et al. (2019), knowledge has two core types, those that are explicit and tacit. Antunes and Pinheiro (2020) suggest that it is easy to store explicit knowledge, and it can be conceptualized on the other side; it is very difficult to communicate, formalize, and share the tacit knowledge because it belongs to the personal trait. To organize, acquire, capture, and communicate both explicit and tacit knowledge of employees through an organizational systematic framework requires knowledge management. To maximize the organization's knowledge, other employees would take advantage of this knowledge in the most effective way (Ode and Ayavoo, 2020). Silvianita et al. (2020) developed knowledge management features as a dynamic idea that blended a system approach (Bashir and Farooq, 2019).

Every sort of knowledge that is acquired, developed, and disseminated must be accompanied by authorization and knowledge storage; otherwise, a company runs the risk of unintentionally forgetting to acquire knowledge (Hussinki et al., 2017). The tacit knowledge is the type on which the organizational innovation process highly depends. By changing

broad knowledge into specific knowledge, new and useful knowledge is developed and translated into goods, services, and processes (Shiranifar et al., 2019). Attia and Essam Eldin (2018) discussed that it is important to stress that an organization will put a lot of effort into remaining inventive, assuring creativity, and achieving long-term competitive advantages if its vital knowledge is not stored properly. A specific system or website is also essential to achieve enhanced knowledge management results for many types of inventions (Singh et al., 2019).

Knowledge policies and strategies, according to the literature on knowledge management, have an impact on a company's ability to innovate and persist (Naim and Lenka, 2017). The antiquities shed light on obtaining market intelligence, which is critical for fostering novelties that best meet customer wants. López-Nicolás and Meroño-Cerdán (2011) studied Spanish enterprises and found that a knowledge management approach improves the inventive capacities and competencies of a firm, resulting in long-term performance. On the foundation of proceedings, the following hypothesis has been framed:

H1: There is a positive relationship between knowledge management and innovation.

Linking the Intellectual Capital and Innovation

Intellectual capital is a collection of solid reserves including institutional explicit knowledge, skills, experience, technology, and contacts that enable an organization to compete in the sector (Liu, 2017a). Roos (2017) defines the concept of intellectual capital as a "multifaceted and heterogeneous concept." Intellectual capital is "knowledge that is of value to an organization (Kianto et al., 2017). Human capital, relational capital, and structural capital are the three categories of interrelated intellectual capital components that scholars study (Li and Liu, 2018). The ability of an organization to create value and compete is mainly determined by its intellectual capital and ability to innovate. This research looks at the impact of several sorts of intellectual capital, like social and human, social capital, on the innovative outcome. Every human being can be a useful asset or a burden to an organization (Xu and Wang, 2018). Human capital is a combined resource derived from workforce tacit knowledge, capacities, and skills (Ginesti et al., 2018). The scientific results of many studies offer compelling reasons for the importance of human capital in the process of innovation since the value and originality of human knowledge are critical to the process (Yong et al., 2019). Furthermore, much more scientific evidence has emerged in the last 15 years demonstrating that the potential of an organization to innovate is closely related to its human capital and that there is a significant relationship between human capital and innovation (Amin and Aslam, 2017; Obeidat et al., 2017; Smriti and Das, 2018).

The connection and collaboration among individuals who share their ideas result in social capital (Al-Jinini et al., 2019). Buenechea-Elberdin et al. (2017) elaborated that the importance of social capital in encouraging adoption and overcoming the limits of a lack of financial, human, and natural capital cannot be overstated. Dabić et al. (2018) stress the importance of social capital in the creation of innovation. Moran (2005)

analyzes the effect of both relational and conceptual involvement of social capital on performance management, emphasizing the importance of relational involvement for enhancing innovation capability, taking into account the extent of personal commonality (proximity), and the notion of trust in the relationship. Liu (2017b) contended that innovation is essentially a collective effort in which social capital plays a critical role. Additionally, previous research suggests that intra-organizational knowledge sharing (social capital) promotes company innovative behavior since it fosters innovation and inspires knowledge and innovation (Mehralian et al., 2018; Barrena-Martinez et al., 2019). Tiwari and Vidyarthi (2018) described why the launch strategy for new products is positively correlated with social capital.

In summary, human capital and social capital play an active role in the innovation activities of a firm. As intellectual capital has primarily focused on the utilization of resources in the organization (Kamukama and Sulait, 2017), the RBV emphasized the creation and utilization of organizational resources and the perspective of intellectual capital effectively and efficiently, taking the maximum benefits and values from the existing resources and capability (Korobov et al., 2017). Moreover, human resource management (HRM) scholars' resource-based theory serves as a strategy for an organization that has human capital, which is the essential element of innovation (Yong et al., 2019). The perspective of resource-based theory covers tangible and intangible resources like human capital and social capital as the major force of innovation (Burvill et al., 2018). Based on this discussion, the following hypothesis is established;

H2: There is a positive relationship between intellectual capital and innovation.

Linking Knowledge Management and Entrepreneurial Orientation

A firm's knowledge depends mainly on its internal and external environment and the environmental dynamism is a source of opportunity and resources (Bojica and Fuentes, 2012). The company's equity knowledge is a great resource for entrepreneurial ventures, assisting firms in determining the value of recently discovered opportunities and advising on how to better represent the new markets. It also creates awareness of market imbalance that entrepreneurial activities could decrease (López-Nicolás and Meroño-Cerdán, 2011; Rosenbusch et al., 2011). Consumers' wants are often difficult to articulate; thus the business must share some of the same tacit knowledge as its customers in order to understand their needs and develop new products (Kamukama and Sulait, 2017). As a result, knowledge management is crucial not only for identifying opportunities but also for maximizing them.

As a result, a company that does not gain information from its peer relationships may miss out on the possibilities to better exploit entrepreneurial prospects, reducing the impact of these opportunities on performance (Bojica and Fuentes, 2012). According to the literature, having a lot of knowledge-based resources and a lot of network capacity are vital for turning entrepreneurship into excellent performance (Moustaghfir et al., 2013). On the one hand, since market and

technology knowledge strengthen the relationship between entrepreneurial orientation and firm performance, a collection of knowledge-based capabilities can be used to identify and exploit entrepreneurial possibilities. Furthermore, businesses with better prior knowledge find and exploit more connected opportunities. As a result, we can conclude that having a high degree of market and technology expertise is a critical condition for attaining the goals of corporate entrepreneurship. Furthermore, some scholars argue that having a strong knowledge base, as well as increasing it through organizational learning, may be a key determinant of the relationship between entrepreneurial activities, business innovation, and performance (Monteiro et al., 2019; Ruiz-Ortega et al., 2020). Such activities can play an essential role in the firm's ability to be entrepreneurial orientation and improve performance. So, based on the existing literature, this study hypothesized that;

H3: There is a positive relationship between knowledge management and entrepreneurial orientation.

Linking Intellectual Capital and Entrepreneurial Orientation

Prior literature indicates that intellectual capital positively influences entrepreneurial orientation (Monteiro et al., 2019; Poblete and Mandakovic, 2020). Entrepreneurial orientation, as a strategy, may facilitate the business through looking forward, grab the market opportunities, introducing the innovative products, differentiating the processes, and making a stable position of the organization (García-Villaverde et al., 2018). If intellectual capital capacities are utilized properly, they enhance human assets and organization abilities toward the entrepreneurial orientation attributes (Wach et al., 2018). Moreover, intellectual capital enhances the knowledgeable resources and capacities, that help to compete in an uncertain situation as well as improve the entrepreneurial orientation activities that help to take a right (Dabić et al., 2018; Martens et al., 2018). Human capital is linked with entrepreneurial orientation because high-quality human capital provides more knowledge that influences entrepreneurial orientation attributes. Such experience is considered essential to take an entrepreneurial decision proactively.

Social capital gives support to the development of entrepreneur activities; those organizations that have good social capital and entrepreneurial orientation behavior tend to have an influencing position in networks and thus these organizations have the tendency to grab more opportunities (Aljanabi, 2017). Prior studies indicate that intellectual capital has a positive impact on entrepreneurial orientation because as a knowledgeable resource of an organization, it enhances the entrepreneurial activities and is helpful in decision making (Guzmán et al., 2019).

The most relevant characteristic of the RBV is the focus on the internal forces of a firm, emphasis on the proper use of organizational resources, and creating and managing intangible organizational resources in a proper manner (Gupta et al., 2019). Intangible sources of organization and entrepreneurial orientation are essential to managing the several aspects and

capabilities to compete in a dynamic market (Hock-Doeppen et al., 2021). According to RBV, the resources that are rare, valuable, difficult to imitate, and non-substitutability are the fundamental requirements of today's firm to survive (Kollmann et al., 2016). Accumulating intellectual capital in a way to extend a the entrepreneurial orientation of a firm can be helpful for the survival of a firm (Alshanty and Emeagwali, 2019). Therefore, based on this discussion, the following hypothesis is established;

H4: There is a positive relationship between intellectual capital and entrepreneurial orientation.

Linking Entrepreneurial Orientation and Innovation

Entrepreneurial orientation refers to the strategic orientation of a firm and it represents how firms exploit knowledge-based resources to discover and exploit new opportunities (Rodrigo-Alarcón et al., 2018). Entrepreneurial orientation is the organizational capability to find out the unexplored opportunity and can accept the risk under dynamic circumstances, and innovation is also the organizational skill and capability to utilize the organization's resources and transform that knowledge and resource for granting new products and processes (de Guimarães et al., 2018). Prior studies testify to the relationship between entrepreneurial orientation and innovation and found that innovation is the key indicator of entrepreneurial orientation (Arzubiaga et al., 2018; Zhai et al., 2018). As the above explained that the entrepreneurial orientation is the key element for entrepreneurial behavior that is conceived as a new venture and continually explored new opportunities by utilizing the existing knowledge and information. Entrepreneurs are more aware of the economic dynamics and take that dynamic as an opportunity, more aware of the new information and trends that lead to enhancing the innovation activity (Tang et al., 2012). Moreover, for innovation, an organization needs intensive and extensive knowledge that highly depends on an organizational workforce which analyzes the market trend on time and drives the organization toward innovation by utilizing organization resources (Genc et al., 2019).

Ferreira et al. (2020) argued that entrepreneurial orientation plays a crucial role in collecting resources and transferring them into enhancing innovation. According to the RBV perspective, the organization is a blend of various tangible and intangible resources and capabilities to manage these resources (Ciampi et al., 2021). The entrepreneurial orientation is one of the key capabilities to managing organizational resources because it is intended to gain a competitive advantage by utilizing resources and capabilities (Aljanabi, 2017). Therefore, entrepreneurial orientation analyzes the environmental dynamics and proactively takes the opportunity for innovation. Thus, based on this discussion, the following hypothesis is suggested;

H5: There is a positive relationship between entrepreneurial orientation and innovation.

The Mediating Role of Entrepreneurial Orientation

In this study, we propose a mediation mechanism of entrepreneurial orientation in the relationship between knowledge management, intellectual capital, and innovation.

First, we discuss the mediating role of entrepreneurial orientation between the relationship of knowledge management and innovation. Several studies tried to test entrepreneurial orientation as a mediator like self-concept characteristics and performance, leadership style and performance (Al-Jinini et al., 2019), cultural background and performance (Soomro and Shah, 2019), and transformational and transactional leadership and performance (Arham et al., 2017). However, the existing literature has some mixed evidence showing the importance of entrepreneurial orientation in the relationship between knowledge management and innovation (Alvino et al., 2020; Ciampi et al., 2021).

Entrepreneurial businesses are more inclined to pursue a variety of opportunities and venture into a variety of fields (Isichei et al., 2020). Additionally, when businesses explore a variety of options, an entrepreneurial attitude can help them stand out (Montiel Campos, 2017). A high level of knowledge convergence has the ability to achieve strategic consistency and produce synergies between diverse businesses, resulting in improved organizational value. Without an effective framework for information integration, an entrepreneurial stance may not go very far. The following hypothesis is presented in light of the little research on entrepreneurial orientation as a mediator;

H6 (a): Entrepreneurial orientation mediates the relationship between knowledge management and innovation.

Second, the study discusses the mediating role of entrepreneurial orientation between the relationship of intellectual capital and innovation. Intellectual capital boosts the entrepreneur orientation activities because entrepreneur orientation decides on the base of organization resources, and intellectual capital is the intangible asset of the organization (Caseiro and Coelho, 2018). Moreover, Rezaei and Ortt (2018) explain that environmental factors influence entrepreneurial orientation proactively and take the opportunity to grab the highly dynamic environment. As a result, opportunities are raised; therefore, entrepreneurs take a risk and ultimately drive innovation (Genc et al., 2019). Teixeira et al. (2019) explain that innovation has the potential risk but it provides great benefits to the organization in return, but intellectual capital provides leverage for enhancing the entrepreneurial orientation activities which reduced the perceived risk in innovation and also increases the profitability of an organization.

Entrepreneur orientation develops organizational knowledge and the ability to make a decision. Kianto et al. (2017) argued that intellectual capital and entrepreneurial orientation are the internal capabilities of organizations that are also related to the external market condition and innovation. Inspiring from the entrepreneurship literature, one of the more significant findings to emerge, is that entrepreneurship comes to play as a lever to mobilize a company's various knowledge resources more effectively and as the mediator between intellectual capital components and innovation (Kollmann et al., 2016; Poblete and Mandakovic, 2020). Moreover, the RBV addresses the issue of how to acquire and exploit distinct resources of

an intellectual capital to achieve entrepreneurial orientation and innovation within a firm to enhance its competitive performance (Alshanty and Emeagwali, 2019). Thus, based on this discussion, entrepreneurial orientation plays a fundamental role in assembling resources and also converts them into enhancing innovation. Hence, the following hypothesis is established;

H6 (b): Entrepreneurial orientation mediates the relationship between intellectual capital and innovation.

Leader's Education as Moderator

Existing studies tested different moderators like knowledge intensity as a moderator between knowledge processes and innovativeness (Andreeva and Kianto, 2011), innovation culture in the relationship between knowledge assets and product innovation (Denicolai et al., 2014), and convergence federation between knowledge management and innovation (Islam and Ikeda, 2014). Moreover, moderating effect of knowledge-centered culture, knowledge-oriented leadership, and knowledge-centered HR practices in the relationship between knowledge exploration and innovation outcomes of companies was tested by Lei et al. (2019), while social media capability between information technology (IT)-enabled knowledge ambidexterity and innovation performance was examined by Benitez et al. (2018). Similarly, the literature also suggests different moderators in the relationship between intellectual capital and innovation, such as dynamic capability between intellectual capital and innovative performance were investigated by Han and Li (2015), social capital and entrepreneurial orientation in the relationship between intellectual capital and innovation were tested by Wu et al. (2008), social capital between knowledge sharing and professionals' innovative behavior were tested by Moustaghfir et al. (2013), social networks in the relationship between knowledge management and the radical innovation process, strategic knowledge management in the relationship between three components of intellectual capital, firm innovation, and market performance were examined by Cabrilo and Dahms (2018).

However, the above literature suggests that there are no or only a few studies that have investigated the impact of a leader's education level on the proposed relationships. For example, Flanigan et al. (2017) and Li et al. (2019) investigated the demographic characteristics between leadership and small firm financial performance. However, there is some imprecise evidence of moderation of leaders' education between the study variables. In the literature, the level of education for leaders in diverse organizations has garnered a lot of attention, with mixed outcomes. According to the study by Silva (2014), higher education is not required for the success of company leaders, but it can be beneficial to the success of leaders and organization. Higher levels of education for a CEO have been linked to increased corporate innovation in other research (Flanigan et al., 2017). Therefore, this study formulated the moderating effect of the leader's education level in the relationship between intellectual capital and knowledge management and innovation:

H7 (a): A leader's education will moderate the effect of knowledge management on entrepreneurial orientation such that higher levels of education will increase the strength of the positive association between knowledge management and entrepreneurial orientation.

H7 (b): A leader's education will moderate the effect of intellectual capital on entrepreneurial orientation such that higher levels of education will increase the strength of the positive association between intellectual capital and entrepreneurial orientation.

The conceptual model depicting the relationships is given in **Figure 1**.

MATERIALS AND METHODS

Sample and Data Collection

This study used an exploratory research design. The nature of the study was cross-sectional and based on quantitative data. The study generated primary data through an email survey performed using a sample of Pakistani SMEs in the Information Technology (IT) sector. To select the sample, we chose IT firms registered in the company directory of the Pakistan Software House Association (PSHA). The PSHA has almost 896 active IT companies, which possess expertise in custom software development, enterprise resource planning (ERP), financial solutions, mobile content, document management, enterprise computing, and business process outsourcing. The major reason for selecting the IT firms is the high potential for innovation and greater contributions of these firms to economic development as well as in creating new opportunities for other business services.

Moreover, intellectual capital and product innovation are more relevant for these companies than for service companies. The IT Sector of Pakistan is relatively well developed and has had a slightly better rate of growth in recent years. The data were collected through a structured email survey from the CEO, director of innovation, or from the top executives from July to August, 2020.

Following the procedure of Engelen et al. (2014) an email was sent to each company with an invitation to fill out a survey and a letter explaining our research background and purpose. We have taken a number of steps to boost response rates, including allowing the participants to complete the survey offline and return it via regular mail, fax, or email; providing respondents with a report of our survey results, which includes descriptive statistics and anonymous comparisons of participating companies; and sending two personalized reminder emails to all potential respondents. Finally, we received results from 410 of 896 companies that are invited to complete the survey (45.75% response rate). We eliminated 17 surveys that were incomplete and as a result, 393 responses remained for data analysis. Firm age is measured using the experience of the firm. For the classification in terms of the size of the SME, we followed the study by Bojica and Fuentes (2012). Bojica and Fuentes referred to the EU's Directive 78/660/CEE, which considers small firms to be those with fewer than 50 employees and medium-sized firms to be those with fewer than 250 employees.

Table 1 present the demographic characteristics of the sample. A total of 393 firms participated in this study, 8.9% of firms' age is 1–3 years, 22.1% of firms' age is between 4 and 7 years, 33.8% of participants firms' age is 8–10 years, and 28.2% firms' age is above 10 years. Moreover, 49.6% of the questionnaires

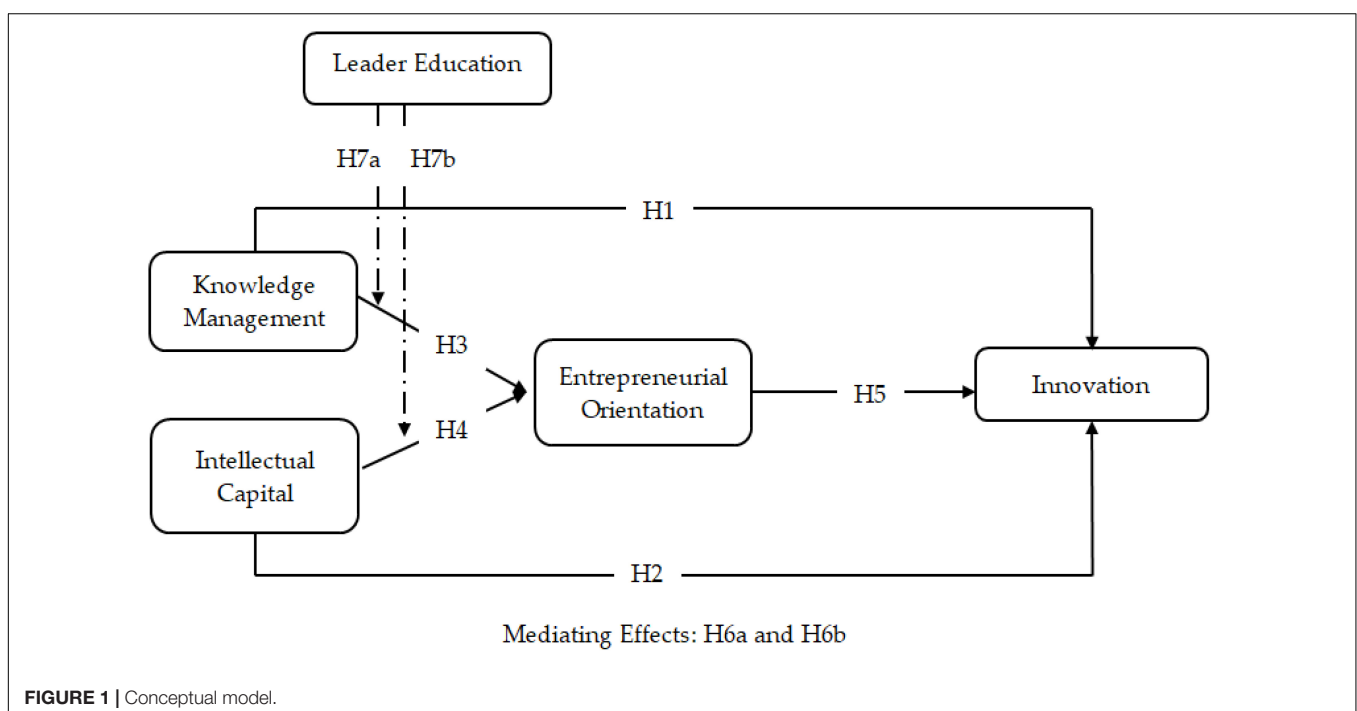


TABLE 1 | Sample characteristics.

Age of firm	Frequency	Percent
1–3 years	43	10.9
4–7 years	106	27.0
8–10 years	133	33.8
Above 10 years	111	28.2
Firm size	Frequency	Percent
10–50 employees	175	44.5
51–100 employees	129	32.8
101–250 employees	64	16.3
Above 250 employees	25	6.4
Respondents positions	Frequency	Percent
CEO	195	49.6
Director/Manager innovation	165	42.0
Other top Managers	33	8.4
Respondents education	Frequency	Percent
Bachelors	167	42.5
Masters	144	36.6
MS/Ph.D	39	9.9
Other	43	10.9
Total	393	100.0%

were answered by the CEOs, and 42.0% were responded to by directors/manager innovation. Furthermore, 8.4% were answered by top managers, who report directly to the CEO. Respondent's education data show that 42.5% of respondents have bachelor's degrees and 9.9% have a Ph.D. and 10.9% have other qualifications.

Measures

Knowledge Management Process

The knowledge management process is a combination of three elements including knowledge acquisition, knowledge sharing, and knowledge utilization practices (**Appendix**). This study adopted nine items measurement scale of knowledge management from the study of Obeidat et al. (2016) that aggregates three dimensions of knowledge management, such as acquisition, sharing, and utilization. A sample item for knowledge acquisition is, "we hire new employees as a source for acquiring new knowledge." A sample item for knowledge sharing is, "we share information and knowledge necessary for the tasks." A sample item for knowledge utilization is, "the firm utilizes available knowledge to improve its performance." All items were measured on a 5-point Likert scale, ranging from 1 for strongly disagree to 5 for strongly agree.

Intellectual Capital

The intellectual capital was measured using a 5-point Likert scale with the help of two dimensions, such as human and social capital. Human capital was evaluated through five items scale adapted from the study of Al-Jinini et al. (2019). A sample item is, "our employees are highly skilled." Moreover, to measure the social capital, we adapted four items scale from the study of Al-Jinini et al. (2019). A sample item is, "our company documents its projects to use it in other projects."

Entrepreneurial Orientation

This study operationalized entrepreneurial orientation through innovativeness and proactiveness. Entrepreneurial orientation was rated using a 5-point Likert scale. To measure innovativeness and proactiveness, we adopted five measurement constructs from the study by Al-Jinini et al. (2019). A sample item for innovativeness is, "employees are motivated to think and perform innovatively." A sample item for proactiveness is, "our company offer a new products more than their competitors."

Innovation

This study conceptualizes innovation as two-dimensional constructs, such as product innovation and process innovation. Innovation was evaluated using 5-point Likert scales. Moreover, to measure product and process innovation, we adopted 8-items scale from the study by Al-Jinini et al. (2019). A sample item for product innovation is, "our company introduces modifications to its existing product and services." A sample item for process innovation is, "the company work processes are constantly updated."

Leaders' Education

To measure leaders' education, we used 5-points Likert scale and 6 items were adapted from the study by Más-Machuca (2014). A sample item is, "our company leaders educate employees to encourage knowledge sharing in the organization."

RESULTS

Data Analysis and Results

The data were analyzed using the Smart-PLS software 3.0 version. This software is currently considered one of the suitable software to apply partial least squares structural equation modeling (SEM) (Sarstedt and Cheah, 2019). PLS-SEM was recommended in most business management studies (Ringle and Sarstedt, 2016). The method is preferred for theory testing and confirmation and is appropriate for checking the existence of complex relationships (Hair et al., 2017). The PLS-SEM allows for the construction of a research paradigm based on a theory that involves transforming theories and concepts into unmeasured variables (latent) and practical concepts into metrics, all of which are connected by a theory or hypothesis (Becker et al., 2012). Cheah et al. (2018) suggest that the PLS-SEM model should be assessed in three phases: identifying the global model assessment, checking the measurement model's validity, and analyzing the relevance of the routes inside the SEM.

Measurement Model

To test the reliability of constructs, Cronbach's alpha, composite reliability, and AVE values were assessed. According to Henseler and Fassott (2010), the criterion for ensuring the composite reliability (CR) is that all values must be higher than 0.7. All values of composite reliability are presented in **Table 2**. The values lie between the ranges of 0.944 and 0.963, which confirms the composite reliability of all of the constructs. Moreover, the Cronbach's alpha for all constructs was also above the threshold

TABLE 2 | Measurement model.

Variable and constructs	Loadings	α	CR	AVE	VIF
Entrepreneurial orientation		0.942	0.955	0.811	
INO1	0.895				3.390
INO2	0.905				3.804
INO3	0.847				2.819
PRO1	0.929				4.627
PRO2	0.924				4.357
Innovation		0.956	0.963	0.765	
INN1	0.814				2.963
INN2	0.901				3.195
INN3	0.867				3.407
INN4	0.874				3.441
INN5	0.893				4.878
INN6	0.863				3.182
INN7	0.861				3.484
INN8	0.920				2.381
Intellectual capital		0.950	0.957	0.714	
HC1	0.864				3.380
HC2	0.819				2.769
HC3	0.856				3.276
HC4	0.809				2.656
HC5	0.817				2.734
SC1	0.857				3.293
SC2	0.874				3.877
SC3	0.890				4.155
SC4	0.817				2.741
Knowledge management		0.953	0.960	0.725	
KA1	0.925				5.504
KA2	0.858				3.805
KA3	0.877				3.858
KS1	0.850				2.801
KS2	0.853				3.823
KS3	0.867				3.873
KU1	0.769				2.328
KU2	0.853				3.389
KU3	0.805				2.597
Leader education		0.931	0.944	0.741	
LE1	0.907				3.405
LE2	0.648				1.642
LE3	0.845				3.066
LE4	0.939				5.788
LE5	0.925				5.198
LE6	0.868				2.798

α , Cronbach's alpha; CR, Composite Reliability; AVE, Average Variance Extracted; VIF, Variance Inflation Factor.

value of 0.7 suggested by Hair et al. (2011). Furthermore, the average variance extracted (AVE) criterion allows its value to be greater than 0.50 (Fornell and Larcker, 1981). Therefore, **Table 2** shows that the AVE values of the constructs ranged from 0.714 to 0.811 and met the criteria. Prior researchers argue that if the values of AVE are above the acceptable level of 0.5, it indicates adequate convergent validity (Bagozzi and Yi, 1988; Henseler and Fassott, 2010).

Additionally, discriminant validity was calculated using the Fornell–Larcker criterion as findings are expressed in **Table 3**. The findings show that most of the correlations of the constructs with each other are fewer than the square roots of their AVEs, demonstrating that our measures have discriminant validity (Fornell and Larcker, 1981). Besides, discriminant validity was also assessed using Heterotrait-Monotrait ratio (HTMT) criteria (Henseler et al., 2014). The results listed in **Table 4** indicate that HTMT values were satisfactory and below the threshold of 0.85 as suggested by Hair et al. (2011). We also calculated the variance inflation factors (VIFs) for all constructs in our model to test for multicollinearity. All VIF values were below 5.788, lower than the threshold of 10, indicating no concerns regarding multicollinearity issues in the data (Ringle and Sarstedt, 2016). Finally, Harman's single factor test was used to check for common method bias in the data. According to Harman's technique, common method bias exists when one component emerges from factor analysis and explains more than 50% of the variance (Podsakoff, 2003). We used the rotated solution to transfer all the items into a one-factor analysis, yielding four factors; the first factor's eigenvalue explains 29.38 percent of the variance (50 percent). As a result, it is clear that this study does not suffer from common technique bias.

Structural Model

The structural model was evaluated through the 5,000 bootstrap method with the help of Smart-PLS software. The fitness of the structural model was assessed by the standardized root mean squares residual SRMR value. According to Henseler and Fassott (2010), a good structural model should have a value below the 0.08 SRMR value. Therefore, the findings from the structural model show a 0.049 value of SRMR that was acceptable below the threshold. Moreover, to assess the value of R^2 , the structural model explained (13.7%) variance in entrepreneurial orientation and (25.5%) variance explained in innovation. As suggested by prior researchers the value of R^2 and Q^2 should be greater than 0.10 or zero (Hair et al., 2011; Henseler et al., 2014). Furthermore, the results provided in **Table 5** and **Figure 2** indicate that the values of R^2 and Q^2 are greater than the threshold value. Hence, the structural model was acceptable and met the criteria for further analysis.

Hypothesis Testing

The study analyzed the hypotheses with bootstrapping to explore the significance level between all the variables. All the hypotheses were statistically significant and the results are shown in **Table 6** and **Figure 3**. The findings of H1 indicate that knowledge management has a positive and significant effect on innovation with a standardized path coefficient (0.193**, $t = 3.649$, $p = 0.001$). Therefore, H1 was accepted. Moreover, the results of H2 show that intellectual capital has a positive and significant influence on innovation with a standardized path coefficient (0.194**, $t = 3.433$, $p = 0.001$). Thus, H2 was supported. Furthermore, the findings of H3 illustrate that knowledge management has a positive and significant impact on entrepreneurial orientation with a standardized path coefficient (0.189**, $t = 3.223$, $p = 0.001$). Hence, H3 was accepted. Additionally, the results of H4

TABLE 3 | Fornell-Larcker criterion.

	Entrepreneurial orientation	Innovation	Intellectual capital	Knowledge management	Leader education
Entrepreneurial orientation	0.901				
Innovation	0.424	0.875			
Intellectual capital	0.299	0.317	0.845		
Knowledge management	0.221	0.291	0.138	0.852	
Leader education	0.141	0.027	0.083	-0.002	0.861

Items with diagonals are the square root of the AVE. Items under diagonals are the correlations.

TABLE 4 | Heterotrait-Monotrait Ratio (HTMT) criterion.

	Entrepreneurial orientation	Innovation	Intellectual capital	Knowledge management	Leader education
Entrepreneurial orientation					
Innovation	0.439				
Intellectual capital	0.308	0.323			
Knowledge management	0.229	0.288	0.141		
Leader education	0.133	0.075	0.094	0.046	

TABLE 5 | Path coefficients (direct effects).

Hypotheses	Relationships	β	t	p	R^2 = Entrepreneurial orientation 0.137; Innovation = 0.255 Q^2 = Entrepreneurial orientation 0.106; Innovation = 0.188
H1	Knowledge management → Innovation	0.193	3.649	0.000	
H2	Intellectual capital → Innovation	0.194	3.433	0.001	
H3	Knowledge management → Entrepreneurial orientation	0.189	3.223	0.001	
H4	Intellectual capital → Entrepreneurial orientation	0.233	4.326	0.000	
H5	Entrepreneurial orientation → Innovation	0.324	5.755	0.000	
	Leader education → Entrepreneurial orientation	0.110	2.483	0.013	

show that intellectual capital has a positive and significant effect on entrepreneurial orientation with a standardized path coefficient (0.223**, $t = 4.326$, $p = 0.001$). Therefore, H4 was supported. Meanwhile, we tested H5 and the findings explore the entrepreneurial orientation that has a positive and significant impact on innovation with a standardized path coefficient (0.324**, $t = 5.755$, $p = 0.001$). Hence, H5 was accepted.

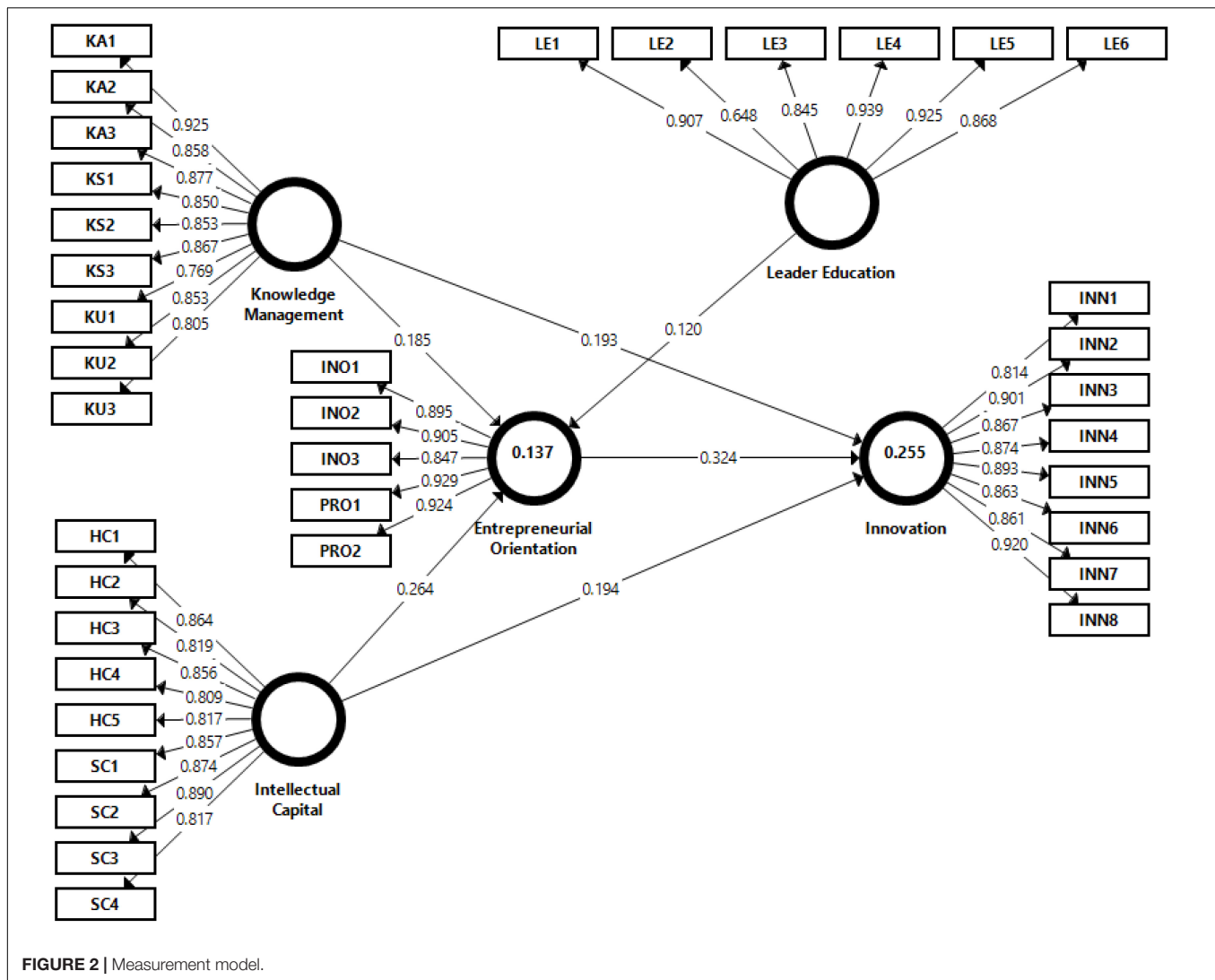
Besides, we tested the indirect effect of entrepreneurial orientation in the relationship between knowledge management and intellectual capital on innovation. The results of H6a and H6b were presented to indicate that entrepreneurial orientation has an indirect positive and significant influence on the related knowledge management and intellectual capital on innovation with a standardized path coefficient (0.061**, $t = 2.926$, $p = 0.001$; 0.075**, $t = 3.565$, $p = 0.001$). Likewise, to assess partial and full mediation effects, we followed the approach by Hair et al. (2017) approach using the variance accounted for VAF and analyzed the direct, indirect, and total effects. According to this method, if the value of VAF is between 20 and 80%, it presents partial mediation and if the value of VAF is more than 80%, a full mediation exists between the variables. Thus, the findings listed in **Table 7** show that the value of VAF is below 80%, which presents partial mediation. Hence, H6a and H6b were accepted.

Lastly, we assessed the moderating effect of a leader's education in the relationship between knowledge management and intellectual capital on entrepreneurial orientation. The findings are expressed in **Table 8** and show that leader education strengthens the association between knowledge management and entrepreneurial orientation with a standardized path coefficient (0.097**, $t = 1.710$, $p = 0.042$). Thus, H7a was supported. Furthermore, H7a findings mention that leader education strengthens the association between intellectual capital and entrepreneurial orientation with a standardized path coefficient (-0.040 **, $t = 0.727$, $p = 0.467$). Thus, H7b was not accepted.

DISCUSSION AND CONCLUSION

Discussion

The knowledge-based view shows that as a rare, unique, valuable, and irreplaceable resource (Iqbal et al., 2018), knowledge is the most critical asset for enterprises to establish, share, and systematize sustainable competitive advantage. Researchers have believed that intellectual capital is a key factor to boost the innovation and performance of the firm (Subramaniam and Youndt, 2005), especially for those SMEs which may have

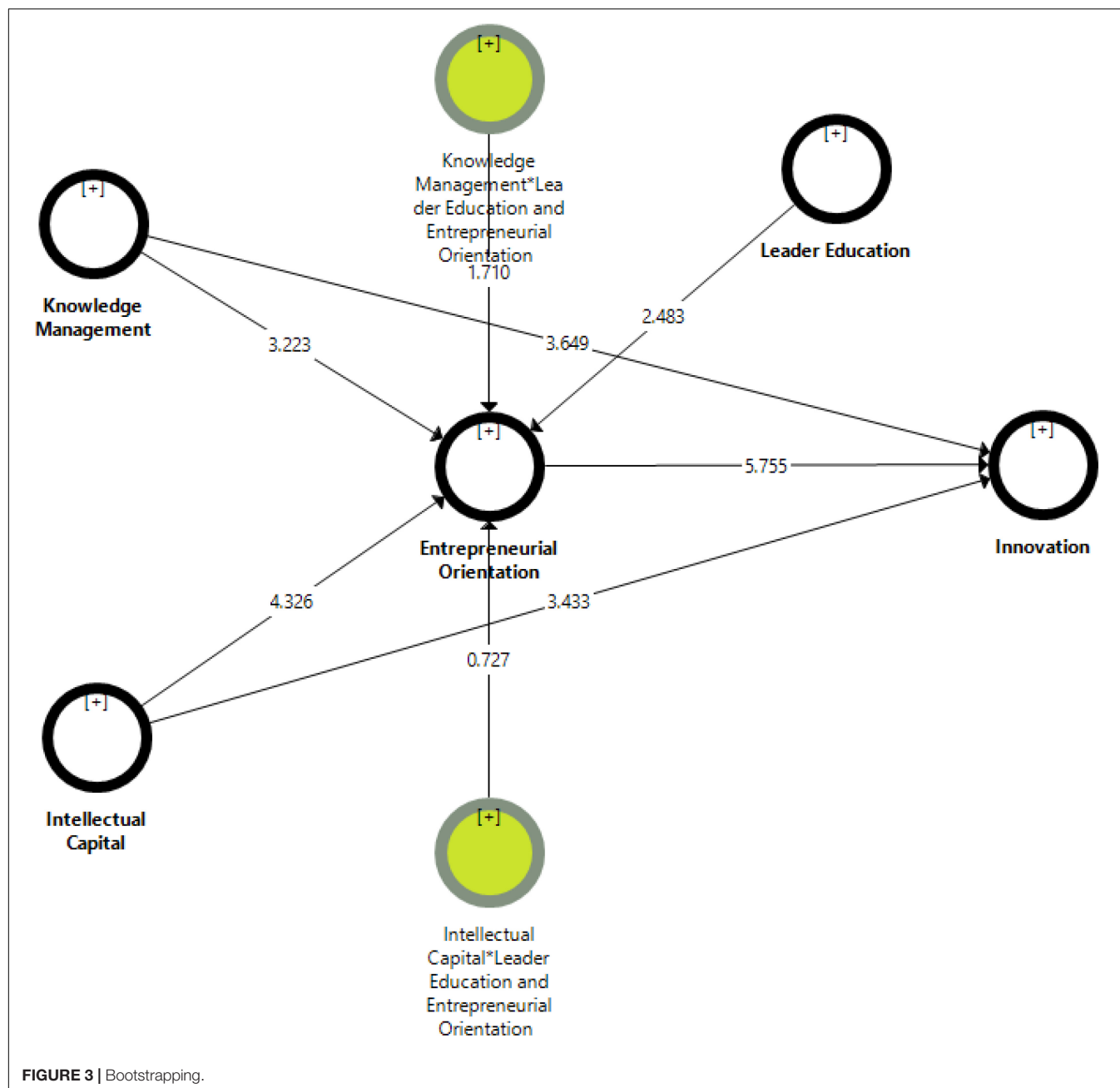


difficulties in competing in the market (McDowell et al., 2018). In addition, as knowledge management requires knowledge acquisition, communication, and compilation (Teixeira et al., 2019), researchers recommend that companies use knowledge through strategic capabilities, such as innovation to improve corporate performance (Bojica and Fuentes, 2012; Roxas et al., 2013). Based on this view, we studied the mediating effect of entrepreneurial orientation on the relationship between knowledge management, intellectual capital, and innovation.

The first objective of the current study is to find the statistical relationship between knowledge management, intellectual capital, and innovation in IT sector firms of Pakistan. Prior literature suggests that knowledge management and intellectual capital are significantly important for SMEs and IT sector firms, in particular. But knowledge management and intellectual capital are not well researched in the IT sectors of Pakistan. Therefore, based on prior literature and understandings, the researchers have developed and proposed the existence of a statistical relationship between knowledge management,

intellectual capital, and innovation. This proposition is tested and verified through the empirical data and found significant, as is supported in previous studies (López-Nicolás and Meroño-Cerdán, 2011; Sarwat and Abbas, 2020) on knowledge management and innovation (Han and Li, 2015; Buenechea-Elberdin et al., 2017; Li et al., 2019) as well as on intellectual capital and innovation.

This study aims to test the relationship between knowledge management, intellectual capital, and entrepreneurial orientation in the IT sector of Pakistan. The role of intellectual capital practices in terms of human and social capital are the important factors within the organization to trigger the entrepreneurial orientation. This research recognizes that appropriate knowledge management processes and intellectual capital practices among employees provide the firm with ultimate support in the industry. These study findings revealed a positive and significant relationship between knowledge management and entrepreneurial orientation similar to the study by Arzubaga et al. (2018) and Al-Jinini et al. (2019), and between intellectual



capital and entrepreneurial orientation. A similar result is also reported in previous studies (Wu et al., 2008; Dabić et al., 2018).

Measuring the postulated relationship between entrepreneurial orientation and innovation is also the aim of the study. The study found a significant and positive relationship between entrepreneurial orientation and innovation. Previous literature suggests that an improvement in the entrepreneurial orientation of a firm can promote innovation. These findings are in line with the prior studies (Masa'deh et al., 2018; Alrowwad et al., 2020). For the survival and embrace of the innovation in the organization, there is a need to move according to the changing market by adopting new technology, learning new

skills, and also making a blend of all resources, such as internal or external that improve the innovation (Amin and Aslam, 2017).

This research requires measuring the anticipated effects of entrepreneurial orientation as a mediator among knowledge management, intellectual capital, and innovation. The results suggest that entrepreneurial orientation proves as an area of substantial importance in promoting innovation in the IT sector of Pakistan. These findings argue that entrepreneurial orientation partially mediates the relationship between knowledge management, intellectual capital, and innovation, and the results are in line with the past literature (Rezaei and Ortt, 2018; Mostafiz et al., 2021).

TABLE 6 | Specific indirect effect.

Hypotheses	Relationship	β	t	p
H6a	Knowledge management \rightarrow Entrepreneurial orientation \rightarrow Innovation	0.061	2.926	0.003
H6b	Intellectual capital \rightarrow Entrepreneurial orientation \rightarrow Innovation	0.075	3.565	0.000

TABLE 7 | Mediation analysis (entrepreneurial orientation as a mediator).

Exogenous variable	Direct effect	Indirect effect	Total effect	VAF (%)	Mediation	Endogenous variable
Knowledge management	0.189	0.061	0.250	24.4%	Partial mediation	Entrepreneurial orientation
Intellectual capital	0.233	0.075	0.308	24.3%	Partial mediation	Entrepreneurial orientation

TABLE 8 | Moderating effect (leader education as a moderator).

Hypotheses	Relationship	β	t	p	Decision
H7a	Knowledge management \times Leader education and entrepreneurial orientation	0.097	1.710	0.042	Yes
H7a	Intellectual capital \times Leader education and entrepreneurial orientation	-0.040	0.727	0.467	No

The current study considers the moderating role of a leader's education in the relationship between knowledge management, intellectual capital, and entrepreneurial orientation in IT sector firms in Pakistan. The results show that a leader's education significantly moderates the effect of knowledge management on entrepreneurial orientation. However, a leader's education does not moderate the effect of intellectual capital on entrepreneurial orientation such that low levels of education will decrease the strength of the positive association between intellectual capital on entrepreneurial orientation. This finding is in line with the prior study by Flanigan et al. (2017).

Conclusion

This manuscript contributes to the entrepreneurial orientation and literature on knowledge management, intellectual capital, and innovation. The research outlines the theoretical perspective that knowledge management and intellectual capital, support a firm to extend and deploy its entrepreneurial orientation to improve its innovation, especially if the firm operates in a turbulent market. In so doing, the study shows that the firm should use some consistent strategies for knowledge management and intellectual capital accumulation to build the desired innovation capacities. The theoretically derived research model, which links knowledge management, intellectual capital, and innovation, and also the moderating role of a leader's education was empirically validated using an empirical study of 393 small and medium-sized firms in the IT sector of Pakistan.

IMPLICATIONS

Theoretical Contributions

The study has advanced the theoretical contribution regarding knowledge management, intellectual capital, innovation, and entrepreneurship research in the following aspects. First, the research introduced knowledge management as an antecedent

of entrepreneurial orientation and innovation to cover the existing gap. Moreover, this study measures intellectual capital as a first-order construct distinguishing it in human capital and social capital. Second, this study examined entrepreneurial orientation as a mediator between knowledge management, intellectual capital, and innovation, which was previously, not discussed by the prior researchers. Third, this research introduces a leader's education as a moderator between knowledge management-entrepreneurial orientation and intellectual capital, entrepreneurial orientation relationships that were previously ignored in the relevant literature.

Another notable contribution of this study is that it examined a mediator that was otherwise considered an independent variable traditionally and answered whether entrepreneurial orientation positively mediates the relationships between knowledge management process and intellectual capital on innovation. In this sense, the findings of the study demonstrated that entrepreneurial orientation characteristics, such as risk-taking, innovativeness, and proactiveness, are critical to the effective deployment of knowledge application and innovation. Furthermore, this study contributes to the existing literature as it examines the relationship in a context of a collectivistic country as these conceptions are earlier developed and tested in Latin America and Western culture (Rosenbusch et al., 2011; McDowell et al., 2018). Hence, this study was conducted in the IT sector of Pakistan to fill the gap as suggested by Agostini et al. (2017) that future researchers could add more contributions to investigate the intellectual capital and innovation relationship in different sectors to increase the generalizability of constructs.

Practical Implications

Moreover, this study provides implications for managers, entrepreneurs, and policymakers who are directly involved particularly in the IT sector of Pakistan. Knowledge management and intellectual capital seem to be more beneficial for firms with

high levels of intellectual capital accumulation and knowledge-based resources. However, managers have to craft appropriate resource combinations to take advantage of both intellectual capital and knowledge to leverage the innovation and to translate it into superior firm performance. The creation of intellectual capital and knowledge help firms in harnessing product and process innovation as well as facilitates the firms to make it sustainable. To promote intellectual capital and knowledge management to get competitive advantages, managers can use different entrepreneurial mechanisms. Moreover, by focusing on intellectual capital, knowledge management, and entrepreneurial orientation, firms can set the grounds for generating new, innovative, and creative ideas as well as thoughts to be innovative. As the study recommends the mediating impact of entrepreneurial orientation, the owners and managers in SMEs, particularly IT firms are required to commit their complete potential to ensure entrepreneurial orientation and also motivate their employees to practice it.

Furthermore, the study provides insights into the role of a leader's education in promoting entrepreneurial orientation and innovation, particularly for SMEs who practice intellectual capital might improve innovation in their companies if they have a more qualified leader. As the innovation index shows that Pakistan is occupying a low position, the firms should hire more educated leaders to implement a successful innovation process in SMEs. The findings of the research are also important from a social perspective, particularly for the accumulation of social capital. Concerning intellectual capital development, the firms that form social capital are more likely to get success. Evidence for the argument can be found in the knowledge-intensive SMEs that are evident of heavy investment in resources, such as physical assets, strong relationships at personal as well as a team level, maintaining high trust levels, control norms, and strong networks across permeable limits. An investment in social capital enables a firm to foresee the market changes and meeting with customer demands more appropriately. Thus, understanding the social perspective helps managers to understand the social ties and invest in corporate social responsibility at the appropriate time.

Limitations and Future Research Directions

This study provides some limitations and future research directions for upcoming researchers. First, the study is cross-sectional; so the underlying analyses of results could be vulnerable. However, a longitudinal analysis is required to

examine and elucidate the postulated relationship among study variables at different times. Second, the limitation addresses how the variables are measured. The study uses self-reported measures, raising probable issues of common method biases. However, self-reported questions are found to be more appropriate to measure the firm responses to the study variables. To address the common method biases issue, VIF is calculated using the procedure prescribed by Podsakoff (2003). This theoretical model is generalized in the information technology industry and therefore another scholar may generalize this model in Pakistan in any other sector and it has the potential to be generalized in any other under developing country for boosting the business performance. The single industry study is one more limitation of this study. Future studies can add emotional intelligence or leader's efficacy as a moderator. Moreover, the future study may testify to this model with actor-network theory.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by National Textile University, Faisalabad, Pakistan. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

QY and SA proposed the research, analyzed the results, and wrote the manuscript. WJ, MM, and NS revised the whole manuscript and extensively edited the manuscript. All authors contributed to the article and approved the submitted version.

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APPENDIX

Knowledge Management Process

Knowledge Acquisition

KA1: We hire new employees as a source for acquiring new knowledge.

KA2: We provide an open environment to help our employees acquire new knowledge.

KA3: We continually gather information that is relevant to our operations and activities.

Knowledge Sharing

KS1: We share information and knowledge necessary for the tasks.

KS2: We exchange knowledge between employees in order to achieve our goals with little time and effort.

KS3: We promote sharing of information and knowledge between team members and various units.

Knowledge Utilization

KU1: The firm effectively manages various sources and types of knowledge.

KU2: The firm utilizes available knowledge in improving services provided to its customers.

KU3: The firm applies available knowledge in order to improve its performance.

Intellectual Capital

Human Capital

HC1: Our employees are highly skilled.

HC2: Our employees are widely considered the best in our industry.

HC3: Our employees are capable of developing new ideas in their jobs.

HC4: Our employees are considered experts in their particular jobs and functions,

HC5: Our employees develop new ideas and knowledge.

Social Capital

SC1: Our company uses intellectual property rights (patents/registered software, and copyrights) as a way to store knowledge.

SC2: Our company protects knowledge and key information to avoid loss if key people left the company.

SC3: Our company documents its projects in order to use it in other projects.

SC4: Our company possesses work methods and procedures in support of innovations and new products.

Entrepreneurial Orientation

Innovativeness

INO1: Our company empowers its employees to try on new ideas regardless of their job position.

INO2: Employees are motivated to think and perform innovatively.

INO3: Imitating the innovation of another corporation is a company's innovation.

Proactiveness

PRO1: Our company offers new products more than their competitors.

PRO2: Our company emphasizes the importance of creating new innovative products.

Innovation

INN1: Our company introduces modifications to its existing product or services.

INN2: Our company constantly develops new products or services.

INN3: The companies' new products and services are often perceived as novel by customers.

INN4: In new products and service introductions, our company is often first-to-market.

INN5: In comparison with the company's competitors, our company has introduced more innovative products and services during the past years.

Process Innovation

INN6: The work processes of our company are constantly updated.

INN7: Our company emphasizes the development of new ways to provide its services.

INN8: Our company constantly uses up-to-date technology to enhance products and services.

Leaders' Education

LE1: Our company leaders educate employees to encourage knowledge sharing in the organization.

LE2: Our company leaders support employees in getting an education.

LE3: Our company leaders educate the employee in an effective way.

LE4: Our company leaders educate the employees to generate innovative ideas.

LE5: Our company leadership has the ability to manage a work a time.

LE6: Our company leadership is highly qualified.



The Influence of Innovation Climate on Creative Role Identity: The Mediating Role of Flow

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Creative role identity is an important antecedent of innovative behaviors. Both the mechanism of how external factors and individual factors affect the formation of creative role identity and details of this process have yet to be discovered. Based on data collected from 226 students in 6 classes at a university in Guangdong during the development of innovative projects, the influence of innovation climate on the students' creative role identity, especially the mediating effect of flow, was investigated. The results show that the innovation climate has a positive impact on creative role identity and that flow plays a partial mediating role in this relationship.

Keywords: innovation climate, creative role identity, flow, situational strength theory, entrepreneurship education

INTRODUCTION

How to stimulate individual innovation behavior has become an important issue faced by researchers and practitioners. The turbulence brought about by the COVID-19 epidemic has made enterprises increasingly need colleges and universities to cultivate talents who can actively innovate and tolerate high uncertainty to ensure the competitive advantage in an uncertain environment. Many studies have shown that creative role identity is an important antecedent of the encouragement of individuals to produce innovative behaviors (Wang and Cheng, 2010). Farmer et al. (2003) applied role identity theory to the field of creativity research and proposed the concept of creative role identity to describe the extent to which employees define themselves as creative individuals. The concept was subsequently followed by researchers. The significance of creative role identity is that individuals consciously transform external expectations and role requirements into a part of their self-awareness through identity adjustment mechanisms, and try their best to keep their attitudes and behaviors consistent with their social roles (Wang and Cheng, 2010). To facilitate the innovative behaviors of individuals, organizations must understand how employee's creative role identities are formed.

However, existing studies mainly focus on the impact of self-factors on the creative role and seldom focus on the antecedents caused by external factors. Since 1950, when Guilford called on researchers to focus on the importance of creativity in education and other social domains, research on creativity in academia has increased significantly (Runco, 2004) and has focused on people's "inner self," emphasizing the recognition of personal attributes of knowledge and creativity (Finke et al., 1992). Human-centered research disconnects individual creativity from its environment. However, the complexity of human behavior means that individual behavior cannot be studied in a vacuum, and the interactive effects of individual differences and situational characteristics must be considered simultaneously (Mischel and Shoda, 1999). In fact, creativity

is a “situational” activity (Loi and Dillon, 2006). According to situational strength theory (Meyer et al., 2010), the situational strength of an individual’s organization (such as a leader’s behavioral style and organizational climate) provides important external cues for the suitability of an individual’s specific behavior/behavioral performance/behavioral intention. Psychological factors, such as individual traits, interests, values, cognition, and emotions, work together to significantly hinder (or promote) the transformation of specific behaviors, behavioral performance, and behavioral intentions.

Innovation climate, as an important environmental factor affecting innovation willingness and innovation behavior, has always been a concern of the academic community (Choi, 2004; Eisenbeiss et al., 2008). However, there is still no clear conclusion on how innovation climate affects creative role identity, and further theoretical demonstration and empirical testing are needed (Newman et al., 2020).

According to situational strength theory, situational strength affects behavior/intentions through individual psychological factors. Flow is a construct in positive psychology, proposed by Csikszentmihalyi (1988), which means that people may experience a unique sense of flow, and move into a state in which they feel excited, have a sense of enjoyment, and are bursting with amazing creativity. Therefore, in the process of considering the influence of innovation climate on creative self-identity, we choose flow as a mediating variable to try to open the “black box” of the above process.

This paper takes innovative education in the field of pedagogy as the research background. From the perspective of pedagogy, the “disease” that stifles creativity in traditional classrooms has afflicted students for a long time. In this paper, a view of constructing a new way of classroom organization at the school and teacher levels to find an “unconventional learning climate” (Tan, 2001) that stimulates students to learn and explore through active and wholehearted participation is presented (Tan, 2001; Kampylis, 2006). The aim is that students could not only express their own creativity, but also become systematically more creative, and that ultimately all learners could attain creative achievement.

In our research objects—innovation and entrepreneurship courses at a university in Guangdong, China—students develop a complete innovation project in a relatively short period of time. This project engages students in a miniature version of the innovation activities within organizations, which is very beneficial when studying individual innovation behavior in different organizational innovation climates (in this study, different classes). Based on the data collected by 226 students in 6 classes in a Guangdong university during the development of innovative projects, this study put the innovation climate and creative role identity theory and the flow theory in psychology into the situation of classroom teaching for discussion and then attempts to reveal the key path through which the innovation atmosphere affects individual creative role identification.

In general, from the perspective of situational strength theory, this study analyzes the psychological mechanism of the influence of innovation climate on individual creative role identity. This paper makes the following contributions to the theory. First, it studies the antecedents of creativity role identity, introduces situational strength theory, and provides a new perspective for research on creativity role identity. Second, it proposes and verifies the influence mechanism of the external environment on role identity of creativity and discovers the key influence of flow as a psychological mechanism in this process. Third, this study is an extension of the research on relationship between external atmosphere and individual role identity in the context of pedagogy and provides useful new insights into educational methods improvement. The above theoretical contributions will also have important practical implications for enriching the teaching methods of colleges and universities in China and then promoting the cultivation of innovative talent.

HYPOTHESIS DEVELOPMENT

Innovation Climate and Creative Role Identity

The concept of organizational climate originates from the study of the psychological climate in the field of psychology. It is generally used to describe the dynamic and complex relationship between environmental stimuli and human behavior (Litwin and Stringer, 1968). Amabile et al. (1996) defined the organizational innovation climate as the degree to which individuals perceive support for creativity and innovation in their organizational environment, including factors that encourage creativity, autonomy and freedom, resources, and pressure, as well as barriers to creativity. The encouragement of creativity (including organizational encouragement, supervisor encouragement, and team encouragement), the degree of autonomy, access to adequate resources, and the opportunity for challenging work have positive effects on employees’ creativity, whereas workload and organizational barriers have negative effects. Existing research has noted that innovation climate and individual creative behavior (Jaiswal and Dhar, 2015), innovation behavior (Bain et al., 2001; Antoni, 2005), and knowledge sharing behavior (Edú-Valsania et al., 2016) have a significant positive correlation. Zhou et al., (2021) considered innovation climate as a situational factor in the process of exploring the influence of individual creativity role identity on innovation behavior and believed that innovation climate played a positive moderating role. The above studies have contributed to research on the influence of innovation climate on innovation behavior, but broader study of its process mechanism and empirical tests is still needed.

Role identity theory is widely used in social psychology and sociology to explain the causes of behavior. Role identity theory emphasizes that the self is the object to be recognized, the role is the element that constitutes the self, and the self contains multiple roles. The formation of roles depends on the environment; the environment provides the basic conditions for the role to be shaped and affects role identification through

Abbreviations: CRI, Creative Role Identity; IC, Innovation Climate; TS, Teacher Support; IWM, Intrinsic Work Motivation; ABS, Absorption; TEA, Teamwork; WE, Work Enjoyment; IM, Incentive Mechanism; OP, Organization Promotion; SDW, Self-Directed Work; RG, Resource Guarantee; TP, Teacher Practice.

three forces (Charng et al., 1988): (1) social network and social structure (Stryker, 1980), (2) social support (Turner, 1968), and (3) positive representations of individual roles by important people in the environment (Erez and Earley, 1993).

Creative role identity reflects employees' self-concept in their perception of innovation and innovative behavior in their organization; thus, it is an important psychological factor that affects innovative behavior (Farmer et al., 2003). As a product of value judgment, the behavioral decision-making that drives individuals' creative role identity has a positive impact on their intrinsic motivation to display innovative behaviors.

As Scott and Bruce (1994) indicated, organizational innovation support includes support for innovation from the organization, superiors, and colleagues. This support is also an important part of the organizational innovation climate (Amabile et al., 1996). In a strong innovative climate, individuals will perceive the support and encouragement of their superiors and colleagues for creative activities. When superiors encourage employees to carry out innovative behaviors, they express their expectations with positive supportive behaviors (Tierney and Farmer, 2004). This superior support affects employees' intrinsic motivation and can influence their creativity by stimulating their intrinsic motivation (Amabile et al., 1996). Riley and Burke (1995) analyzed social relations and role identity and found that "colleagues" in work relationships have more direct communication opportunities with individuals at work, so colleagues' expectations will shape employees' creative role identity. Expectations are linked to supportive behaviors. For example, when superiors expect employees to be creative, they will express their expectations by exhibiting positive supportive behaviors (Tierney and Farmer, 2004). Therefore, it is reasonable to believe that the support of colleagues is very important for employees and that this has a direct impact on their creative role identification. Various types of social and emotional support within an organization help employees realize their creative roles, thereby stimulating their intrinsic motivation for creative work (Hirst et al., 2009; Wang and Cheng, 2010). This discussion suggests that an organization's encouraging attitudes toward creativity and the specific supportive behaviors of superiors and coworkers both convey important situational support signals to employees that can help encourage them to form a creative role identity.

Based on the above analysis, we propose the first hypothesis:

H1: Innovation climate has a positive impact on creative role identity.

Flow as a Mediator

Researchers have focused on the influence of innovation climate on individual innovation behavior for years. However, sociological theory generally holds that the factors that influence individual behavior are multifaceted. The impact of environmental factors on individual behavior may be complex. An example is the perspective of social cognition theory, which argues that motivating factors (including environmental factors) that influence human behavior may stimulate people to act by

evoking core beliefs rooted in individuals (Glăveanu and Tanggaard, 2014). On this basis, Kang et al. (2016) found that team innovation climate promotes employees' innovative behavior by enhancing employees' enthusiasm for invention, and with the increase in proactive (risk-taking) climate, innovation climate and innovation enthusiasm (employee innovation) become stronger. Magni et al. (2018) found that team innovation climate promotes innovative practice by increasing individuals' attitudes toward proactivity and risk-taking. Nevertheless, the process mechanism by which organizational innovation climate affects employees' innovative behavior intentions/results is still unclear, and more comprehensive analysis and empirical tests are needed (Newman et al., 2020). For example, current research focuses too much on the role of individual factors (cognition, spirit) in the process of the innovation atmosphere affecting individual innovation behavior, ignoring the current state of the individual. In fact, from the perspective of pedagogy, focusing on whether the environmental atmosphere can promote individual actions by affecting the individual state is as important as mining the beliefs of the students themselves.

Therefore, we focus on an important concept in positive psychology—flow. Csikszentmihalyi (1988) coined the term "flow," describing the concept as follows: "The state in which people are so involved in an activity that everything else seems irrelevant; the experience itself is so enjoyable, So much so that people will even pay a huge price for doing so."

Following Csikszentmihalyi's (1988) research on flow, Landhäuser and Keller (2012) concluded that people's work performance is improved when they experience flow at work. The generation of flow can also improve an individual's work engagement. Bakker (2005) proposed the concept of work-related flow and believed that the flow experience of individuals in the process of work mainly includes three elements: absorption, work enjoyment, and intrinsic work motivation. Absorption refers to a state of total concentration during which employees are completely immersed in their work. Enjoyment means that employees enjoy their work and feel happy. Intrinsic motivation refers to employees being motivated by the intrinsic aspects of their work tasks and wanting to continue their work.

Flow theory is widely used in the field of education. In research on the antecedents of flow, some scholars study human factors. Mesurado et al. (2016) pointed out that when students believe that they have autonomy in learning, they are more likely to have flow experience and participate more in learning activities; Hong et al. (2020) further discussed that learning motivation can stimulate the flow experience and then have a positive and direct impact on learning engagement (Özhan and Kocadere, 2020). Yoo and Kim (2018) found that students who like to discuss their work with others are more likely to present a report successfully, which makes students more likely to have a higher level of flow experience in the next teaching activity; Chen et al. (2017) emphasized that students with higher prosociality cooperate closely with others in a game, which enables team members to have a good flow experience; Yoo and Kim (2018) suggested that creating a moderate sense of tension during class can make students more focused. Other scholars have studied the influence of resource factors on flow.

Vasiliou et al. (2014), Huang and Lin (2017), Pelet et al. (2017), Kim and Ko (2019), Fang and Huang (2021), etc., all considered that resource security, such as providing tablet computers and AR, is very important in their respective studies. It creates a sense of presence for the students and makes it easier for them to experience flow. Some scholars have also put forward innovative and interesting viewpoints on the influence of the curriculum setting, proving the important role of the practices of teachers and teacher support. For example, a dialog-style teaching method presented by two teachers makes the classroom more like a drama performance, which can make students focus better on class (Wang et al., 2021); the higher the level of simulation of real-world scenarios in practical courses, the timelier the feedback provided, and the more likely students are to experience flow (Yoo and Kim, 2018); a humorous climate can increase the frequency of flow experiences (Bartzik et al., 2021); the application of advanced teaching models and concepts in classroom teaching can make students more willing to devote themselves to learning and have more fun (Yang and Hsu, 2020). Some scholars have also studied the influence of task difficulty factors on flow in the classroom. Hung et al. (2015) believe that challenging game tasks are more likely to make people immerse themselves in activities, concentrate their energy, and experience enjoyment, thereby improving the flow experience. Demir and Seferoglu (2021) concluded in more detail that paired tasks reduce the task difficulty across the whole class so that students' abilities and task difficulty are more closely matched, thereby making the flow experience better than single-person tasks. Therefore, we can conclude that the innovation climate in class, including teacher practice, teamwork setting, and teacher support, helps generate students' flow experience.

The organizational innovation climate as perceived by individuals is their cognitive interpretation of the organizational innovation environment (Isaksen et al., 1999). Discussing only the direct influence of the innovation climate on creative role identity is not enough to clarify its influence mechanism. The innovation climate, which is an external factor, can only influence the formation of creative role identity by shaping an individual's perception and psychological state. We believe that the key mediating factor explaining the formation process of creative role identity is flow, that is, an individual's experience of immersing themselves in a climate of innovation and enjoying innovation.

Csikszentmihalyi (1988) pointed out three basic requirements for the generation of flow: first, clear goals and challenging tasks; second, timely feedback about results, timely and appropriate reinforcement, and support to encourage and increase the occurrence of creative behaviors; and third, a balance between the individual's skills and the challenge level of the task. A task that is too challenging for the individual's abilities will cause deep frustration and anxiety. A task that is not challenging enough will first be experienced as easy but will soon become boring (Hoffman and Novak, 1996). The challenging work dimension and resource support dimension of an innovative organizational climate satisfy the first and third points, while encouragement by the organization, superiors, and colleagues promotes the realization of the second point. Therefore, in organizations with a strong innovation climate, individuals are

more likely to experience the generation of flow in innovation activities.

Flow experience leads to certain flow results (Csikszentmihalyi, 1988). In the field of education, the outcomes of flow are often individual and generally positive. Flow can improve students' satisfaction and acceptance of the course (Mulik et al., 2020), making it easier to achieve the unity of knowledge and action; it can also enhance students' determination to perform tasks, improve learning performance (Admiraal et al., 2011), make them enthusiastic about taking on more difficult tasks (Eisenberger et al., 2005), and ultimately promote their innovative behavior.

According to flow theory, when an individual is addicted to an activity and enjoys it, he or she will actively research it or explore it in great depth. This kind of focused, selfless, and playful spirit helps individuals break their routine, explore new things, and expand their divergent thinking and creativity, thereby contributing to the creation of creative role identities.

We thus pose our second hypothesis:

H2: Flow mediates the positive effect of organizational innovation climate on creative role identity.

METHODS AND DATA

Sample and Data Collection

The importance of a school education in fostering students' creativity has been proven (Cropley, 2001; Starko, 2017). Based on the research objectives of this paper, the survey adopts the method of convenience sampling. We focused on a sample of college students at a vocational university in China and selected a total of 226 students in 6 classes from a literature college and a science college. The survey was conducted toward the end of the innovation and entrepreneurship course to ensure that the students participating in the survey have just experienced the course fully and maintain a relatively deep experience of the course. We collected data through offline questionnaires. Before giving out the questionnaire, the teacher explained the purpose of this research and promised that the questionnaire would be used only for academic research. During the investigation process, the teacher did not guide the interviewed students on a subjective bias and left enough time for the students to complete the questionnaire. The teacher distributed 226 questionnaires, which were all valid. Among the 226 respondents, men accounted for 46% and women, 54%. Engineering majors accounted for 51.3%, with 36 students from the architectural engineering class and 80 students from the municipal administration class. The number of liberal arts majors accounted for 48.7%, with 82 students from the investment class and 28 students from the finance class. **Table 1** summarizes the characteristics of the respondents.

Measurement

The measurement scales used in this study are mainly from the Western research literature. To ensure the validity of the measurements in the Chinese context, we adopted a translation

TABLE 1 | Characteristics of the respondents ($N=226$).

		Frequency	Percentage
Gender	Male	104	46.0
	Female	122	54.0
Class	Architectural engineering	36	15.9
	Investment	82	36.3
	Finance	28	12.4
	Municipal administration	80	35.4

and back translation procedure to revise the scales. The respondents used a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) to evaluate how well each item in the questionnaire described their situation.

We measured the respondents' creative role identity (CRI) using the creative personal identity (CPI) scale alternative of Karwowski (2012). We retained all five items: (1) I think I am a creative person; (2) My creativity is important to who I am; (3) Being a creative person is important to me; (4) Creativity is an important part of myself; and (5) Ingenuity is a characteristic that is important to me.

We adopted Bakker's (2008) flow scale, which consists of 13 items measuring three independent dimensions, namely, absorption (4 items), enjoyment (4 items), and intrinsic motivation (5 items).

To measure innovation climate, we mainly referred to Amabile's KEYS (Assessing the Climate for Creativity) scale. As this study was conducted at a university, we adjusted the scale according to the specific circumstances, including incentive mechanisms, teacher practice, teamwork, teacher support, resource guarantee, organizational promotion, and self-directed work.

RESULTS

Reliability and Validity

Table 2 demonstrates the descriptive statistics for the study, including the means, standard deviations, kurtosis, skewness, and PLS loadings of all 41 variables. All of the factor loadings were above the proposed level of 0.7 Hair et al. (2021), proving indicator reliability. **Table 3** shows all of the constructs' Cronbach's alpha (CA) and composite reliability (CR) values, which surpassed the recommended threshold of 0.70, indicating sufficient reliability. The average variance extracted (AVE) values were higher than 0.5, confirming the convergent validity of the research data (Bagozzi and Yi, 1988). Discriminant validity was checked by a correlation test. Because the square root of each construct's AVE was greater than its correlation coefficients with other constructs, discriminant validity was proven.

To prove the internal consistency reliability, the values of CR should be higher than 0.7, and the values of average variance extracted (AVE) should be higher than 0.5 to confirm the convergent validity (Bagozzi and Yi, 1988). In this study, the values of CR are 0.964, 0.967, and 0.936 for flow, IC, and CRI, respectively, and the values of AVE are 0.677, 0.592, and 0.746

TABLE 2 | Means, standard deviations, and PLS loadings.

Item	Mean	SD	Kurtosis	Skewness	PLS Loading
Flow					
<i>Absorption</i>					
ABS1	3.960	0.918	0.489	-0.827	0.820
ABS2	3.174	1.053	-0.637	0.039	0.804
ABS3	3.366	1.077	-0.603	-0.340	0.884
ABS4	3.567	0.989	-0.503	-0.299	0.932
<i>Work enjoyment</i>					
WE1	4.036	0.930	1.008	-1.044	0.910
WE2	4.049	0.960	0.846	-1.013	0.951
WE3	4.067	0.916	0.266	-0.835	0.960
WE4	4.022	0.938	0.982	-0.994	0.946
<i>Intrinsic work motivation</i>					
IWM1	3.964	0.944	1.177	-1.050	0.893
IWM2	3.598	1.035	-0.118	-0.545	0.782
IWM3	3.808	0.984	0.053	-0.654	0.899
IWM4	4.018	0.916	1.532	-1.088	0.801
IWM5	3.933	0.921	-0.218	-0.626	0.890
Innovation climate					
<i>Incentive mechanism</i>					
IM1	3.848	0.883	0.442	-0.675	0.895
IM2	3.929	0.873	0.655	-0.751	0.906
IM3	3.906	0.889	1.469	-0.966	0.912
IM4	3.946	0.864	0.765	-0.773	0.896
<i>Teacher practice</i>					
TP1	3.978	0.899	1.723	-1.108	0.913
TP2	4.076	0.870	1.727	-1.130	0.928
TP3	4.103	0.932	2.158	-1.338	0.944
<i>Teamwork</i>					
TEA1	3.929	0.913	0.945	-0.884	0.931
TEA2	4.000	0.881	1.363	-1.024	0.932
TEA3	4.036	0.891	0.372	-0.795	0.932
<i>Teacher support</i>					
TS1	4.018	0.930	2.112	-1.274	0.925
TS2	4.067	0.866	1.765	-1.127	0.894
TS3	4.062	0.899	1.001	-1.014	0.901
TS4	4.094	0.909	1.791	-1.229	0.893
<i>Resource guarantee</i>					
RG1	2.750	1.102	-0.518	0.267	0.979
RG2	2.763	1.078	-0.514	0.225	0.938
RG3	2.710	1.122	-0.493	0.286	0.882
<i>Organization promotion</i>					
OP1	3.826	0.941	1.199	-0.973	0.835
OP2	3.929	0.908	1.385	-1.009	0.940
OP3	4.040	0.965	1.471	-1.191	0.887
<i>Self-directed work</i>					
SDW1	3.594	1.000	0.092	-0.516	0.870
SDW2	3.759	0.894	1.135	-0.789	0.909
SDW3	3.612	0.943	0.087	-0.406	0.904
<i>Creative role identity</i>					
CRI1	3.554	0.953	-0.057	-0.341	0.785
CRI2	3.911	0.907	1.166	-0.979	0.884
CRI3	3.897	0.903	0.081	-0.638	0.876
CRI4	3.728	0.917	0.322	-0.551	0.903
CRI5	3.571	1.002	-0.478	-0.211	0.809

CRI, Creative Role Identity; IC, Innovation Climate; TS, Teacher Support; IWM, Intrinsic Work Motivation; ABS, Absorption; TEA, Teamwork; WE, Work Enjoyment; IM, Incentive mechanism; OP, Organization Promotion; SDW, Self-directed Work; RG, Resource Guarantee; TP, Teacher Practice.

for flow, IC, and CRI, respectively. The reliability and validity of the measurement scales have been confirmed. **Table 3** presents the CRs and AVEs.

TABLE 3 | Reliability, validity, and correlations of the constructs.

	Cronbach's alpha		CR	AVE	ABS	CRI	IM	IWM	OP	RG	SDW	TEA	TP	TS	WE
ABS	0.883	0.920	0.742	0.862											
CRI	0.906	0.930	0.727	0.606	0.853										
Flow	0.956	0.962	0.661	0.861	0.718										
IC	0.957	0.964	0.569	0.659	0.771										
IM	0.924	0.946	0.814	0.542	0.685	0.902									
IWM	0.906	0.931	0.730	0.728	0.717	0.661	0.854								
OP	0.866	0.918	0.789	0.529	0.675	0.760	0.725	0.888							
RG	0.932	0.953	0.872	0.106	0.163	0.064	0.080	0.069	0.934						
SDW	0.875	0.923	0.800	0.649	0.789	0.640	0.716	0.684	0.154	0.894					
TEA	0.924	0.952	0.868	0.568	0.663	0.707	0.661	0.714	0.048	0.686	0.932				
TP	0.920	0.949	0.862	0.620	0.643	0.805	0.715	0.757	0.023	0.638	0.788	0.929			
TS	0.925	0.947	0.816	0.616	0.678	0.790	0.738	0.797	0.039	0.698	0.820	0.880	0.904		
WE	0.957	0.969	0.887	0.703	0.643	0.652	0.853	0.685	0.050	0.646	0.693	0.746	0.757	0.942	

AVE, Average Variance Extracted; CR, Composite Reliability.

Testing of Hypotheses

We controlled for gender, class, and weekly class hour variables to avoid their potential effects on creative role identity. A PLS bootstrapping algorithm was used to obtain the saliency results. Smart-PLS was used to analyze data, and the basic information of subsamples was set at a larger number of 5,000 to obtain conventional PLS estimates with bootstrap significance. **Figure 1** shows the results of the model. The study shows that in the proposed model, IC can explain 66.7% of the change in flow ($R^2 = 66.7\%$); while the explanatory power of IC and flow for the change in CRI is 61.8% ($R^2 = 61.8\%$).

According to the PLS analysis results, IC was positively related to flow ($\beta = 0.834$, $p = 0.000$), IC was significantly related to CRI ($\beta = 0.571$, $p = 0.000$), and flow significantly affected CRI ($\beta = 0.268$, $p = 0.001$). Hence, all the hypotheses were strongly supported. **Table 2** shows these values.

Table 4 shows the total effects of flow and IC on CRI. **Table 4** indicates that IC had a larger total effect on CRI than flow did, as IC had an indirect effect on CRI. The mediating effect of flow between IC and CRI was proven. This result provides important implications for colleges to conduct educational reforms.

DISCUSSION

Discussion of Results

This study links the impact of innovation climate on creative role identity in universities with flow and brings interdisciplinary contributions to innovation education and innovation talent cultivation. A questionnaire survey was conducted on 226 students from 6 classes of a vocational university selected for this study. The empirical results support the two hypotheses of this paper well. The main conclusions of this study are as follows:

The innovation climate has a significant positive impact on the identity of individual creative roles.

1. The research results support the innovation climate created by colleges and universities through innovation and entrepreneurship activities and course design, which can stimulate students' creative role identity. The innovation climate is an important antecedent that affects the creative role identity and then affects the willingness to innovate and the behavior of innovation.
2. The main contribution of flow is to mediate the positive effect of innovation climate on creative role identity. It verifies the view of situational strength theory that the environment influences intentions and behaviors through individual psychological factors. This model helps to explain how the innovation climate can better influence students' individual creativity in university innovation education and provides new ideas for classroom organization.

Theoretical Contributions

In general, from the perspective of situational strength theory, this study analyzes the influence mechanism and individual psychological mechanism of the influence of innovation climate

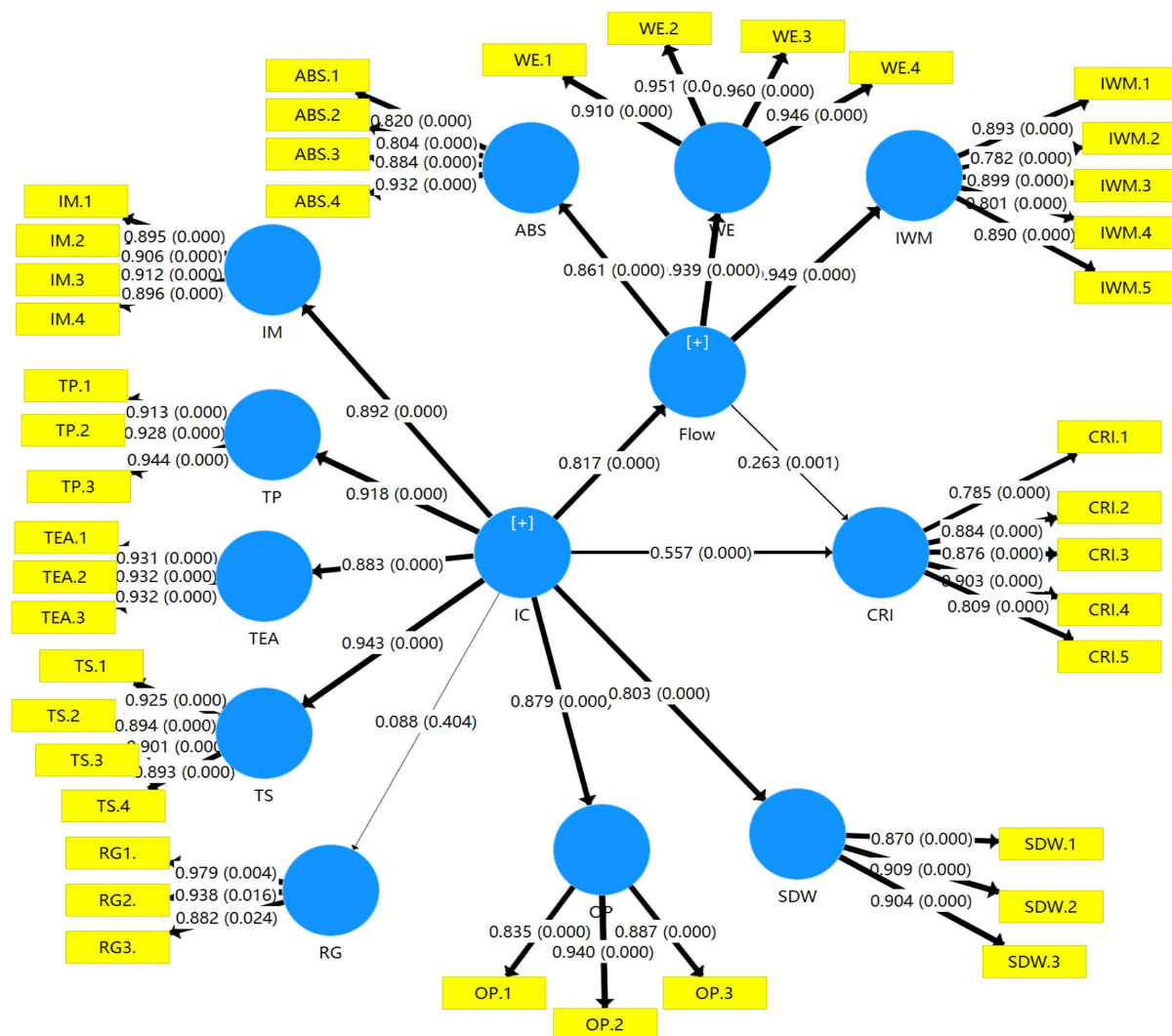


FIGURE 1 | The results of PLS analysis.

TABLE 4 | Direct, indirect, and total effects of each factor on creative role identity.

	Flow (direct effect)	CRI (direct effect)	CRI (indirect effect)	CRI (total effect)
Flow		0.263**		0.263***
IC	0.817***	0.557***	0.215	0.771***

** $p < 0.01$, and *** $p < 0.001$.

on individual creative role identity. The theoretical contributions of this research are as follows:

First, we found that previous research suggested that creative role identity can drive individuals to produce innovative behaviors. However, few studies have investigated the antecedents and motivational mechanisms of creative role identity. Our research addresses this important gap by linking school innovation climates with a student's creative role identity.

We introduce situational strength theory to study the antecedents of creative role identity and regard innovation climate as a psychological impact, which provides a new perspective for the research of creative role identity and extends the understanding of the antecedents of creative role identity.

Second, this study proposes and verifies the influence mechanism of the external environment on creative role identity, discovers the key role of flow as a psychological mechanism in this process, and unpacks an important mechanism linking innovation climate to creative role identity. Previous studies have noticed a significant positive correlation between innovation climate and individual creative behavior, but the detailed psychological mechanism has not been explored in depth. Using role identity theory and situational strength theory, we adopt a new theoretical framework to explain the mediating role of flow between innovation climate and creative role identity and point out that fully engaged and highly excited of mental state is an important way to connect the external environment and

role identity. It is helpful to open the “black box” in the process of the influence of innovation climate on creative identity and enrich the theory of creativity research. Our research has found that if an organization wants an innovation climate to have a stronger positive effect on creative role identity and even innovative behavior, an effective way is to build a flow experience to stimulate individuals’ desire to learn and explore. This allows individuals to not only express their creativity but also to become more creative systematically and ultimately to attain creative achievement.

Third, this study is an extension of the research on the relationship between external climate and individual role identity in the context of pedagogy, providing useful new insights for educational methods. In the teaching activities of the project method, the innovation climate created by the school influences the students’ creative role identity through the flow classroom and then promotes the students to produce innovative behaviors and innovation results.

Managerial Implications

Our research has important practical implications for university innovation education. In particular, the tide of innovation sweeping the world will eventually lead the development of creativity education to converge, that is, to cultivate talent with creative spirit and creative ability. Therefore, it has become an urgent task for universities to carry out in-depth innovation education reform and cultivate high-level innovative talent.

Our research has implications for the development of innovation educational methods in colleges and universities and the cultivation of innovative talent.

Implications for school administrators:

1. Schools should further create a supportive environment for innovation and entrepreneurship education, establish a variety of incentive mechanisms to encourage innovation, and provide abundant learning resources and incubation resources. For example, they could create a free creative innovation laboratory, a prototype production room, an exhibition area for creative works, etc., and build a business incubation base based on regional industries.
2. Integrate creativity-inducing training into the curricula, build a diverse innovation practice platform, and organize various forms of innovation and entrepreneurship community activities. For example, they could hold creative competitions with rewards at the end of a course to select the outcome and they could create an innovation climate through the extension of competition and feedback mechanisms inside and outside the classroom.
3. Better nurture teaching staff and cultivate innovative teachers while supporting teachers in innovating teaching methods, deepening the reform of classroom teaching, and creating a classroom climate with high student participation and vitality. For example, schools could establish an innovation education teacher club, develop a multistage teacher training system, and promote the formation of a dynamic mechanism among teachers to allow them to spontaneously participate in innovative teaching reform and research.

Creativity education in colleges and universities is an educational process in which teachers use creativity courses and creative education strategies to cultivate college students’ creative thinking ability and stimulate college students’ innovative behaviors. Implications for teachers:

1. Set clear goals and assign challenging tasks to enhance students’ intrinsic motivation for learning when developing courses, carrying out teaching design, and organizing teaching activities.
2. Ensure timely feedback of results, strengthen students’ active learning behavior, and improve students’ concentration and learning enthusiasm.
3. Improve analysis of the learning situation, balance the students’ skills and the difficulty of the challenge, and meet the personalized learning needs of students at different levels with learning tasks of different difficulty.
4. Adhere to the student-centered model, establish an open learning climate, encourage peers to learn from each other, take into account the differences between students, allow students to gain positive emotional experience, enjoy the learning process and enjoy the student-centered model, and support students as active constructive learners.
5. Build environment resources for active teaching that include features, such as virtual simulation in order to relieve students’ learning fatigue and enhance their learning motivation and interest.
6. Teachers should continuously improve their own innovative thinking and innovative ability, change the traditional paradigm of their teaching philosophy, and use new theories, new concepts, and new methods to improve themselves, to broaden and deepen their knowledge, display creative thinking, be able to use creative techniques to carry out creative teaching reform. Ultimately, developing these skills can help teachers fully demonstrate a winning personality in innovation education, gain the love of students, build a harmonious relationship between teachers and students, and play an exemplary role.

Research Limitations and Future Research

The limitations of this study and future research directions are as follows: (1) Selected sample of this study was the researchers’ students. Although the proportion of engineering and liberal arts majors was considered, the limitations of convenient sampling still exist. When conditions are available, stratified sampling can be adopted in universities and vocational colleges nationwide to conduct more complete research. (2) More diverse research samples are needed. The research sample consisted of university students. Although the sample group was suitable for the main research purpose, there are still some differences between the characteristics of university students and employees at enterprises. Future research should continue to take other samples (such as employees at enterprises) to verify the validity of the model and increase the external validity of the research conclusions. (3) When analyzing the effect of innovation climate on creative role identity, this study focused on the mediating role of flow. To further explore how the effect of innovation climate on creative role identity changes under different mediating variables and open the “black box” of the relationship between the two, future research can

introduce other classical mediator variables for analysis and build multiple models.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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BD and JW designed the study, performed the experiments, and wrote the manuscript. JH and JC performed the experiments and analyzed the data. All authors contributed to the article and approved the submitted version.

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Deriving Public Innovation Capacity: Evidence From the Korean Public Sector

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By actively coping with changes, a government providing public services can also improve the quality of those public services and help citizens improve their quality of life in the face of rapidly changing social structures, environments, and values. Accordingly, this study will typologize public innovation capacity (PIC) in terms of the individual, middle manager, and organizational levels. This study typologizes public innovation capacity in terms of the individual, middle manager, and organizational levels through mini-round Delphi analysis and exploratory factor analysis and confirmatory factor analysis using survey. This capacity is a precondition of the specificity of the public sector (generating public interest by providing public services) and universal value of HR (human resource) research (creating performance). It provides the basic capacity within the public sector to enhance the quality of public services and create positive outcomes.

Keywords: public innovation capacity, Korean public sector, Delphi analysis, individual, middle manager, organizational levels

INTRODUCTION

By actively coping with changes, a government providing public services can also improve the quality of those public services and help citizens improve their quality of life in the face of rapidly changing social structures, environments, and values (Gieske et al., 2019). Osborne and Plastrik (1998) defined innovation in the public sector as the fundamental transformation of public systems and organizations to create dramatic increases in their effectiveness, efficiency, and capacity to innovate and stressed its importance. Walker (2007) argued that the public sector pursues innovation based on laws and systems or does not have an established concept of innovation, which is why it is difficult for it to seek innovation in a groundbreaking way. The external environment, supply-demand principle, profit generation, and regulations of the public sector are different from the private sector's circumstances; thus, innovation might not be considered a priority in the public sector (Lewis et al., 2018). There are various reasons to seek innovation in the public sector, but the key is to provide high-quality public services in the right place and at the right time (Demircioglu and Audretsch, 2019; Wynen et al., 2019), which could create public value and pursue the public interest.

The most important factor in change management that induces organizational innovation is the recognizing the need for change among members in response to a sense of crisis that if they do not change they will be eliminated (Hayes, 2022). However, unlike private organizations, public organizations are relatively less sensitive to changes in the environment (Longo and Cristofoli, 2008). In particular, in Korea, since the stability of public organizations is guaranteed according

to the law, it is relatively difficult to create a sense of crisis that organizations may disappear or become unemployed, even if they do not change compared to the private sector (Kim, 2012).

After the New Public Management (NPM) was implemented, the concept of innovation was introduced to the public sector (De Vries et al., 2018), but there have been difficulties in producing and spreading innovation in the public sector due to its low compensation and high risk (Bugge and Bloch, 2016). Moreover, to solve the chronic problems connoted by public services such as legal limitations on the target and scope of public services and a decrease in publicness for contracting-out and to maximize the effectiveness of public services by efficiently using internal resources that have already been obtained, it is necessary to actively establish strategies to seek innovation (Demircioglu and Audretsch, 2019; Meijer, 2019).

Over the last decade we have meet massive dynamics in key organization circumstances such as a 4th industrial revolution, big data, and so on. However, due to the lack of innovators and discussions about their roles, such efforts could not directly lead to the enhanced quality of public services (Hjelmar, 2019). Public organizations have led innovation in managerial aspects such as implementing new management techniques or establishing innovation agencies rather than pursuing fundamental innovation of the actors in organizations; that is why there have been limitations in internalizing innovation and producing results thereof. Here, we try to highlights how innovation can build bridges across organizations to response organizational environment change. In addition, in the case of Korea, it is different from other countries in that public officials were the driving force behind the country's innovative change (Kim, 2012). However, while the old generation led the nation's development through dedication to the organization and continuous innovation efforts, the new generation pays more attention to values such as personal life satisfaction rather than organization commitment or innovation (Park and Park, 2018). In doing so, this study judges that the innovation capability of public organization's members is most important for the sustainable development of Korean society.

Previous studies have actively discussed various factors that affect the innovative behaviors of organizational members from both theoretical and practical viewpoints, rather than focusing on innovation capacity (e.g., De Vries et al., 2018; Cinar et al., 2019; Wynen et al., 2019). In particular, the study focused on the difference between public innovation from the NPM perspective and cooperative innovation based on governance (Sørensen and Torfing, 2011; Sørensen, 2012). More specifically, it has been empirically proved that independence of wages and duties as well as procedural legitimacy have a positive effect on the innovative behaviors of members (Ramamoorthy et al., 2005). Holzer and Callahan (1998) proved that support from top managers, work-related training, organizational structure, a system to promote innovation, the resources used in the organization (human and material), compensation, and incentives had effects on innovative behaviors; in addition, organizational learning and an appropriate level of job stress also turned out to have an effect on innovation (Lemon and Sahota, 2004). Specifically, it focuses on the positive effects

on organizations equipped with innovation capabilities rather than the components of innovation capabilities that individuals should possess. Therefore, this study can be differentiated from previous studies in that it focuses on the innovation capability itself. Accordingly, this study will typologize public innovation capacity (PIC) in terms of the individual, middle manager, and organizational levels (see **Figure 1**). This capacity is a precondition of the specificity of the public sector (working in public interest by providing public services) and universal value of HR research (creating performance). It provides to secure the basic capacity within the public sector in order to enhance the quality of public services and create positive outcomes.

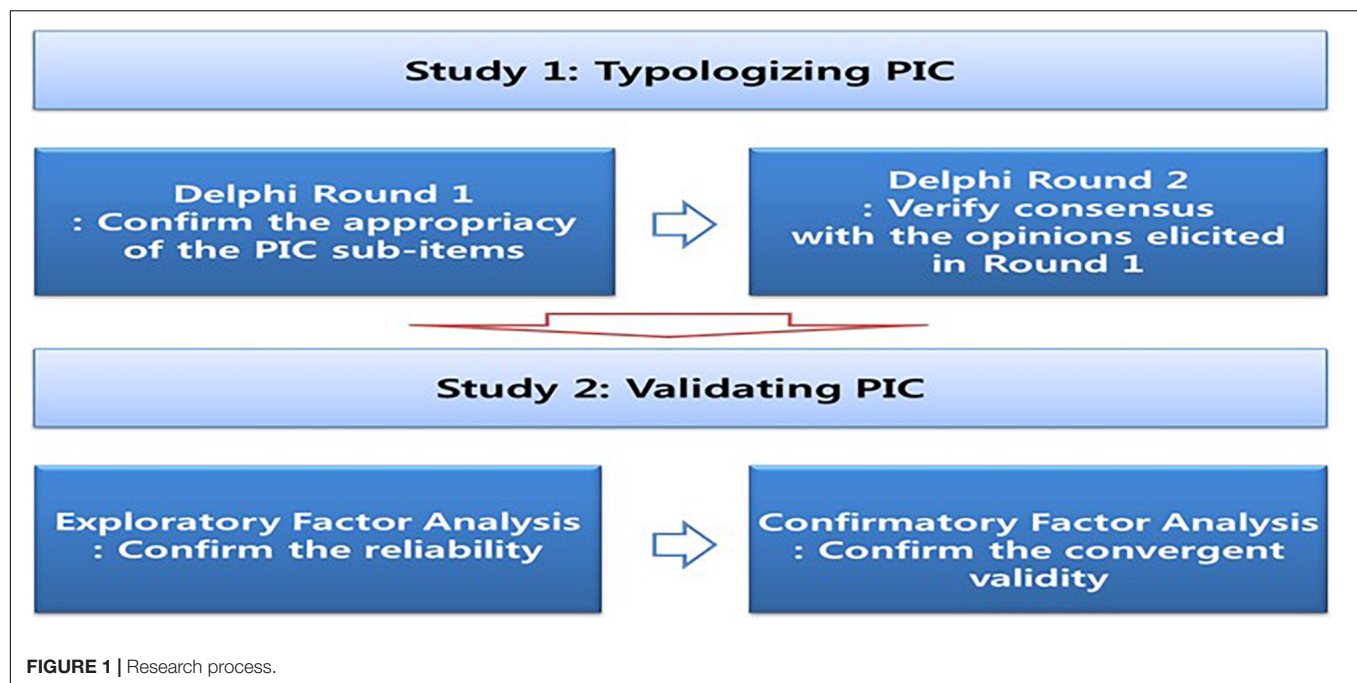
This research consists of five parts. First, the introduction briefly overviews the importance of innovation in the public sector; why the public sector needs to verify the PIC. The second section of literature review draws the institutional and theoretical backgrounds of PIC and the concepts of PIC. Third, the study applies the Delphi method for the purpose of gathering the viewpoints of experts in the field of PIC. Fourth, to determine the factor structure of PIC at the individual, middle manager, and organizational levels, this study tests EFA (exploratory factor analysis) and CFA (confirmatory factor analysis). Finally, the discussion part suggests research implications and limitations in the HR (human resource) field.

LITERATURE REVIEW

Institutional and Theoretical Background of Public Innovation Capacity

As the roles of the public sector increased and terms such as “welfare” or “administrative state” became generalized and widely used, issues began to arise due to the public sector's intervention in various parts of society. Moreover, the negative roles and actions of the public sector were expressed in the form of citizens' distrust, conflicts, or economic crises. Accordingly, there have been discussions about public innovation based on the hostility toward the public sector's huge role and awareness of the need to maximize its performance and efficiency (Sørensen and Torfing, 2011; Cannaerts et al., 2016; Demircioglu and Audretsch, 2019). Innovation efforts in the public sector based on NPM perceived the private sector as a competitor, implemented private management techniques in the public sector, and strived to create a competitive environment (Bloch and Bugge, 2013; Demircioglu, 2017; Demircioglu and Audretsch, 2019). As such, NPM is an important element in designing the direction of innovation in the public sector and has encouraged the development of various types of innovation (De Vries et al., 2018).

The PIC mainly consists of the role and functional shift of the government, entrepreneurial-customer-centric e-government, and privatization; it also mainly consists of efficiency, democracy, transparency, decentralization, and reform of organizational structures and management skills (Walsh et al., 2016; Demircioglu, 2017). After the faith in the efficiency of bureaucracy was shattered, NPM was implemented

**TABLE 1 |** Characteristics of the Delphi participants.

Category	No.	Gender	Age	Job status	Job tenure	Education
Academic expert	1	Male	40s	Professor	Over 10 years	Doctor
	2	Male	40s	Associate Professor	Over 5 years	Doctor
	3	Female	30s	Assistant Professor	Over 5 years	Doctor
	4	Female	30s	Senior Researcher	Under 3 years	Master
	5	Female	30s	Senior Researcher	Under 3 years	Master
	6	Female	30s	Senior Researcher	Over 5 years	Doctor
	7	Male	30s	Senior Researcher	Under 3 years	Master
	8	Male	40s	Senior Researcher	Over 5 years	Doctor
Public officials who are in charge of human resource departments	9	Male	40s	Grade 6	Over 10 years	Bachelor
	10	Male	40s	Grade 4	Over 10 years	Bachelor
	11	Male	40s	Grade 5	Over 15 years	Bachelor
	12	Male	30s	Grade 7	Over 3 years	Bachelor
Public officials who are working at human resource development institutes	13	Male	50s	Grade 4	Over 15 years	Master
	14	Female	40s	Grade 7	Over 10 years	Bachelor

with a focus on improving efficiency in the public sector by adopting business logic and management skills. This raised fundamental questions about the efficiency of the public sector and contributed to encouraging government innovation or reform. In particular, innovation in terms of NPM, characterized by its emphasis on performance and accountability through performance management, downsizing, and expansion of privatization, can be considered as a movement that breaks away from the conventional government-led administration (Andersen and Jakobsen, 2018).

As NPM received attention as a typical model of public innovation capacity, it positioned itself as a new management strategy in the public sector. Meanwhile, countries such as the United Kingdom institutionalized the participation of stakeholders, including citizens, in decision making and

emphasized government innovation for prompt government measures, whereas the United States maintained a certain level of the key parts of NPM while emphasizing New Public Service, which focuses on humanism, serving citizens, and communitarianism (Denhardt and Denhardt, 2000). Park and Joaquin (2012) discovered that the reform values of NPM (effectiveness) and post-NPM (humanistic) coexist in public institutions in the United States. This indicates that NPM reform values and post-NPM reform values are not replaced by a single value but are mediated according to the government's policy director, or values are pursued like the ebb and flow.

Currently, the innovation value of NPM still has a strong influence in discussions of innovation in the public sector of Korea, but it is necessary to utilize innovation with more

TABLE 2 | Results of Delphi Round 2.

Individual PIC			Secure validity	Content validity	Degree of consensus		
Criteria	Designation	Capacity index	Coefficient of variation	CVR	Quadrant factor	Convergent diagram	Consensual diagram
Individual characteristic capacity	Value innovation	Public value (state view, public service view, ethical belief)	0.08	1	4.75–5	0.12	0.95
		Self-control ability	0.29	0.71	4–5	0.50	0.75
		Accountability (administrative, legal, professional, moral)	0.12	0.85	4.75–5	0.12	0.95
	Sum		0.10	0.71	4.25–5	0.37	0.84
	Creativity political sense	Political judgment force	0.26	0.71	4–5	0.50	0.75
		Adaptability (job, organization, interpersonal)	0.11	1	4–5	0.50	0.75
		Insight	0.16	0.71	4–5	0.50	0.75
	Sum		0.13	0.42	3.66–4.66	0.50	0.79
	Innovation achievement-oriented	Challenging	0.05	1	5	0	1
		Enterprising	0.09	1	4–5	0.50	0.75
		Goal-oriented	0.07	1	5	0	1
	Sum		0.06	1	4.66–5	0.22	0.92
Job performance	Innovative work performance	Job expertise based on KSA	0.13	0.85	4–5	0.50	0.75
		Public service mindset toward citizens	0.17	0.71	4–5	0.50	0.78
		Display self-leadership to perform duties efficiently	0.16	0.71	4–5	0.50	0.75
		Foreign language skill to acquire advanced cases	0.30	0	3–4.25	0.62	0.65
		Performance-centered duties	0.11	1	4–5	0.50	0.78
		Policy and business briefing ability	0.28	0.42	3–5	1	0.50
		Sum	0.12	0.57	3.91–4.5	0.31	0.86
	Innovation planning	Strategic thinking	0.07	1	5	0	1
		Policy management ability	0.43	0.42	3.75–5	0.62	0.69
		Creative problem-solving ability	0.14	0.85	4–5	0.50	0.75
		Crisis and change management ability	0.12	0.85	4.75–5	0.12	0.95
		Rational decision making	0.14	0.85	4–5	0.50	0.78
	Sum		0.10	0.71	4–4.8	0.40	0.83
	Smart Information Management	Business information and share and tacit knowledge building	0.16	0.71	4–5	0.50	0.75
Relationship formation	Innovation win–win relationship formation	Collaborative work performance	0.07	1	5	0	1
		Empathic ability	0.23	0.85	4.75–5	0.12	0.95
		Network formation ability	0.37	0.57	3.5–5	0.75	0.75
		Conflict management	0.19	0.85	4–5	0.50	0.78
		Communication skills	0.24	0.85	4–5	0.50	0.78
	Sum		0.12	0.71	4.2–4.85	0.32	0.86
	Innovative network formation	Stakeholder integration ability	0.28	0.57	3.75–5	0.12	0.73
		Peddling political influence	0.48	0.14	1–4	0.66	0
	Sum		0.30	0.14	2.87–4.5	0.81	0.60

(Continued)

TABLE 2 | (Continued)

Middle manager PIC			Secure validity	Content validity	Degree of consensus		
Criteria	Designation	Capacity index	Coefficient of variation	CVR	Quadrant factor	Convergent diagram	Consensual diagram
Individual characteristic capacity	Value innovation	Accountability (administrative, legal, and professional, moral)	0.12	0.85	5	0	1
		Distribution and process fairness	0.26	0.71	4–5	0.50	0.80
		Ethics as a public official	0.24	0.85	4–5	0.50	0.80
		Seek social values	0.07	1	5	0	1
		Spirit of sacrifice to the organization and country	0.28	0.71	3.75–5	0.62	0.73
		Sum	0.11	0.57	4.1–5	0.45	0.81
	Innovation achievement-oriented	Goal-oriented	0.08	1	4.75–5	0.12	0.95
		Public entrepreneurship (innovation, initiative, and risk taking)	0.09	1	4–5	0.50	0.90
		Sum	0.08	1	4.5–5	0.25	0.90
	Creativity index	Flexible thinking	0.09	1	4–5	0.50	0.80
		Emotional intelligence	0.23	0.57	3.75–5	0.62	0.73
		Positive psychological capital (resilience, hope, self-efficacy, and optimism)	0.19	0.85	4–5	0.50	0.78
		Sum	0.13	0.71	4–5	0.50	0.78
Job performance	Innovative work performance	Strategy for actioning vision	0.13	0.85	4–5	0.50	0.80
		Environmental analysis ability	0.10	1	4–5	0.50	0.80
		Business convergence skill	0.09	1	4–4.25	0.12	0.94
		Job expertise based on KSA	0.08	1	4.75–5	0.12	0.95
		Sum	0.06	1	4.37–4.5	0.06	0.98
	Innovative planning	Ability to develop and manage policies	0.08	1	4.75–5	0.12	0.95
		Creative problem-solving skills	0.09	1	4–5	0.50	0.80
		Reasonable decision making	0.09	1	4–5	0.50	0.80
		Future forecasting ability	0.13	0.85	4–5	0.50	0.80
		Sum	0.08	0.85	4.5–5	0.25	0.90
	Innovative motivation	Persuasive power for member motivation	0.13	0.85	4–5	0.50	0.80
		Coaching and feedback about subordinates' work	0.09	1	4–5	0.50	0.80
		Sum	0.10	0.85	4.37–5	0.31	0.88
Org. management	Innovative process	Establishment and propagation of vision	0.10	1	4–5	0.50	0.80
		Organizational learning management	0.14	0.85	4–5	0.50	0.75
		Strategic resource management (training, development, and utilization)	0.13	0.85	4–5	0.50	0.78
		Establish and manage the organization and members' goals	0.17	0.71	4–5	0.50	0.78
		Smartness of change response	0.19	0.85	4–5	0.50	0.75
		Efficient authority delegation	0.09	1	4–5	0.50	0.80
		Sum	0.09	0.85	4.16–4.8	0.35	0.85

(Continued)

TABLE 2 | (Continued)

Middle manager PIC			Secure validity	Content validity	Degree of consensus			
Criteria	Designation	Capacity index	Coefficient of variation	CVR	Quadrant factor	Convergent diagram	Consensual diagram	
Relationship formation	Innovative conflict management strategy	Manage and mediate conflicts	0.07	1	5	0	1	
		Build inclusive teamwork	0.15	0.85	4.75–5	0.12	0.95	
		Manage the diverse needs of the members	0.16	0.71	4–5	0.50	0.80	
	Innovation win–win relation-ship formation	Sum	0.10	0.85	4.3–5	0.35	0.86	
		Participate in official and non-official mentoring	0.29	0.42	3–5	1	0.50	
		Mediator of vertical and horizontal communication	0.09	1	4–5	0.50	0.80	
		Listening to members' opinions	0.28	0.57	3.75–5	0.62	0.75	
		Builds social capital in the org. (trust and network)	0.09	1	4–5	0.50	0.80	
		Followership	0.26	0.57	4–5	0.50	0.78	
		Sum	0.09	0.71	4.15–4.6	0.25	0.89	
Organizational PIC			Secure validity	Content validity	Degree of consensus			
Criteria	Designation	Capacity index	Coefficient of variation	CVR	Quadrant factor	Convergent diagram	Consensual diagram	
Org. goal	Establish innovation model	Establish and share vision	0.53	1	4.75–5	0.12	0.95	
		Establish and implement strategies	0.53	1	4.75–5	0.12	0.95	
		Sum	0.53	1	4.75–5	0.12	0.95	
Innovative support	Develop and use core competencies	Develop and use core competencies	0.10	1	4–5	0.50	0.80	
		Actively support efficient policy implementation	0.53	1	4.75–5	0.12	0.95	
		Develop policies to achieve organizational goals	0.14	0.85	4–5	0.50	0.80	
		Sum	0.09	0.85	4.5–5	0.25	0.90	
Org. members Individual characteristic capacity andJob performance	Value innovation	Willingness of social value realization	0.08	1	4.75–5	0.12	0.95	
		Owner spirit	0.24	0.85	4–5	0.50	0.80	
	Innovation achievement-oriented	Sum	0.07	1	4.5–5	0.25	0.90	
		Public service mindset toward the citizens	0.08	1	4.75–5	0.12	0.95	
		Display self-leadership for job duty	0.11	1	4–5	0.50	0.80	
		Performance-oriented followership/leadership	0.13	0.85	4–5	0.50	0.80	
		Ability to manage public service quality	0.14	0.85	4–5	0.50	0.80	
		Job expertise based on KSA	0.13	0.85	4–5	0.50	0.80	
		Actively change management in response to environment change	0.08	1	4.75–5	0.12	0.95	
		Sum	0.09	0.57	4.29–5	0.35	0.85	
		Org. management	Innovative process	Intelligent public management	0.26	0.71	4–5	0.50

(Continued)

TABLE 2 | (Continued)

Organizational PIC			Secure validity	Content validity	Degree of consensus		
Criteria	Designation	Capacity index	Coefficient of variation	CVR	Quadrant factor	Convergent diagram	Consensual diagram
Innovative culture	Innovative culture	Enabling learning organization	0.11	1	4–5	0.50	0.80
		Simplification of decision process	0.16	0.71	4–5	0.50	0.80
		Strategic resource management (training, development, and utilization)	0.07	1	5	0	1
		Security and efficient utilization of resources (budget, manpower, etc.)	0.41	0.57	3.25–5	0.87	0.65
		Active vertical and horizontal communication	0.08	1	4.75–5	0.12	0.95
		Sum	0.07	0.85	4.29–4.7	0.20	0.91
		Cooperation-oriented culture for organizational social capital construction	0	1	5	0	1
		Future-oriented culture for dynamic organization building	0.08	1	4.75–5	0.12	0.95
		Flexible organizational structure for rigid culture mitigation	0.45	0.42	1.75–5	1.6	0.35
		Open culture for information acquisition and innovation creation	0.12	0.85	4.75–5	0.12	0.95
		Support a flexible work environment	0.19	0.85	4–5	0.50	0.80
						1	
				0.42	3–5		0.50
			0.24				
		Convergence culture through balanced personnel management				0.50	
				0.71	4–5		0.80
Innovation network formation	Innovation network formation		0.16				
		Performance-oriented culture for improving public service quality				0.37	
				0.85	4.1–4.85		0.84
		Sum	0.10				
		Political support/tact for securing resources	0.28	0.57	3.75–5	0.62	0.69
Innovation network formation	Innovation network formation	Internal and external cooperative network management	0.10	1	4–5	0.50	0.80
		Sum	0.15	0.57	3.87–5	0.56	0.75

Bold: Significant.

diverse management techniques in order to more sensitively meet the diversified needs and demands. This indicates that a one-size-fits-all model or value can no longer meet all needs in the

public sector (Park and Joaquin, 2012). Accordingly, this study will also discuss PIC in terms of the institutional backgrounds of NPM and post-NPM.

TABLE 3 | Characteristics of the survey participants.

Variables	Classify	Frequency (%)	Variables	Classification	Frequency (%)
Gender	Male	333 (69.81)	Education	Less than college	34 (7.13)
	Female	140 (29.35)		Bachelor	324 (67.92)
	No response	4 (0.84)		Master	98 (20.55)
Age	20s	30 (6.29)		Doctor	17 (3.56)
	30s	124 (26.00)		No response	4 (0.83)
	40s	236 (49.48)		Grade 9(Assistant)	6 (1.26)
	50s	95 (19.92)		Grade 8(Senior Assistant)	17 (3.56)
	No response	2 (0.42)		Grade 7(Manager)	74 (15.51)
Job tenure	Under 3 years	49 (10.27)	Rank	Grade 6(Senior Manager)	251 (52.62)
	3–5 years	30 (6.29)		Grade 5(Deputy Director)	97 (20.34)
	5–10 years	68 (14.26)		Grade 4(Senior Deputy Director)	22 (4.61)
	10–15 years	104 (21.80)		Over Grade 3(Senior Civil Service)	4 (0.84)
	Over 15 years	224 (46.96)		No response	6 (1.26)
	No response	2 (0.42)			

N: 477

Public Innovation Capacity

Previous studies discussed the concept of innovation capacity as human skills demonstrating technical proficiency (Lall, 1992); resources to discover a new environment (Szeto, 2000); future-oriented developmental competency; the ability to create new resources; human, material, and environmental capabilities to achieve outcomes; and the capacity to create new resources by integrating organizational resources (Pierre and Fernandez, 2018). To summarize such definitions, innovation capacity includes the expertise of members and organizational resources that can create new resources in a future-oriented view.

However, while the literature on innovation capacity in the private sector has a long history, consideration of public innovation only began in the 1980s (Walker, 2007). To make public innovation work, governments require a PIC (Meijer, 2019, p. 618). Also, to promote the quality of life and satisfaction of citizens, a public sector that demonstrates innovation (Wynen et al., 2019) must reinterpret new resource creation in terms of creating public interest and spreading social values. The concepts of PIC are based on theories of public innovation (the significance of individuals, organizations, and networks in public innovation) and innovative systems (the role of government systems in public innovation) (Meijer, 2019, p. 617).

This study classifies PIC into three levels—individual, middle manager, and organizational—in terms of the internal resources or capital in an organization. Moreover, this study presumed

that the three levels of PIC may interact with one another and increase the performance of public service. Individual PIC that can be converted into human capital is defined as the capacity of organizational members to secure task expertise and perform their tasks creatively (Snell and Dean, 1992). Middle managers' PIC can be understood as the social capital of the organization, defined as the capacity of middle managers to motivate their junior staff by interacting with them and inducing cooperation within the organization (Youndt and Snell, 2004). Finally, PIC at the organizational level is defined as the organizational structure or culture that uses human and material resources in the right place at the right time, strategically manages human resources, and actively deals with changes in the external environment in terms of organizational capital (Pierre and Fernandez, 2018). In sum, this study defines PIC as the “task expertise of organizational members in providing high-quality services for citizens and the role of middle managers in displaying, maintaining, and managing this expertise and organizational resources.”

In this study, the reason for classifying PIC into three dimensions, such as individuals, middle managers, and organizations, that is, we assumed the sub-attributes of innovation capacity will be different depending on the entity expresses it. The research was conducted that assuming the PIC at the individual, middle manager, and organizational level as the organization capital. Specifically, PIC at the individual level that can be replaced by human capital is defined as organizational

members securing work expertise and performing work creatively (Snell and Dean, 1992). Middle manager's PIC can be understood as the social capital of an organization, which is defined as the ability of middle managers to motivate and induce collaboration within the organization through interactions with subordinates (Youndt and Snell, 2004). Organizational PIC is interpreted in terms of organizational capital. In other words, it is defined as an organizational structure and culture that utilizes human and material resources in the right place, strategically manages human resources, and actively responds to external environmental changes. In doing so, we attempt the following research question:

Research Question: Is public innovation capacity composed of sub-dimensional capacity constructs, i.e., individual, middle manager, and organizational levels? Are these latent variables statistically and empirically distinct?

STUDY 1: TYPOLOGIZING PUBLIC INNOVATION CAPACITY

Research Method Participants

This study applied the Delphi method¹ for the purpose of gathering the viewpoints of experts² in the field of PIC. The principles of this method are based on the notion of collective wisdom in decision making, assuming that the combined opinions of several people come closer to the truth than the opinion of one individual (Fuermaier et al., 2019, p. 341). For the Delphi panel, this study selected a total of 14 participants, consisting of 4 public officials who are in charge of human resource departments in public organizations, 2 public officials working in capacity building training at human resource development institutes, and 8 academics who specialize in organizational and personnel management (see Table 1).

Delphi Process

According to Kim (2015), the Delphi method is carried out in four rounds, but recently, the “mini-round Delphi,” which has only two rounds, has frequently been used to compensate for the Delphi method's weakness of requiring too much money and time. Therefore, in this study, I employed a two-round modified Delphi method to gather the views of the expert panel in terms of PIC.

The first-round Delphi (April 4–16, 2018)³ was the round in which PIC was assessed based on the experience and knowledge

of the experts. The questionnaires were developed based on the literature review on innovation capacity in Korean private or public organizations in Round 1. To confirm the appropriacy of the PIC sub-items, I designed semi-open questions with options like agree, eliminate, and modify (if modifying, I asked for a comment) to give the experts the freedom to present their views and contribute new concepts. Individual characteristics were collected in Round 1.

The second-round Delphi (April 23–30, 2018) pursued the goal of verifying the consensus on the opinions elicited in Round 1. I asked the experts to state their agreement with the issues proposed in Round 2 using a five-point Likert scale (ranging from strongly disagree to strongly agree).⁴ All roundxs were sent to each expert via e-mail to combine the PIC sub-items.

Research Results Results of Delphi Round 1

If the revised opinions were deemed appropriate after the researcher examined the opinions of the expert panel, these opinions were actively reflected in revising the sub-factors of individual PIC. To begin with, individual attribute capacity was renamed “individual characteristic capacity.” Items with redundant meanings such as ethics and accountability as public officials in the sub-indexes of individual characteristics were revised into the single item of responsibility (administrative, legal, professional, and political). Moreover, indexes that connoted the attributes of different capacities such as customer/beneficiary-oriented and business minded were eliminated from individual attribute capacity. Thus, the sub-indexes of individual attribute capacity were ultimately reduced from 12 to 9. Job performance capacity consisted of a total of 12 sub-indexes after adding displays of self-leadership, policy, and business briefing skills. It was pointed out that the organizational management capacity group was inappropriate as a sub-group of individual innovation capacity, and thus it was eliminated and the sub-indexes such as mediation and integration skills or exertion of influence over stakeholders were absorbed by interpersonal capacity. Finally, interpersonal capacity was renamed as “relationship building capacity,” and the sub-indexes absorbed from the organizational management capacity group were added, ultimately forming seven items in total.

The individual attribute capacity of middle managers was renamed “individual characteristic capacity.” Items with

extracted a variable with a high frequency (appearing over three times), using abstracts (all words used in a sentence [average of 10 sentences]) via network analysis. Individual, middle manager, and organizational PIC were classified based on the classification standard of the capacity groups examined in the theoretical background section: individual PIC was classified into individual attribute capacity, job performance capacity, organizational management capacity, and interpersonal capacity; middle manager PIC into individual attribute capacity, job performance capacity, organizational management capacity, and interpersonal capacity; and organizational PIC into organizational goal capacity, job performance capacity, and organizational management capacity.

⁴Based on the questionnaire collected in the second-round Delphi survey, the basic statistics (mean, standard deviation, and median) were analyzed using SPSS 21.0. We also conducted a content validity analysis to ensure the validity of the survey items; performed a stability analysis to determine whether to repeat the Delphi survey; and calculated the quartile, convergence, and consensus to analyze the degree of consensus among the experts.

¹The validity of Delphi studies is dependent on the competence and knowledge of panel members; therefore, a heterogeneous group of experts who possess a wide understanding of the desired subject matter should be selected (Lamm et al., 2021, p. 3). Primarily, with the use of the Delphi technique, the issues generated are limited to the insights of the expert panel members (Lamm et al., 2021, p. 10). Although measures were taken to reduce bias and assemble a heterogeneous panel, the results may not be generalizable to all contexts (Lamm et al., 2021, p. 10).

²Expert selection: identified relevant public official and academic experts, related to work and research on PIC.

³The items in the first-round Delphi survey consisted of 34 items for individual PIC, 32 items for middle manager PIC, and 29 items for organization PIC deduced based on word appearance frequency on content analysis. The items

TABLE 4 | Results of the reliability and validity tests.

Classification	PIC			Cronbach's alpha		AVE		CR
Individual	Value innovation capacity			0.843		0.694		0.910
	Job innovation capacity			0.924		0.540		0.837
	Relations innovation capacity			0.895		0.674		0.899
Middle manager	Job innovation capacity			0.945		0.566		0.857
	Organizational management innovation capacity			0.944		0.612		0.876
Organization	Organizational goal innovation capacity			0.937		0.690		0.910
	Human resource innovation capacity			0.910		0.620		0.885
	Organizational support innovation capacity			0.940		0.445		0.793
Results of the CFA								
Suggested cut-off value	df	x ²	x ² /df	NFI	TLI	CFI	IFI	RMSEA
	—	—	<3	>0.90	>0.90	>0.90	>0.90	<0.08
Individual	98	289.16	3.97	0.936	0.940	0.951	0.951	0.077
Middle manager	226	847.49	3.75	0.927	0.939	0.946	0.946	0.074
Organization	165	666.57	4.04	0.925	0.934	0.942	0.943	0.078

redundant meanings such as ethics and accountability as public officials in the sub-indexes of middle manager characteristics were revised into the single item of responsibility (administrative, legal, professional, and political). Moreover, items such as persuasive power and initiative were eliminated, and new sub-indexes such as emotional intelligence or positive psychological capital (resilience, hope, self-efficacy, and optimism) were created. Thus, the sub-indexes of middle manager attribute capacity were ultimately increased from 9 to 10. Items that were included in organizational management capacity such as coaching/feedback and motivation were added to job performance capacity, as well as new sub-indexes such as policy development and ability to predict the future. Thus, the sub-indexes ultimately increased from 7 to 10. As for organizational management capacity, sub-indexes that moved to job performance capacity such as coaching/feedback and motivation and new items such as agile responses to change and strategic human resource management (talent hunt, development, and use) were added, and thus the sub-indexes decreased from 12 to 9. Finally, interpersonal capacity was renamed “relationship building capacity,” and items such as interpersonal relations and teamwork were eliminated, while items such as participation in official and unofficial mentoring, attentive listening of members’ opinions, and followership were added. Thus, the sub-indexes ultimately increased from four to five.

For the sub-indexes of organizational goal capacity, sharing and achievement of vision was revised to collection and sharing of vision and design of the direction for organizational goals was revised to development of effective policies to achieve organizational goals. There was a total of five sub-indexes, which was the same as before. Job performance capacity was renamed “individual characteristics and job performance capacity of members,” and items such as ownership, display of self-leadership, and will to fulfill social values were added. Items with similar meanings such as job skills and expertise were

revised to job expertise based on the KSA (Knowledge, Skill, and Ability), ultimately increasing the sub-indexes from seven to eight. For organizational management capacity, work efficiency, organizational innovativeness, and cooperation of subordinate organizations were eliminated. In light of the opinion that budget management ability and sufficiency of resources have similar meanings and thus must be integrated into a single index, they were revised into resource (budget, personnel, etc.) securement and efficient use. Moreover, new items such as an open culture and strategic human resource management (talent hunt, development, and use) were added, and thus the sub-indexes were ultimately reduced from 17 to 15.

Results of Delphi Round 2

Table 2 shows the results of the statistical analysis on individual, middle manager, and organizational PIC. The coefficient of variation of stability was lower than 0.80, indicating that there was a high degree of consensus. The content validity when the scope was set to 4 (slightly valid) and 5 (highly valid) was a minimum of 0.31 for the 14 respondents, indicating that they were all valid. Convergence was lower than 0.50 and close to 0, showing almost no deviation in the collection of opinions, and consensus was higher than 0.70 and close to 1, indicating that all opinions arrived at consensus (Park, 2015). Items that did not satisfy the statistical thresholds were eliminated, and the names of variables were changed or new items were added based on the experts’ opinions (see red-colored items).

STUDY 2: VALIDATING PUBLIC INNOVATION CAPACITY

Research Method

Participants

Based on the Delphi results, the study developed a survey questionnaire on PIC (see **Supplementary Appendix**). The

questionnaire was constructed in sentence form to better clarify the three dimensions of PIC. A total of 1,290 questionnaires were distributed to 43 central government agencies; 477 were collected from 30 agencies and used for the study. The distributions of the socio-demographic characteristics of the sample are provided in **Table 3**. Male comprised 69.81% of the sample and female comprised 29.35%. More people were in their 30s (26.00%) than in any other age group. In terms of education, “bachelor” was the most common with 67.92%, followed by “master” (20.55%). In terms of the respondents’ rank, “grade 6” was the most frequent (52.62%), followed by “grade 5” (20.34%) and “grade 7” (15.51%). In terms of job tenure, “over 15 years” was the most common, with 46.96%.

Exploratory Factor Analysis and Confirmatory Factor Analysis

We employed an exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to operationalize the PIC variables using public employees’ survey data that was collected from July to October 2018. First, the study conducted an EFA using SPSS 21.0 and confirmed the reliability of the research variables (i.e., internal consistency) through the eigenvalues, factor loadings, % of variation, and Cronbach’s alpha. Then, in order to confirm the validity (i.e., external consistency), the study conducted a CFA using AMOS 21.0 and checked the goodness of fit based on the suggested cut-off value. In addition, the study confirmed the convergent validity results using average variance extracted (AVE; over 0.05) and critical reliability (CR; over 0.70).

Results of the Reliability and Validity Tests

The Cronbach’s alpha of all research variables was higher than 0.70, the AVE was higher than 0.50, and the construct reliability was higher than 0.70, thereby ensuring the reliability and convergent validity of the research variables. The AVE of organizational support capacity was 0.445, which was quite a lot lower than the threshold, but it was still used as a research variable because the Cronbach’s alpha and construct validity were satisfactory (see **Table 4**).

To determine the factor structure of PIC at the individual, middle manager, and organizational levels and verify the construct validity, the study conducted a higher-order CFA using AMOS 21.0. This was to verify the theoretical validity and legitimacy of PIC deducted through the EFA. To verify the results of the CFA, the study verified the validity of the research variables based on goodness of fit such as absolute, relative, and simplicity (Lee et al., 2019). χ^2 , NFI, TLI, CFI, IFI, and RMSEA were identified to verify the goodness of fit of the research variables in PIC. The results of the CFA satisfied the acceptable fit index presented, thereby ensuring the convergent validity of the sub-variables of PIC at the individual, middle manager, and organizational levels (see **Table 4**).

Discussion

Value innovation capacity in individual PIC is comprised of the fundamental values of public officials such as the value of public office, self-management skills, responsibility, etc.; job innovation

capacity is comprised of the behavioral capabilities to perform innovation duties such as insight, taking on challenges, being goal oriented, having an enterprising spirit, tenacity, strategic thinking, creative problem-solving skills, analytical decision making, etc.; and relations innovation capacity is comprised of the capabilities to manage a personal network within an organization such as performing collaborative duties, empathic ability, conflict management, communication skills, etc.

Job innovation capacity in middle manager PIC is comprised of the behavioral capabilities of middle managers that can innovatively perform their duties based on ethical knowledge and expertise in responsibility, ethics, and meeting the public interest; being goal oriented; showing public entrepreneurship; having analytical skills, job expertise, policy development skills, creative problem-solving skills, etc. Organizational management innovation capacity is comprised of the capabilities to strategically manage the organization considering the diverse needs of members, such as the ability to predict the future and provide a vision; practicing organizational learning management and strategic human resource management; distributing authority, managing conflicts, etc.

Organizational goal innovation capacity is comprised of organizational PIC that contributes to organizational innovation based on the establishment of strategic management models, such as establishing a vision and strategies for government departments, developing and using core competencies, supporting efficient policy implementation, developing policies, etc. Human resource innovation capacity is comprised of the behavioral capabilities of organizational members who innovatively perform their duties based on ethical knowledge and expertise, such as the creation of public interest, ownership, displays of self-leadership, a public service mindset, performance-oriented followership, public service quality management skills, etc. Finally, organizational management innovation capacity is comprised of innovative organizational cultural capacities that support organizational members in bringing about innovation, such as data-based decision making, strategic human resource management, flexible work environment support, active communication, Holacracy, openness, a convergence culture, systematic network management, etc.

CONCLUSION

Previous studies have diversely topologized innovation capacity such as internal/external resources (Romijn and Albaladejo, 2002), structural/functional capacity, internal management/external innovation capacity, and internal innovation/external innovation capacity. This study limited the research scope to public organizations and topologized PIC by classifying it into three levels: individual, middle manager, and organizational. According to Jing and Osborne (2017), innovation in the public sector enables service providers to provide higher-quality services by disclosing public information to the beneficiaries (nations or citizens) and providing more public services. Furthermore, the authors emphasized the role

of public officials as “innovators,” claiming that innovators in the public sector are the members of public organizations. In this view, the study decided that elucidating the PIC of individuals, middle managers, and organizations, who are the innovators in the public sector, is the most fundamental stage in discussing government innovation; thus, the study topologized PIC. Sørensen and Torfing (2011) stated that innovation is divided into three phases: first change (producing or delivering good products, services, or solutions), second change (changing the repertoire such as services and organizational customs), and third change (transforming the purpose of policies and theories of programs). PIC in this study could connote all three phases of innovation change. For example, the strategic thinking, creative problem-solving skills, analytical decision making, goal-oriented nature, and public entrepreneurship of individuals and middle managers indicate the first change. Data-based decision making, strategic human resource management, flexible work environment support, active communication, Holacracy, and open and convergence cultures indicate the second change. Establishing a vision and strategies for government departments, developing and using core competencies, supporting efficient policy implementation, and establishing strategic management models such as policies indicate the third change.

Moreover, the sub-factors of individual, middle manager, and organizational PIC connoted the factors of NPM and post-NPM innovation values (Park and Joaquin, 2012). More specifically, public values, ethics, the creation of public interest, empathic ability, communication skills, distribution of authority, conflict management, flexible work environment support, active communication, Holacracy, and open and convergence cultures reflect post-NPM values. Taking on challenges, being goal oriented, having an enterprising spirit, tenacity, strategic thinking, creative problem-solving skills, public entrepreneurship, analytical decision making, performance-oriented followership, and public service quality management skills reflect NPM values.

Theoretical and Practical Implications

First, this study developed and verified indexes for individual, middle manager, and organizational PIC, and attempted to establish concepts regarding PIC in the public sector. Through typologizing PIC, this study was able to explain the PIC of individuals, middle managers, and organizations in terms of organizational and human resources theories, such as self-efficacy, creativity, intrinsic motivation, job crafting, trait theory, behavioral theory, contingency theory, the behavioral life-cycle model, resource-based theory, etc. The theoretical background at the individual, middle manager, and organizational levels in the sub-factors of PIC was ultimately deduced from the results of the statistical analyses. For example, there were “I have self-management skills”(self-efficacy), “I have creative problem-solving skills” (creativity), “I am always up for challenges” (intrinsic motivation), and “I have the ability to manage change” (job crafting) at the individual level; “my middle manager is goal-oriented” (trait theory), “my middle manager manages and mediates conflicts” (behavioral theory), “my middle manager has strategies to fulfill the vision”

(contingency theory), and “my middle manager manages the diverse needs of the members” (behavioral life-cycle model) at the middle manager level; and “our department develops policies to achieve organizational goals” (resource-based theory), “the members of our department have a public service mindset toward the citizens” (resource-based theory), and “our department makes decisions based on data” (resource-based theory) at the organizational level. These results have significance in that they interpreted the organizational and human resources theories in terms of various aspects of the new concept of PIC, thereby expanding the application scope of the theories.

Second, the PIC developed in this study can be used as a diagnostic tool to verify the level of PIC in Korean public organizations. Previous studies presented measurements of the levels in the personnel management system; organizational system; structure or culture, such as recruitment, selection, and evaluation; and diversity management as indexes to measure the level of government or personnel reform (Hong et al., 2008). This study developed indexes of PIC at the individual, middle manager, and organizational levels that can lead and diffuse innovation in the Korean public sector, assuming that the main actors of government innovation are government employees. Moreover, the indexes of PIC presented in this study were developed based on a theoretical review of innovation studies conducted in the public and private sectors, thereby including the universality of the public sector (fulfillment of the public interest, expansion of public values, etc.) and specificity of the private sector (creativity, entrepreneurship, etc.), which can be applied to various organizations. Thus, indexes of PIC can also be indexes used to measure the PIC of public enterprises, lower-level local governments, and even social enterprises and central government agencies.

Finally, in order to enhance innovation capabilities at the individual, middle manager and organizational level, it is necessary to more actively implement the strategic human resource management policy. The linkage among human resource management functions must be secured so that the strategic human resource management functions within the organization can be effectively implemented. In other words, based on the systematic definition of competency required for individual jobs and series, the system of securing human resources – training and development – performance management – compensation should be integrated and operated.

Research Limitations and Future Research Directions

This study limited its subject to the Korean public sector in typologizing and verifying the PIC. Furthermore, it failed to convey all of the opinions in the public sector, such as those of public enterprises and lower-level local governments, while conducting the survey. In other words, there may be insufficient grounds to generalize the results of this study in the Korean public sector. To elaborate and secure the validity of the PIC indexes in this study, future research must distribute the questionnaire to all public organizations and restructure

the sub-indexes. Moreover, as discussed in the theoretical background section, there are various types of public service and methods of providing them, and thus discussing PIC only within public organizations may have had a negative impact on expanding the scope of research. Therefore, future research must diversify the PIC indexes according to the various types of public service (everyday service, protective service, developmental service, minimum social security service, etc.), and develop indexes based on the actors that provide public services (public sector, private sector, NGOs, social enterprises, etc.). It is necessary to develop indexes of PIC that coincide with the characteristics of agencies by expanding the scope of research to public enterprises, lower-level local governments, executive agencies, public research institutes, social enterprises, and NGOs that require innovation.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2022.898399/full#supplementary-material>

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Materialism Predicts College Students' Entrepreneurial Intention: A Serial Mediation Model

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Entrepreneurship is perceived as a critical pillar for unemployment alleviation and economic growth, especially in the era of COVID-19, which highlights the importance of the entrepreneurial potential of college students. The current research focused on the role of personal values in the entrepreneurial process and investigated the relationship between materialism and entrepreneurial intention among college students. Few studies have been examined this relationship, and the underlying mechanisms were also not identified. From the perspective of personal value, we hypothesized that materialism could positively predict entrepreneurial intention. Moreover, based on McClelland's theory of need for achievement and the theory of planned behavior, a serial mediation model, with achievement motivation and entrepreneurial attitude as the mediators, was proposed. We conducted a correlational study on a sample of 1,002 Chinese university students to examine our hypotheses. They participated in an online survey and completed the measurement of entrepreneurial intention, entrepreneurial attitude, materialism, and achievement motivation. The hypothesized models were examined through serial mediation bootstrapping procedures. The results showed that materialism positively predicted college students' entrepreneurial intention, and this relationship was serially mediated through achievement motivation and entrepreneurial attitude. Materialism boosted college students' achievement motivation, which in turn was associated with a more positive entrepreneurial attitude and subsequently stronger entrepreneurial intention. The present research is the first to empirically examine this association's mechanism and establish a serial mediation involving achievement motivation and entrepreneurial attitude. For the theoretical contribution, the present research provides a more comprehensive picture of the role of personal values in entrepreneurship by complementing the effect of materialism. And regarding the practical implications, the present research implies the silver lining of materialism and points out a possible way to enhance college students' entrepreneurial intention, i.e., entrepreneurial education could take advantage of the characteristics of materialism and transform the "harmful" value into socially beneficial entrepreneurial intentions through enhancing their achievement motivation and positive attitude toward entrepreneurship.

Keywords: materialism, entrepreneurial intention, achievement motivation, entrepreneurial attitude, theory of planned behavior

INTRODUCTION

A slew of studies and reports documented that the outbreak of COVID-19 led to skyrocketing unemployment worldwide (e.g., Kawohl and Nordt, 2020; Tamesberger and Bacher, 2020). Among them, young graduates who have just finished their studies and looked for their first job are one of the most vulnerable groups in the labor market (Lambovska et al., 2021). Research has shown that many American college students lost a job or offer due to COVID (Aucejo et al., 2020), and Chinese college students faced a similar difficult situation (Mok et al., 2021). Entrepreneurship is a vital force in the economy (Okpala, 2012), which can reduce unemployment and help economic growth (Carree and Thurik, 2010). In particular, entrepreneurship is often perceived as an effective solution to graduate unemployment (Awogbenle and Iwuamadi, 2010; Chigunta, 2017), highlighting the importance of improving college students' entrepreneurial intention (Bird, 1988; Kautonen et al., 2015).

Studies abound concerning the influencing factor of entrepreneurial intention. Recently, an increasing number of researchers advocated improving understanding of the role of personal values in entrepreneurial intention (Fayolle et al., 2014), and it has become a fast-growing area of entrepreneurship research (Hueso et al., 2021). Most studies were based on a theoretical perspective that explores how Schwartz's four dimensions of values influence entrepreneurial intentions. For example, studies have remarked that self-enhancement value (Liñán et al., 2016; Gorgievski et al., 2018; Karimi and Makreel, 2020) could positively predict entrepreneurial intention.

However, few studies have focused on the role of specific values that are prevalent in real life. Materialism, a personal value stressing the ownership of material wealth and economic success (Richins, 2004; Kasser, 2016), is prevalent worldwide (Siahtiri and Lee, 2019). More importantly, research has shown that the materialism of students increased over their college years (Jiang et al., 2021). Nevertheless, the effect of materialism on entrepreneurial intention and the psychological mechanism underlying the effect remains unclear. Figuring out the role of materialism in entrepreneurial intentions helps design programs to enhance the entrepreneurial intentions of college students based on their existing values. Therefore, the current research aims to address these issues by examining the relationship between materialism and entrepreneurial intention and further exploring the mechanism under this relationship.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

The Relationship Between Materialism and Entrepreneurial Intention

From the perspective of personal value, Schwartz's value theory (Schwartz, 1992) outlined a circular structure of personal values with two dimensions and four integrated values: on the one hand, self-enhancement vs. self-transcendence, and on the other

hand, openness to change vs. conservation. Individuals with self-enhancement values strive to acquire prestige and social status, desire control over others and resources, as well as value showing competence and personal success according to societal standards. This conflicts with self-transcendence values that stress benevolence and universalism.

Schwartz's value theory further presumed that adjacently located values usually lead individuals to similar behaviors or decisions. Materialism is located near self-enhancement values but opposite to self-transcendent values (Burroughs and Rindfleisch, 2002; Kilbourne et al., 2005; Karabati and Cemalcilar, 2010; Dittmar and Isham, 2022). Previous studies have shown that entrepreneurial intention is correlated positively with self-enhancement values (Liñán et al., 2016; Gorgievski et al., 2018; Karimi and Makreel, 2020; Ammeer et al., 2021) but negatively with the work values that are similar to self-transcendent values (Lechner et al., 2018). In this sense, materialism may also be able to predict entrepreneurial intentions positively.

Moreover, according to Richins and Dawson (1992), "materialists place possessions and their acquisition at the center of their lives", view these [possessions] as essential to their satisfaction and well-being in their life," and "tend to judge their own and others' success by the number and quality of possessions accumulated" (Richins and Dawson, 1992, p.304). Obtaining more money is one of the primary goals of materialists, as it allows them to own more abundant and luxurious possessions (Kasser, 2016). They may prefer to work longer hours and earn more money rather than spending that time leisurely (Richins and Dawson, 1992) in order to raise their living standard (Sidhu and Foo, 2015). Meanwhile, entrepreneurship is typically perceived as a career path that realizes personal needs regarding income, status, and prestige (Hirschi and Fischer, 2013), implying a positive association between materialism and the college students' entrepreneurial intention. Actually, entrepreneurs from a wide range of countries tend to possess materialistic values (McGrath et al., 1992).

To our knowledge, only one study directly examined the relationship between materialism and college students' entrepreneurial intention, which found a positive but insignificant correlation (Fatoki, 2015). However, the sample size of this study was relatively small ($N = 146$), and only business school students were included, which may render the results inconclusive and require further investigation. Despite the lack of direct and conclusive evidence, several studies regarding materialism and entrepreneurship-related variables provide indirect evidence. It has been found that materialism was positively correlated with college students' interest in entrepreneurship (Frunzaru and Leovaridis, 2016) and female microentrepreneurs' entrepreneurial self-efficacy (Salim et al., 2020), which have a substantial effect on entrepreneurial intention (Zhao et al., 2005; Nowiński et al., 2019). Likewise, materialists were found to work hard to complete challenging tasks (Vohs et al., 2006), and starting a business can be viewed as a challenging task.

In short, based on Schwartz's value theory, the definition of materialism, and relevant studies mentioned above, we offer our first hypothesis,

H1: Materialism could positively predict college students' entrepreneurial intention.

Achievement Motivation and Entrepreneurial Attitude as the Underlying Mechanisms

The mechanisms underlying the relationship between materialism and entrepreneurial intention also remained unclear. One possible mediator is achievement motivation. Achievement motivation is a subjective and internal drive to push individuals to pursue success and prompt them to reach the goals they perceive to be valuable (Stewart and Roth, 2007). Based on McClelland (1961) theory of need for achievement (nAch), achievement motivation is significantly related to entrepreneurial intention (e.g., Collins et al., 2004; Bhatti et al., 2021; Biswas and Verma, 2021), even singled out as the most prevalent predictor of entrepreneurship (Babb and Babb, 1992). Achievement motivation is not only positively linked to entrepreneurial behavior but also materialism (e.g., Zhang et al., 2020), especially when the goal one aims to achieve is economic goals (Sirgy et al., 2013). Materialism might activate high motivation and effort to achieve wealth (Larsen et al., 1999). The above analysis suggested that achievement motivation might be a mediator between materialism and entrepreneurial intention. That is, materialists may show a stronger need for achievement and thus be more inclined to start-up their own business.

Furthermore, according to the theory of planned behavior (TPB; Ajzen, 1991) that states intentions are affected and predicted by certain specific attitudes, the role of achievement motivation may need to be realized by enhancing entrepreneurial attitude. Entrepreneurial attitude refers to the degree to which the individual holds a positive personal valuation about being an entrepreneur (Liñán and Chen, 2009). Research-based on TPB has shown that entrepreneurial attitude could mediate the relationship between achievement motivation and entrepreneurial intention (Karimi et al., 2017; Maharani et al., 2020; Bağış et al., 2022), which implies that entrepreneurial attitude might be another mediator that exists between achievement motivation and entrepreneurial intention.

Together with the evidence above, achievement motivation and entrepreneurial attitude seem to link materialism to entrepreneurial intention. Furthermore, borrowing from entrepreneurship research and TPB, literature has shown that entrepreneurial motivation and entrepreneurial attitude could serially mediate the effect of entrepreneurial education on entrepreneurial intention, i.e., entrepreneurial education heightened the entrepreneurial motivation, which next improved the entrepreneurial attitude and thus promoted college students' entrepreneurial intention (Mahendra et al., 2017). In other words, achievement motivation and entrepreneurial attitude do not occur simultaneously but sequentially. To explain such association from the personal value side, albeit without direct evidence, a study regarding online time players showed that materialism significantly led to the pursuit of achievement, and such motivation fully mediated the effect of materialism on attitude toward online games

(Chang and Zhang, 2008). Therefore, we have reason to believe that achievement motivation and entrepreneurial attitude could sequentially explain the association between materialism and entrepreneurial intention.

In sum, based on the theories and studies discussed above, it appears that materialism may predict entrepreneurial intention through a sequential path of achievement motivation and entrepreneurial attitude: college students with a higher level of materialism may be more motivated to achieve success and further be more favorable toward entrepreneurship, thus more willing to become an entrepreneur. Hence, we hypothesized that,

H2: Achievement motivation and entrepreneurial attitude serially mediate the relation between materialism and entrepreneurial intention of college students.

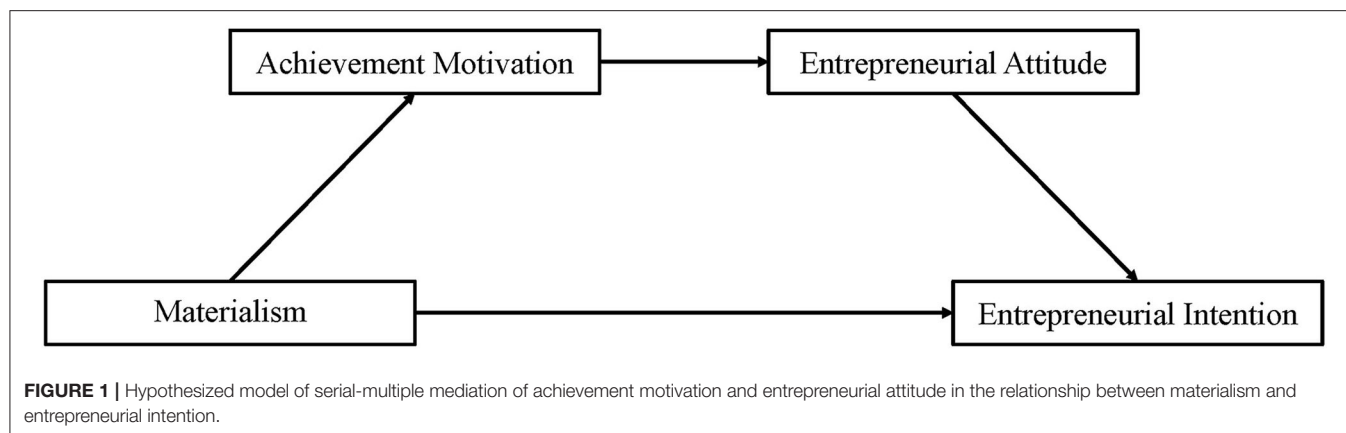
The Present Study

To sum up, the present study has two goals. First, we aimed to examine the relationship between materialism and entrepreneurial intention. Based on Schwartz's value theory, we hypothesized that materialism would positively predict entrepreneurial intention. Second, we aimed to explore the possible mechanism underlying the relationship between materialism and entrepreneurial intention. Based on McClelland's theory of nAch and TPB, we proposed a serial mediation model where achievement motivation and entrepreneurial attitude play as mediators sequentially in the association between materialism and entrepreneurial intention (see **Figure 1**). The conceptual model hypothesized that a higher level of materialism would be associated with stronger achievement motivation, which would then be associated with a more positive entrepreneurial attitude; the more positive entrepreneurial attitude would, in turn, be associated with a greater entrepreneurial intention. The hypothesized model was examined through an online survey with a large sample.

MATERIALS AND METHODS

Participants and Procedure

Considering the impact of COVID-19, we collected data through an online survey questionnaire platform (<https://www.wjx.cn>). We designed and built the questionnaire on this platform. Only after all items had been completed could the participant submit the questionnaire. And owing to the IP restriction, one participant was only permitted to submit a reply once. The instruction for this survey was as below, "Thank you very much for taking the time to participate in this survey. Please fill out the following questionnaire according to your true feelings. The answer to a question is neither right nor wrong, nor good nor bad. Since the format of the questions in each section is not quite the same, please read the instructions in front of the questions carefully before you start answering them. According to the Statistics Act and the norms of scientific research, we will keep all the information collected confidential, including your personal information and your answers to the questions, and will not disclose them to outsiders."



The sampling method employed for this study was cluster sampling and convenience sampling. Specifically, in order to enhance the sample diversity, the survey link is distributed through two channels. The first channel is sending the survey link to college counselors of various departments in one university. These counselors shared the link in class WeChat groups, and students were invited to complete the questionnaire online and voluntarily. The second channel is posting the survey link on the online survey platform where we designed our questionnaire. College student users of this platform voluntarily complete the questionnaire with a return of the website points as rewards. Data from 787 to 359 college students was collected separately through the two channels, i.e., a total of 1,146 Chinese college students voluntarily participated in this online survey. One hundred forty-four participants failed the attention check. Data from the remaining 1,002 participants ($M_{age} = 21.58$, $SD_{age} = 3.16$; 52.29% females) were analyzed. Details of sample demographics were as shown in Table 1.

Measures

As in previous studies (e.g., Zhao et al., 2021), a short version of the scale was chosen to measure the research variables in order to reduce participants' dropout rates and increase their involvement with the survey. All items for measures were administrated in Chinese. The scales developed initially in English have been translated into Chinese, and the reliability and applicability of the translated version have been verified in previous studies (Tang and Tang, 2007; Hu et al., 2014; Wang et al., 2017). The scales are arranged in the following order: the measure of entrepreneurial intention, the measure of entrepreneurial attitude, the measure of achievement motivation, and the measure of materialism. Moreover, similar to the previous studies (e.g., Bergenholtz et al., 2021; Tufa, 2021), we adopted the original number of scale points for each measure, i.e., entrepreneurial intention and entrepreneurial attitude were measured on a 7-point Likert scale, and materialism and achievement motivation were measured on a 5-point Likert scale. Using different numbers of scale points in one survey is helpful to reduce common method bias (Jordan and Troth, 2020).

TABLE 1 | Demographic information of the current sample ($N = 1,007$).

Demographic variables	Frequency	Percentage (%)
Gender		
Male	478	47.71
Female	524	52.29
Grade		
Freshman	188	18.76
Sophomore	183	18.26
Junior	179	17.86
Senior	187	18.66
Postgraduate	265	26.45
Discipline of Students' Majors		
Science and engineering	232	23.15
Economics and management	548	54.69
Literature and history	179	17.86
Arts	24	2.40
Others	19	1.90
Family income level ^a		
Lowest	63	6.29
Lower-middle	228	22.75
Middle	527	52.59
Upper-middle	175	17.47
Highest	9	0.90

^aFamily income level measured by a single question, i.e., "What is your family's current income level in the local area?".

Entrepreneurial Intention

Entrepreneurial intention was measured using the 5-item scale developed by Chen et al. (1998). All the items were rated on a 7-point Likert scale (1 = totally disagree, 7 = totally agree). Sample items include "I am going to try hard to set up my own business" and "I have been preparing to set up my own business." The scores of five items were accumulated and averaged. A higher score indicated a stronger entrepreneurial intention. Cronbach's alpha was 0.94 in our sample.

Materialism

A 3-item version of the Material Values Scale (Richins, 2004) was used, a 5-point Likert scale ranging from 1 = totally disagree to

5 = totally agree. The three items are “I admire people who own expensive homes, cars, and clothes,” “I like a lot of luxury in my life,” and “I’d be happier if I could afford to buy more things.” Higher average scores for the three items indicated higher levels of materialism held by the participants. Cronbach’s alpha for the scale was 0.70.

Achievement Motivation

We adapted four items from Tang and Tang (2007) measure of achievement motivation (e.g., “I desire to achieve a higher position for myself in society,” and “I hope to fulfill a personal vision”). Similarly, the participants responded to each item using a 5-point Likert scale (1 = totally disagree, 5 = totally agree). The total scores were also averaged, and higher scores indicate higher levels of achievement motivation. Cronbach’s alpha for the scale was 0.78 in this sample.

Entrepreneurial Attitude

The entrepreneurial attitude was measured on a 7-point Likert scale (1 = totally disagree, 7 = totally agree) with the 5-item questionnaire developed by Liñán and Chen (2009) (e.g., “Being an entrepreneur implies more advantages than disadvantages to me” and “A career as an entrepreneur is attractive for me”). The total scores were also averaged, and a higher average score indicated a more positive entrepreneurial attitude. Cronbach’s alpha for the scale was 0.93 in this sample.

Control Variables

Following the practice of previous studies, the participants’ gender (Nowiński et al., 2019) and family income (van der Zwan et al., 2016) are likely to exert potential influences on our dependent variable—entrepreneurial intention. Thus, they were treated as covariates when examining the hypotheses. A single item measured family income (What is your family’s current income level in the local area?) answered on a 5-point scale (1 = the lowest level, 5 = the highest level).

Statistical Strategies

Discriminant Validity

We conducted confirmatory factor analyses (CFAs) to test the discriminant validity of the measured variables and the common method variance, using Mplus version 8.0. Regarding the discriminant validity, we first built a four-factor model (i.e., entrepreneurial intention, entrepreneurial attitude, materialism, and achievement motivation) and explored its psychometric properties, including comparative fit index (CFI), Tucker-Lewis index (TLI), standardized root mean square residual (SRMR) and root mean square error of approximation (RMSEA) as previous studies (e.g., Ding and Yu, 2021; Su, 2021). Then, we built three competitive models by combining the correlated factors into one and compared them with our hypothesized model. We did not rely upon chi-square as it has been found to be too sensitive to sample sizes over 250 (Bentler and Bonett, 1980). Following the suggestions of previous studies, CFI values > 0.95, TLI values > 0.90, SRMR value < 0.08 (Hu and Bentler, 1999; Hu et al., 2014) and RMSEA values < 0.08 (MacCallum et al., 1996) indicated an acceptable model fit.

Common Method Variance

Since the current study deployed self-report questionnaires, it is essential to examine whether serious common method bias existed (Hariguna, 2021). Following the suggestion of Podsakoff et al. (2003), an unmeasured latent method factor method was applied to test the degree of common method bias. We constructed a latent method factor and loaded the method factor on all indices of entrepreneurial intention, materialism, achievement motivation, and entrepreneurial attitude. Suppose the five-factor measurement model regarding the common method factor and the four key research variables did not exhibit a significantly better fit to the data than the four-factor measurement model including four key variables. In that case, it turns out that the common method bias of the current study does not pose a severe threat to our results.

Hypothesis Examination

In terms of hypothesis examination, we first conducted linear regression analyses to test the main effect of materialism on entrepreneurial intention (i.e., **Hypothesis 1**). We included control variables to diminish the spurious effects.

Next, Hayes (2017) statistical techniques (PROCESS v3.3) were employed to examine serial mediation (i.e., **Hypothesis 2**). We fitted the theoretically-indicated serial mediation models (i.e., achievement motivation as the first mediator and entrepreneurial attitude as the second mediator) using PROCESS Model 6. Bootstrapping (5,000 resamples) was used to generate bias-corrected 95% confidence intervals (CIs) for the magnitude of all mediating effects. An effect was considered significant if the 95% CI did not include zero. Additionally, the above serial mediation model was tested with and without the control variables (i.e., college students’ gender and family income level).

RESULTS

Discriminant Validity and Common Method Variance Test

Before testing our hypotheses, we conducted a series of CFAs to evaluate the goodness of fit for the measurement model and the discriminant validity of the concepts. Following the cutoffs for the acceptable fit mentioned above (CFI > 0.95, TLI > 0.90, SRMR and RMSEA < 0.08), the results of CFA revealed acceptable psychometric properties of our 4-factor measurement model (see **Table 2**). The chi-square difference values with one degree of freedom (ranging from 375.01 to 1259.21) were all significant, indicating that the 4-factor model yielded the best fit.

Next, we used the unmeasured latent method factor method to test the degree of common method bias. The results demonstrated that the five-factor model regarding the common method factor and key variables ($\chi^2 = 901.11$, $df = 97$, CFI = 0.94, TLI = 0.91, RMSEA = 0.09, SRMR = 0.20) did not exhibit a better fit to the data than the four-factor measurement model including four key research variables. Therefore, the CMV of this study does not pose a serious threat to our results.

TABLE 2 | Results of confirmatory factor analyses (CFA).

Model	χ^2	df	CFI	TLI	RMSEA	SRMR
4-factor <i>inclusive materialism, achievement motivation, entrepreneurial attitude, entrepreneurial intention</i>	685.14	109	0.95	0.94	0.07	0.06
3-factor <i>inclusive materialism, entrepreneurial intention, achievement motivation + entrepreneurial attitude</i>	1558.31	112	0.89	0.86	0.11	0.09
2-factor <i>inclusive materialism, entrepreneurial intention + achievement motivation + entrepreneurial attitude</i>	1831.74	114	0.86	0.84	0.12	0.10
1-factor <i>inclusive materialism + entrepreneurial intention + achievement motivation + entrepreneurial attitude</i>	2322.50	115	0.83	0.79	0.14	0.11

CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of Approximation; SRMR, standardized root mean square residual.

TABLE 3 | Descriptive statistics and zero-order correlations of variables.

	M	SD	1	2	3	4	5	6
1. Gender ^a	0.48	0.50	–					
2. Family income	2.84	0.82	0.09**	–				
3. Materialism	3.26	0.84	–0.03	0.02	–			
4. Entrepreneurial intention	3.72	1.68	0.33***	0.31***	0.08*	–		
5. Achievement motivation	4.00	0.62	0.13***	0.13***	0.32***	0.36***	–	
6. Entrepreneurial attitude	4.46	1.50	0.30***	0.26***	0.15***	0.80***	0.45***	–

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. $N = 1,002$. Gender^a (0 = female, 1 = male).

Hypothesis Testing Preliminary Analyses

We conducted Pearson's correlation analyses to see how the study variables were associated. **Table 3** shows a significantly positive association between college students' materialism and entrepreneurial intention, providing initial evidence for Hypothesis 1. Moreover, in line with expectations, both achievement motivation and entrepreneurial attitude were positively correlated with materialism as well as entrepreneurial intention. At the same time, achievement motivation was also positively associated with an entrepreneurial attitude. These findings met the prerequisites for conducting hypothesis testing.

Testing the Main Effect

As shown in **Table 4** (Model 1), after controlling for gender and family income level, materialism still positively predicted entrepreneurial intention ($\beta = 0.08$, $t = 2.94$, $p = 0.003$, 95% CI = 0.06, 0.28), supporting Hypothesis 1. Next, we conducted a serial mediation model with gender and family income level as the control variables, materialism as the independent variable (IV), entrepreneurial intention as the dependent variable (DV), achievement motivation as the first mediator (M1), and entrepreneurial attitude as the second mediator (M2).

Testing the Serial Mediation Model

Results of the two-path serial mediation model are presented with standardized regression coefficients in **Table 4** (Model 2–Model 4). The direct path from materialism (IV) to achievement motivation (M1) was significant ($\beta = 0.32$, $t = 11.01$, $p < 0.001$, bootstrapped 95% CI = 0.27, 0.38), indicating that the college students with higher materialism had stronger motivation to gain achievement. Meanwhile, the path from achievement motivation (M1) to entrepreneurial attitude (M2) was also significant ($\beta = 0.39$, $t = 13.63$, $p < 0.001$, bootstrapped 95% CI = 0.33, 0.45), demonstrating that students with stronger achievement motivation has more positive attitude toward entrepreneurship. The path from entrepreneurial attitude (M2) to entrepreneurial intention (DV) was significant ($\beta = 0.75$, $t = 34.25$, $p < 0.001$, bootstrapped 95% CI = 0.71, 0.79), revealing that students who has a more positive attitude toward entrepreneurship are more willing to start up their own business. However, the path from achievement motivation (M1) to entrepreneurial intention (DV) was not significant ($\beta = 0.00$, $t = 0.01$, $p = 0.99$, bootstrapped 95% CI = –0.04, 0.04). Similarly, the direct paths from materialism (IV) to entrepreneurial attitude (M2) ($\beta = 0.02$, $t = 0.79$, $p = 0.43$, bootstrapped 95% CI = –0.03, 0.07) and intention (DV) ($\beta = -0.03$, $t = -1.44$, $p = 0.15$, bootstrapped 95% CI = –0.07, 0.01) were not significant.

Figure 2 illustrates the serial mediation model without control variables. Overall, the results without control variables did not change meaningfully compared to those with control variables.

All indirect pathways calculations, including bias-corrected bootstrap 95% CIs, with and without control variables, are presented in **Table 5**. After controlling for gender and family income level, the total indirect effect was 0.11 (bootstrap 95% CI = 0.06, 0.16), and the proposed sequential mediation effect was 0.09 (bootstrap 95% CI = 0.07, 0.12, supporting Hypothesis 2. Alternative indirect pathways such as materialism through achievement motivation and materialism through entrepreneurial attitude were not significant, indicating that neither achievement motivation nor entrepreneurial attitude could solely explain the relationship between materialism and entrepreneurial intention. Similarly, the results without control variables did not change meaningfully.

Given a significant indirect effect but no significant direct effect, the above results indicate that the relationship between materialism and entrepreneurial intention is fully mediated by achievement motivation and entrepreneurial attitude in a sequential manner. The serial mediation model with control variables explained overall the 66% of the variance (65% without control variables) of entrepreneurial intention.

Alternative Models

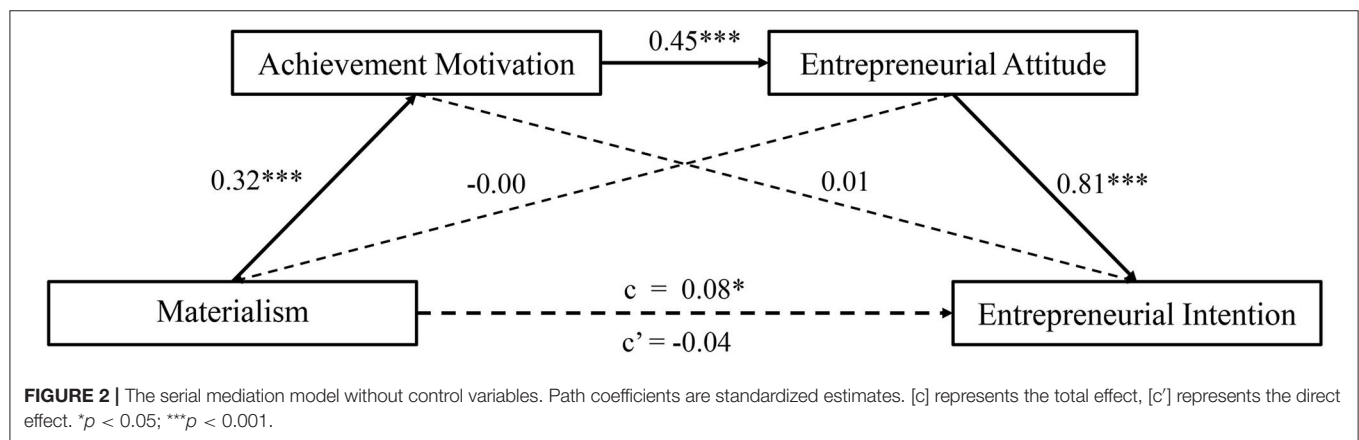
In an alternative model in which the order of the sequential mediators was switched, the serial mediation effect (materialism → entrepreneurial attitude → achievement motivation → entrepreneurial intention) was no longer significant, with values of 0.00 (bootstrap 95% CI = –0.003, 0.003), even controlling for gender and family income level (effect = 0.00, bootstrap 95% CI = –0.003, 0.003). Thus, the order of the proposed

TABLE 4 | Results of the proposed serial mediation model.

	Model 1 (Outcome: EI)		Model 2 (Outcome: AM)		Model 3 (Outcome: EA)		Model 4 (Outcome: EI)	
	β	SE	β	SE	β	SE	β	SE
Control variables								
Gender ^a	0.31***	0.03	0.13***	0.03	0.23***	0.03	0.10***	0.02
Family Income	0.28***	0.03	0.11***	0.03	0.19***	0.03	0.10***	0.02
Main effects								
Materialism	0.08**	0.03	0.32***	0.03	0.02	0.03	-0.03	0.02
AM	–	–	–	–	0.39***	0.03	0.00	0.02
EA	–	–	–	–	–	–	0.75***	0.02
<i>F</i>	80.58***		52.34***		105.63***		394.12***	
<i>R</i> ²	0.20		0.14		0.30		0.66	

*** $p < 0.001$, ** $p < 0.01$. $N = 1,002$. Gender^a (0 = female, 1 = male).

AM, achievement motivation; EA, entrepreneurial attitude; EI, entrepreneurial intention.



mediators is meaningful, such that achievement motivation precedes entrepreneurial attitude in the meditational pathway.

DISCUSSION

Across the world, COVID-19 has resulted in an increase in graduate unemployment (Shahriar et al., 2021). It is often perceived that entrepreneurship among college students is an effective remedy for graduate unemployment (Awogbenle and Iwuamadi, 2010; Chigunta, 2017). Considerable agreement exists about the critical role of entrepreneurial intentions in the decision to start a new firm (e.g., Liñán et al., 2011; Fayolle and Liñán, 2014; Ozaralli and Rivenburgh, 2016; Meoli et al., 2020). Therefore, numerous studies explored the possible factors that could increase or decrease entrepreneurial intention. The current research focused on materialism, a personal value prevalent worldwide but often viewed as a “bad apple,” and revealed that materialism could positively predict college students’ entrepreneurial intention. Such association achieves through strengthening achievement motivation and further promoting a positive entrepreneurial attitude, i.e., the

college students’ materialistic value could translate into high achievement motivation, which in turn is positively related to a favorable entrepreneurial attitude and subsequently higher entrepreneurial intention. The current research implies the silver lining of materialism and points to a new approach to increase entrepreneurial intention, which previous studies have overlooked.

Materialism and Entrepreneurial Intention

From the perspective of personal value, materialism is located in close proximity to self-enhancement values when mapping it onto Schwartz’s value circle model (Burroughs and Rindfleisch, 2002; Kilbourne et al., 2005; Karabati and Cemalcilar, 2010). Self-enhancement values have been viewed as a positive factor in entrepreneurial intention (Liñán et al., 2016; Gorgievski et al., 2018; Karimi and Makreel, 2020). Schwartz’s value circle model presumed that adjacently located values usually lead individuals to similar behaviors or decisions (Schwartz et al., 2012). Previous studies supported this presumption by indicating that work values found near self-enhancement values, such as stressing salary and prestige (Hirschi and Fischer, 2013) or the importance

TABLE 5 | Indirect effects of materialism on entrepreneurial intention.

Pathway	Effect	Boot SE	Boot LLCI	Boot ULCI
<i>With control variables</i>				
Total	0.11	0.03	0.06	0.16
Materialism → AM → EI	0.00	0.01	−0.01	0.01
Materialism → EA → EI	0.02	0.02	−0.03	0.06
Materialism → AM → EA → EI	0.09	0.01	0.07	0.12
<i>Without control variables</i>				
Total	0.12	0.03	0.06	0.18
Materialism → AM → EI	0.00	0.01	−0.01	0.02
Materialism → EA → EI	0.00	0.02	−0.05	0.05
Materialism → AM → EA → EI	0.12	0.02	0.09	0.15

AM, achievement motivation; EA, entrepreneurial attitude; EI, entrepreneurial intention.

of extrinsic awards (e.g., promotion, Lechner et al., 2018), were related to higher entrepreneurial intention. In line with these studies, the present research also provided supportive evidence.

The present research documented that the materialistic value could positively predict entrepreneurial intention as its “neighbors.” Materialists attach importance to acquiring money and material possessions; material possessions are central to their life and happiness; the more possessions they own, the more successful they perceive themselves (Richins and Dawson, 1992). These characteristics lead materialists to an inclination toward a high-paying, high-status job when choosing a career (Kasser, 2002). That is to say, the students with higher materialism have a stronger desire for money, which makes them prefer a career choice that could bring them a high income and thus be better able to indulge in a taste for acquisition. Starting own business is typically described as such a kind of career choice (Hirschi and Fischer, 2013). In this way, materialism would yield an increase in willingness to launch their own venture and consider entrepreneurship as a career option.

Moreover, in line with the previous study (Fatoki, 2015), the present research also identified a positive relationship between materialism and entrepreneurial intention. However, the association found in the current research is significant, which is different from the previous study. The difference in sample size may cause this discrepancy. The sample size of the Fayolle et al. (2014) study may not be adequate, which may lead to the significant results disappearing. Actually, the correlation found in the current study was relatively small ($r = 0.08$). One possible explanation is that materialism might be a distal factor in entrepreneurial intention rather than a proximal one. The previous study has demonstrated that the total effect of distal factors is minor or even subtle compared to proximal factors, and the effect of distal factors needs to be transmitted through mediators (Shrout and Bolger, 2002). Our results regarding the serial mediation model supported the above explanation: the effect of materialism needs to be transmitted through achievement motivation and entrepreneurial attitude. Only when college students’ materialism could activate achievement motivation and achievement motivation subsequently lead to a positive attitude toward entrepreneurship could materialism

better increase college students’ entrepreneurial intention. Otherwise, the effect of materialism might be relatively small, albeit still significant.

The Serial Mediation Model

Another finding of the current research is that achievement motivation and entrepreneurial attitude could explain the association between materialism and entrepreneurial intention. That is, a serial mediation model has been established. It is noteworthy that although the results met the requirements for “full mediation” (i.e., a significant indirect effect but no significant direct effect of materialism on entrepreneurial intention), we do not claim a “full mediation” because the claim of full mediation would likely discourage future research from examining other possible mechanisms and constrain theory development (Rucker et al., 2011).

Consistent with previous studies (Larsen et al., 1999; Chang and Zhang, 2008; Sirgy et al., 2013), the current research indicated that materialism is related to higher achievement motivation. The students who hold a higher level of materialism may put material possessions at the center of their lives and set material acquisition as their personal vision (Richins and Dawson, 1992). To acquire luxurious possession as much as possible, they may need to reap wealth, achieve a higher position in society, and make an effort to achieve their vision. In short, an emphasis on material possessions will motivate college students to seek wealth, place high importance on income and lead them to prioritize the satisfaction gained from the achievement of personal interests, thus exhibiting higher achievement motivation. In line with McClelland (1961) theory of nAch, having a need for achievement motivates entrepreneurship. Achievement motivation brings a positive attitude toward entrepreneurship, as reported in earlier studies (e.g., Kusmintarti et al., 2014; Ajiwibawani and Subroto, 2017; Maharani et al., 2020; Bağış et al., 2022). College students with higher achievement motivation may feel choosing entrepreneurship as a career is more advantageous and attractive and expect becoming an entrepreneur would entail great satisfaction. Finally, such positive inclination formed a willingness to start-up their own business, which coheres with the prediction of TPB (e.g., Liñán et al., 2011; Anwar et al., 2021). In brief, materialism increases entrepreneurial intention through achievement motivation and entrepreneurial attitude.

Besides the serial mediation, the current research also indicated that achievement motivation and entrepreneurial attitude could not independently mediate the relationship between materialism and entrepreneurial intention after controlling the other mediator. This finding suggests that achievement motivation and entrepreneurial attitude might be interdependent when transmitting the effect of materialism to entrepreneurial intention. First, concerning achievement motivation, it is more correlated with entrepreneurial attitude than with intention. And the entrepreneurial attitude was strongly associated with entrepreneurial intention. Both reasons may render the direct effect of achievement motivation on entrepreneurial intention nonsignificant (Rucker et al., 2011). Thus, achievement motivation could not play an independent

mediating role when controlling entrepreneurial attitude. A similar case can be seen in Thelen (2019). Second, a possible reason why entrepreneurial attitude cannot independently mediate the effect of materialism when controlling achievement motivation is that materialism is still a distal factor in entrepreneurial attitude. A piece of evidence is the small correlation between materialism and entrepreneurial attitude ($r = 0.15$). As discussed in the prior section, the effect of distal factors needs to be transmitted *via* mediators (Shrout and Bolger, 2002). Studies regarding self-enhancement values also documented that the direct effect of self-enhancement values on entrepreneurial attitude was insignificant (Gorgievski et al., 2018; Sánchez-Báez et al., 2018), which implied that the effect of materialism on entrepreneurship-related variables might need to be realized through mediators, such as achievement motivation. In other words, achievement motivation can be viewed as a bridge between materialism and entrepreneurial activity.

Theoretical Implications

The current research identified a positive association between materialism and college students' entrepreneurial intention with a large sample, which contributed to the existing literature concerning the role of personal values in entrepreneurial activity by complementing the effect of materialism. Previous studies on personal values mainly focused on Schwartz's four integrated values or their related work values (Hueso et al., 2021). Although materialism partly overlaps with self-enhancement values, it has its own unique features. For example, materialists value power, achievement, salary, and prestige because they view them as tools to acquire more and better material possessions instead of the ultimate goals. Materialists attach importance to the number of material possessions and the symbolic role of acquiring and possessing material wealth for the self and others (Shrum et al., 2013). Therefore, investigating the relationship between materialism and entrepreneurial intentions can provide a more comprehensive picture of the role of personal values in entrepreneurship.

Furthermore, the current research is the first to empirically examine the psychological mechanism underlying the relationship between materialism and entrepreneurial intention and establish a serial mediation involving achievement motivation and entrepreneurial attitude. In addition, most previous studies merely relied on TPB to identify the mediators in the relationship between personal values and entrepreneurial intention (e.g., Gorgievski et al., 2018; Kruse et al., 2019; Yasir et al., 2021), neglecting the role of motivation in the relationship of values-entrepreneurship. By integrating the theory of nAch and the TPB, the present research pointed out a potential path from personal value to the entrepreneurial intention where motivation and attitude both play a significant role, which underlines the impact of motivation and helps break down the barriers between different theories.

Practical Implications

The current research also has practical implications for decreasing materialism and increasing entrepreneurial intention. First, regarding materialism decrease, materialism is often

considered a detriment to “good stuff” such as self-esteem and well-being (for a review, see Kasser, 2016). Hence, a slew of studies has sought ways to reduce materialism through education or intervention programs (e.g., Kasser et al., 2014; Chaplin et al., 2019; Unanue et al., 2021). The present study, however, illustrated an alternative to interventions that could also render materialism harmless. That is, owing to the feature of materialism that places high importance on acquiring money and material possessions, materialism could translate into the high entrepreneurial intention of college students through enhancing their achievement motivation and positive attitude toward entrepreneurship. It is critical to note that we are not encouraging enhancing materialism; instead, we suggest the possibility that educators could take advantage of the characteristics of materialism and transform the “harmful” value into a socially beneficial factor, for example, entrepreneurial intentions.

Second, concerning entrepreneurial intention promotion, earlier studies focused on cultivating students' abilities or traits that they do not possess or need to develop, such as creativity (e.g., Hu et al., 2018; Tantawy et al., 2021) or proactive personality (e.g., Crant, 1996; Neneh, 2019). The current research pointed out another way—leveraging students' existing values to develop entrepreneurial intention. During the university years, students will be engaged in the process of identity construction (Arnett, 2000) that will aid them in clarifying their values. A longitudinal study concerning Chinese college students indicated that materialism showed an increasing trajectory over the college years (Jiang et al., 2021). The growing trend of college students' materialism implied materialism might be an ever-increasing “resource” of entrepreneurial intention. In addition, the current research describes how to use this resource, i.e., translating students' materialistic value into achievement motivation and enhancing their positive entrepreneurial attitude.

In other words, the current research suggests that entrepreneurial education could utilize the current materialistic value of students to increase their entrepreneurial intention. For example, with the help of specific software (Hsueh, 2018; Hananto, 2021) or algorithms (Astuti and Handoko, 2018; Imron and Kusumah, 2018), educators could identify and target the students who hold high materialism through, as well as predicting the likelihood of them starting a business in the future through machine learning (Jen and Lin, 2021; Prayitno et al., 2021; Saputro and Nanang, 2021; Sugiyanto, 2021). And then, entrepreneurial education programs could provide them with decision support systems (Azis et al., 2020; Fujishima, 2022), e-learning classes (Widiyanto et al., 2021), and customized training plans (Thelen, 2021) to improve their achievement motivation and enhance attitudes and skills regarding entrepreneurship.

Limitations and Future Research Recommendations

Notwithstanding its contributions, the present research has some limitations. First, the current research only adopted a cross-sectional design, which is hard to draw causal conclusions. Future research could employ a longitudinal design and measure the research variables at different time points (e.g.,

Hamid et al., 2022) or conduct a laboratory experiment and prime or manipulate students' materialistic value (e.g., Wang et al., 2019), to verify the causal relationship between materialism and entrepreneurial intention.

Second, the present research merely measured the general entrepreneurial intention. In other words, we did not distinguish between the tendency to start a commercial enterprise and that to create a non-profit organization (referred to as social entrepreneurship, Peredo and McLean, 2006). The positive effect of materialism may only exist in the former. That is, materialists may be more willing to become business entrepreneurs rather than social entrepreneurs. Future research could explore the association between materialism and social entrepreneurial intention.

Finally, the current research did not explore possible moderators. Both environmental (e.g., entrepreneurial munificence; Tang and Tang, 2007) and individual factors (e.g., risk preference; Barbosa et al., 2007) may moderate the effect of materialism on achievement motivation or entrepreneurial intention. Future research could establish a moderated mediation model or a moderated serial mediation model to exhibit the mechanisms underlying the association between materialism and entrepreneurial intention with greater comprehensiveness and depth.

CONCLUSION

Overall, the current research identifies materialism as a new positive predictor of entrepreneurial intention and is the first to establish a serial mediation model between materialism and entrepreneurial intention. The current research demonstrates that college students' materialism could increase their entrepreneurial intention by strengthening their achievement motivation and entrepreneurial attitude, i.e., materialism boosted college students' achievement motivation, which in turn was associated with a more positive entrepreneurial

attitude and subsequently stronger entrepreneurial intention. These findings pointed out that, albeit often regarded as a "bad apple," materialism could still exert a positive effect on entrepreneurial intention through certain means, which implies the silver lining of materialism and delineates a possible way to enhance entrepreneurial intention based on the existing value of college students.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available on request without undue reservation. Further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the School of Economics and Management of North China Electric Power University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

YL, YZ, and FZ conceived the research and developed the theoretical framework. YL collected the data, secured funding, and administered the project. YZ performed statistical analyses and wrote the original draft. All authors contributed to the manuscript revision and approved the submitted version.

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Relationship Between Proactive Personality and Entrepreneurial Intentions in College Students: Mediation Effects of Social Capital and Human Capital

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The research aims to explore the influence mechanism of proactive personality on the entrepreneurial intentions of college students. Adopting proactive personality scale, social capital scale, human capital scale, and entrepreneurial intention scale, this research tested valid samples of 300 Chinese college students. The results revealed that proactive personality exerted a significant and positive impact on the entrepreneurial intentions. Social capital played a partial mediating role between the proactive personality and the entrepreneurial intentions. Human capital also played a partial mediating role between proactive personality and entrepreneurial intentions. Social capital and human capital exerted a chain mediation effect between proactive personality and entrepreneurial intentions. The result of this research offers valuable insights to the study of the influence of college students' proactive personality on entrepreneurial intentions and provides entrepreneurship education management in colleges with specific practical suggestions so as to improve entrepreneurial intentions among college students.

Keywords: proactive personality, entrepreneurial intention, social capital, human capital, chain mediation effect

INTRODUCTION

Entrepreneurship can bring technological innovation and organizational breakthroughs, alleviate employment pressure, and promote economic development ultimately (Nguyen, 2021). Colleges are important talent pools of future entrepreneurs, and it was necessary to attach importance to entrepreneurial management to alleviate the employment pressure of college students (Lipkind and Kitrar, 2021). According to studies, the entrepreneurial behavior of college students was fundamentally influenced by their entrepreneurial intentions (Bird, 1988; Krueger, 2007). However, some researchers showed that the entrepreneurial intentions of college students were further improved (Peng et al., 2019). Therefore, exploring the key factor of entrepreneurial intentions of college students is currently an important research issue.

Studies revealed personality traits as important predictors of entrepreneurial intention among various influencing factors related to entrepreneurial intention (Bateman and Crant, 1993; Wu et al., 2019). It was reported that compared to individuals with low levels of proactive personality, the individuals with high levels of proactive personality exhibited greater compatibility with

entrepreneurial activities (Holland, 1987). According to Zareieshamsabadi et al. (2010), proactive personality significantly affected employees' entrepreneurial intentions. Nowadays, there were similar research results in the educational field, showing that the proactive personality of college students had a significant and positive effect on their entrepreneurial intentions (Zeb et al., 2019). Basar (2017) observed that college students with a proactive personality were better at discovering and capturing opportunities, which ultimately assisted them in developing entrepreneurial intentions and, therefore, gaining a competitive advantage over other students. However, studies confirmed that proactive personality could improve entrepreneurial intention, educational organizations possessing the nature of non-profit institutions, showing different characteristics with business organizations. Consequently, taking college students as a research object, this research explores the relationship between proactive personality and entrepreneurial intentions in the hope of obtaining more empirical research evidence.

Based on the social capital theory (Burt, 1995), entrepreneurs obtained resource support by using social capital and thus improved their entrepreneurial intentions (Hsiao et al., 2016). Meanwhile, based on the human capital theory (Schultz, 1961), the human capital accessible to entrepreneurs was the main factor in deciding whether to start a business (Ho et al., 2010). According to the current empirical study, this research noticed that proactive personality had a significant and positive impact on social capital (Nasaj, 2021). Social capital had a significant and positive impact on entrepreneurial intention (Mahfud et al., 2020). Proactive personality had a significant and positive impact on human capital (Seibert et al., 1999). Human capital had a significant and positive impact on entrepreneurial intention (Moradi et al., 2014). Moreover, social capital and human capital were not isolated (Gradstein and Justman, 2000). Social capital had a significant and positive impact on human capital (Wang, 2021).

In summary, existing researches show that proactive personality has a significant and positive impact on entrepreneurial intention, and social capital and human capital have mediation effect on proactive personality and entrepreneurial intention. However, the internal mechanism of social capital and human capital between proactive personality and entrepreneurial intentions of college students is still not clear in educational literature. Especially, colleges are important places to accumulate social capital as well as knowledge and skills. The social and training service colleges may improve college students' social capital and human capital. College students' entrepreneurial intentions may be enhanced due to the improvement of their proactive personality. This is an important task for college innovation and entrepreneurship education management. In this view, this research assumes that social capital and human capital may be important mediating variables between proactive personality and college students' entrepreneurial intentions.

Therefore, this research explores the influence of college students' proactive personality on entrepreneurial intentions and the mediation effect of social capital and human capital between proactive personality and entrepreneurial intentions,

combining social capital theory and human capital theory. This research will help us further understand the important factors influencing the entrepreneurial intentions of college students to improve our knowledge of the potential influencing mechanisms underlying the process and provide colleges with a new direction of promoting college students' entrepreneurial intentions more effectively.

LITERATURE REVIEW

Proactive Personality and Entrepreneurial Intention

"Proactivity refers to active attempts made by the individual to effect changes in his or her environment" (Zampetakis, 2008). Proactive personality refers to a stable and active personality that challenges the status quo by improving the existing environment or creating an entirely new environment rather than passively adapting to the current conditions (Crant and Bateman, 2000). In other words, individuals with a strong proactive personality could identify and exploit opportunities by demonstrating proactive, active, and persistent behaviors until the intended or certain meaningful changes were realized (Bateman and Crant, 1993). Prior research has found that people who are more proactive have higher entrepreneurial intentions (Crant, 1995). According to Thompson (2009), previous entrepreneurial intention refers to the notion that an individual intended to begin a new business and consciously planned to execute it at a certain point in the future. Entrepreneurial intention reflected a subjective intention of an individual during the entrepreneurial process and, therefore, served as a suitable predictor of entrepreneurial behaviors (Bird, 1988). Entrepreneurial intention, an individual's intent to engage in entrepreneurial behavior, is central to understanding entrepreneurial activity in society (Krueger and Brazeal, 1994). Entrepreneurial intention also emphasized personal innovation, initiatives, and a degree of risk-bearing in an individual (Covin and Slevin, 1989). The previous empirical studies showed that personality traits had a significant impact on the entrepreneurial intention of college students (Cai et al., 2021; Jiatong et al., 2021; Murad et al., 2021). As a positive personality trait, individuals with proactive personality were more prone to starting a business. Existing studies demonstrated that employees' proactive personality had a significant and positive impact on their entrepreneurial intentions (Zareieshamsabadi et al., 2010; Paul and Shrivatava, 2016). Researchers found out that, in the educational research field, college students' proactive personality significantly impacted entrepreneurial intentions (Zeb et al., 2019; Hossain and Asheq, 2020). Some other researchers took college students in Istanbul as research objects, and found that proactive personality exerted positively predict college their entrepreneurial intentions (Basar, 2017). Some researchers took Chinese college students as the research object and the results showed that proactive personality had improved their entrepreneurial intention and further effectively transformed it into entrepreneurial behavior (Li et al., 2020a). It showed that the higher the level of proactive personality was, the

greater the entrepreneurial intention would be. Therefore, this research proposes that H1: college students' proactive personality has a significant and positive impact on entrepreneurial intentions.

The Mediating Role of Social Capital Between Proactive Personality and Entrepreneurial Intention

Social capital was the resource comprising interpersonal relationships established by individuals through social relationships and networks (Coleman, 1988). Yang et al. (2011) proposed that the quality of undertaking initiatives was one of the important personality traits that promoted the accumulation of social capital. It was because when individuals with proactive personality faced difficulties and challenges, they would ask for help from others in their social network to expand social capital (Sharifian et al., 2022). Previous research also showed that the high level of proactive personality was beneficial to stimulating individuals' social networking awareness to significantly and positively predict individuals' social capital (Tang, 2016). In educational literature, the research of Le and Lin (2021) showed that college graduates' proactive personality could significantly and positively influence the scale and behavior of their social network, and social network was an important content of social capital (Coleman, 1988). Therefore, college students' proactive personality may significantly and positively impact social capital.

According to the social capital theory, the more interpersonal relationships individuals had to facilitate their actions; the more were their interpersonal relationships. They could utilize these relationships to gain actual or potential resources, and consequently, the greater was the social efficiency (Nahapiet and Ghoshal, 1998). In other words, individuals obtain entrepreneurial resources through social interpersonal relationships to increase the chances of starting a business (Weiss et al., 2019). Subramaniam and Youndt (2005) stated that social capital was one of the most important determinants of entrepreneurship. In comparison to individuals with low social capital, individuals with high social capital exhibited a stronger positive effect on their entrepreneurial intentions (Lee et al., 2014). Certain researchers proposed that social capital was an important condition for developing social entrepreneurial intention (Lan and Luc, 2020). In educational literature, Mahfud et al. (2020) established a structural model for the relationship of entrepreneurial intentions and concluded that social capital exerted a significant and positive effect on entrepreneurial intentions in vocational school students. A large number of studies confirmed that social capital is the significant predictive factor of students' entrepreneurial intentions (Vuković et al., 2017; Pérez-Macías et al., 2021). Therefore, it may be inferred that the higher the social capital of college students is, the greater their entrepreneurial intentions will be.

This research concludes that a proactive personality may increase the social capital gained by college students, which will, in turn, significantly enhance their entrepreneurial intentions. When investigating the mediating relationship between proactive personality and work performance, Thompson (2005) expressed

that employee with proactive personality obtained work performance benefits by developing social capital. Other studies demonstrated that social capital plays a mediating role in the relationship between proactive personality and turnover intention (Yang et al., 2011). It showed that social capital played a crucial mediating role in previous empirical research. Therefore, this research proposes that H2: social capital has a mediation effect in the influence of college students' proactive personality on their entrepreneurial intentions.

The Mediating Role of Human Capital Between Proactive Personality and Entrepreneurial Intention

Human capital was the total of various skills, knowledge, and quality of health, and experience that may collectively develop the economic value of the human body (Schultz, 1961; Subramaniam and Youndt, 2005). Basar (2017) proposed that individuals with a proactive personality actively accumulated human capital as they were more willing to learn and enhance their abilities and knowledge when encountering challenges to resolve problems (Gao et al., 2020). According to studies, the higher the level of proactive personality was, the higher the human capital would be, and vice versa (Demirtas et al., 2017). Seibert et al. (1999) proved that the parameter of proactive personality could positively predict human capital. In educational literature, the researcher discovered that proactive personality had a significant and positive influence on college students' academic record (Ng et al., 2019), an important measure of students' human capital (Rosen, 1989). In this view, students' proactive personality may have a significant and positive impact on human capital, meaning that the higher level the college students' proactive personality is, the more abundant their human capital would be.

Additionally, the human capital theory stated that the ability to study further assisted individuals in acquiring outstanding recognition capabilities, which enabled them to exhibit higher productivity and efficiency in a range of activities (Becker et al., 1980). In this view, human capital may facilitate the productivity of entrepreneurial activities. The higher the education and experience of individuals were, the higher their entrepreneurial intentions would be (Kim et al., 2006). It had been further demonstrated that knowledge management practices had a significant and positive impact on entrepreneurial performance (Li et al., 2020b). Stuetzner et al. (2013) also proposed that human capital positively impacted entrepreneurship. Combining human capital theory, Miao et al. (2015) discovered that human capital had a significant and positive impact on the entrepreneurial intention of overseas returnees. In the educational field, human capital, including education, experience, and training, was the leading factor in forming college students' entrepreneurial intentions (Zhang et al., 2020). Human capital had a significant and positive impact on Chinese college students' entrepreneurial intentions (Moradi et al., 2014). It indicated that when college students had a high level of human capital, they may have greater entrepreneurial intentions.

The present study, therefore, concludes that the proactive personality of college students might increase human capital, which will, in turn, significantly affect the entrepreneurial intentions among these students. Human capital was reported to play a crucial mediating role between international expatriation and entrepreneurial intention (Schlepphorst et al., 2020). Khoshmaram et al. (2020) reported that environmental support exerted a significant impact on entrepreneurial behavior *via* human capital. These evidence-based studies confirmed the mediating role of human capital. Therefore, this research proposes that H3: human capital has a mediation effect in the influence of college students' proactive personality on their entrepreneurial intentions.

The Chain Mediating Role of Social Capital and Human Capital Between Proactive Personality and Entrepreneurial Intention

Human capital theory and social capital theory had independent development and formation paths, but there were two different views in entrepreneurship research (Bozeman and Mangematin, 2004). Researchers noticed that the two might have a positive relationship (Serageldin and Dasgupta, 2001). Coleman (1988) pointed out that social capital is generated in people's relationship with one another, and social capital within families (such as the relationship between parents and offspring), social capital outside families (such as community and neighborhood factors), and social capital as public goods (such as geographical environment and trust among people) all exerted an important impact on the formation of human capital. From this point of view, the social capital of entrepreneurs was profoundly influencing the formation and development of their future human capital. From another point of view, Mosey and Wright (2007) proposed that the difference in entrepreneurs' social capital depended on whether they had previous working experience and entrepreneurial experience, which was actually their human capital. Those with related working experience generally could obtain more social capital. Therefore, it was beneficial for entrepreneurs with more abundant human capital to form and develop social capital.

However, "Guan xi" was a widespread phenomenon in China, which was even considered a part of Chinese culture so that could not be eliminated fundamentally (Hwang, 1987). "Chinese-style relationship" represented the "Guan xi" phenomenon unique to China (Chen and Chen, 2004). By analyzing the social network relationship of Chinese when they look for jobs, Bian (1997) discovered that "Chinese-style relationship" exerted a more important effect during employment. The social network relationship at workplaces better helped Chinese employees to achieve higher career achievements (Farh et al., 1998). One Chinese empirical study showed that social entrepreneurs' successes relied greatly on their social network relationship (Wang et al., 2007). It indicated that "Chinese-style relationship" was undoubtedly important in Chinese society. Therefore, based on China's cultural background, this research believed that the social capital of Chinese college students had a more profound influence on the formation and development

of their human capital compared to college students in western countries.

Davidsson and Honig (2003) verified that social capital and human capital could both promote the establishment of new startups. Other researchers also discovered that social capital and human capital both had a significant and positive influence on college students' entrepreneurial intentions (Jemari et al., 2017). One recent Chinese empirical research showed that the more college students' social capital was, the higher their human capital would be. College students' social capital even had a significant and increasing influence on their entrepreneurial intentions through the mediation effect of human capital (Wang, 2021). Another empirical research exploring employees' personality traits and entrepreneurship influence mechanism demonstrated that social capital and human capital had important mediation effect on internal control personality and entrepreneurship (Hsiao et al., 2016). It can be thus inferred that college students' social capital and human capital may play an important mediating role in proactive personality and entrepreneurial intentions.

To be more specific, Chinese college students' proactive personality may improve their social capital and human capital, while social capital may also promote human capital to enhance their entrepreneurial intentions. Therefore, this research proposes that H4: social capital and human capital have a chain mediating role in influencing college students' proactive personality on their entrepreneurial intentions.

MATERIALS AND METHODS

Research Framework

This research took proactive personality as the independent variable and entrepreneurial intention as the dependent variable to explore the relationship between them, and the chain mediation effect of social capital and human capital in this relationship (Figure 1).

Data Collection and Procedures

Using the convenient sampling method, the study conducted a questionnaire survey on students at a University in Hebei Province, China, on an online questionnaire platform. The selected university is a truly representative sample because the university is one of the demonstration bases of innovation and entrepreneurship education reform in China. In November 2021, teachers at the administration office sent the questionnaires in electronic forms to the students at our request. It took a university student approximately 30 min to fill in the questionnaire. The study distributed 310 questionnaires and received 300 valid ones after eliminating invalid ones, with a 97% response rate. Among the students who returned the valid questionnaires, there were 64 boys (21.3%) and 236 girls (78.7%), including 64 freshmen (21.3%), 164 sophomores (54.7%), 43 juniors (14.3%), and 29 seniors (9.7%). Among them, 85 majors in human resources management (28.3%); 55 majors in international economy and trade (18.3%); 68 majors in information system of department of information management

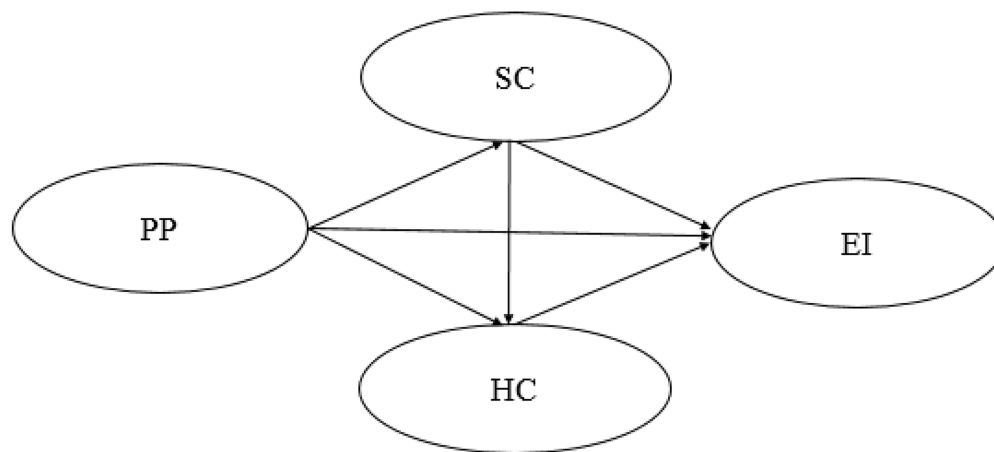


FIGURE 1 | Research framework. PP, Proactive Personality; EI, Entrepreneurial Intention; SC, Social Capital; and HC, Human Capital.

(22.7%), and 92 from other majors (30.7%). The 300 students had participated in entrepreneurship courses or entrepreneurship training activities offered by colleges (100%). According to the formula provided by Israel (1992) for calculating the sample size, that is, $\text{sample size} = z^2 \times p(1-p)/e^2/1 + (z^2 \times p(1-p)/e^2N)$, $z=1.65$, $p=0.5$, $N=15,325$, and $e^2=0.0025$, the formal sample size should be no less than 268. The size of this study met the sampling criteria. The study was conducted in accordance with the Declaration of Helsinki and all subjects were willing to cooperate and had signed informed consent forms. The study gave due consideration to their privacy and wishes and informed them that they could refuse to participate or withdraw from the study at any time (Goodyear et al., 2007).

The analysis of this research consists of two steps: pilot test and formal test. In the pilot test stage, 114 valid questionnaires were collected and SPSS 21.0 was used to conduct item analysis, Exploratory Factor Analysis (EFA) and reliability analysis on these data to test the reliability and validity of the scale. In the formal test stage, 300 valid questionnaires were collected and SPSS 21.0 was used for descriptive statistics and correlation analysis of these data. In addition, AMOS 24.0 was used for measurement model and structural model tests.

Measures

The questionnaire of this research includes four scales: proactive personality scale, social capital scale, human capital scale, and entrepreneurial intention scale, and pilot test data are adopted to make item analysis. The criteria for item analysis are that the t value of each item is greater than the reference value 3 (McIver and Carmines, 1981).

Proactive Personality Scale

The proactive personality scale revised by Shang and Gan (2009) was used. It was a seven-point scoring scale, with the scores ranging from 1 (strongly disagree) to 7 (strongly agree). A higher score indicated a level of proactive personality. The original scale comprised 11 items with no reverse item with a single dimension. The items were further screened through

item analysis, and accordingly, one item was deleted, which was as follows—"If I see others in difficulty, I will try my best to help." A total of 10 items remained finally.

Social Capital Scale

The human capital scale compiled by Snell and Dean (1992) was adopted. It was a seven-point scoring scale, with the scores ranging from 1 (strongly disagree) to 7 (strongly agree). A higher score indicated higher social capital. With a single dimension, the original scale comprised five items with no reverse item. The items were further screened through item analysis, based on which one item was deleted—"I can apply the knowledge from one field to the problems and opportunities in another field." Finally, a total of four items remained.

Human Capital Scale

The human capital scale compiled by Snell and Dean (1992) was adopted. It was a seven-point scoring system, with the scores ranging from 1 (strongly disagree) to 7 (strongly agree). A higher score indicated higher human capital. With a single dimension, the scale comprised five items with no reverse item. In the further screening of items through item analysis, no items were required to be deleted.

Entrepreneurial Intention Scale

The entrepreneurial intention scale compiled by Liñán and Chen (2009) was adopted. It was a seven-point scoring scale, with the scores ranging from 1 (strongly disagree) to 7 (strongly agree). A higher score indicated greater entrepreneurial intention. With a single dimension, the scale comprised six items with no reverse item. When the items were further screened through item analysis, no items had to be deleted.

Exploratory Factor Analysis

As visible in Table 1, this research used pilot test data to conduct EFA. According to the result, Kaiser-Meyer-Olkin (KMO) Test=0.838, the significance of Bartlett's Test of Sphericity value

TABLE 1 | Summary of the Exploratory Factor Analysis.

Item	Proactive personality	Social capital	Human capital	Entrepreneurial intention
Proactive Personality (explained variance ratio = 13.03%)				
1. I am always looking for a better way	0.595			
2. I tend to face a challenge directly.	0.510			
3. If I believe in an idea, nothing can stop me from realizing it.	0.410			
4. If I firmly believe in something, I tend to achieve it whatever.	0.452			
5. Nothing makes me more exciting than seeing my idea turned into reality.	0.551			
6. I am always looking for a new method to make my life better.	0.657			
7. I enjoy facing and overcoming difficulties.	0.587			
8. I am always hoping to be the special one in a group (perhaps in the whole world).	0.558			
Social Capital (explained variance ratio = 13.41%)				
9. I am skilled at solving problems with my classmates.		0.803		
10. I am able to share information with my classmates and learn from them.		0.752		
11. I am able to interact and exchange ideas with my families, teachers, and friends.		0.748		
12. I am able to develop solutions with my families, teachers, and friends.		0.682		
Human Capital (explained variance ratio = 12.89%)				
13. I believe I am highly skilled.			0.722	
14. I am widely considered the best in my profession.			0.712	
15. I am creative and bright.			0.576	
16. I am a professional in practice.			0.782	
17. I believe I can develop new ideas and knowledge.			0.551	
Entrepreneurial Intention (explained variance ratio = 18.28%)				
18. I am willing to work hard to become an entrepreneur.				0.731
19. My career goal is to become an entrepreneur.				0.813
20. I will work hard to start my own business.				0.797
21. In the future, I am ready to start my own business.				0.852
22. I sincerely consider starting my own business.				0.699
23. I strongly wish to start my own business.				0.817
The cumulative explained variance ratio = 55.65%				

was $p < 0.001$. Kaiser and Rice (1974) proposed that, when $KMO > 0.8$, the significance of the value of Bartlett's Test of Sphericity $p < 0.05$ was suitable for factor analysis. Accordingly, the maximum variance rotation method of analysis was used to obtain the rotation component matrix, which revealed four factors with eigenvalues

greater than 1. Subsequently, two items with factor loadings less than 0.3 were deleted ("I am good at turning challenges into opportunities" and "I like to challenge the status quo"). The factor loading of the four factors was between 0.410 and 0.852, which fulfilled the standard criterion of the factor loading, i.e., greater

than 0.3 (Zaltman and Burger, 1975). The explained variance ratio of proactive personality was 13.03%, social capital 13.41%, human capital 12.89%, and entrepreneurial intention 18.28%. The cumulative explained variance ratio of the questionnaire was 55.65%.

Reliability Analysis

This research used pilot test data to conduct reliability analysis. The result is as below: the proactive personality scale contained eight items and the Cronbach's $\alpha=0.796$. The social capital scale contained four items, and the Cronbach's $\alpha=0.793$. The human capital scale contained five items, and the Cronbach's $\alpha=0.811$. The entrepreneurship intention scale contained six items, and the Cronbach's $\alpha=0.907$, indicating that the reliability of each scale is quite good. In conclusion, this questionnaire includes four scales with a total of 23 items. The questionnaire's total Cronbach's $\alpha=0.888$, indicating that the reliability of the questionnaire is quite good.

RESULTS

Measurement Model

This research used formal test data to CFA to test whether the measurement model, composed of four interrelated dimensions, including proactive personality, social capital, human capital, and entrepreneurial intention, fits. The data results of measurement model are as below: $\chi^2=318.657$, $df=224$, $\chi^2/df=1.423$, CFI=0.977, GFI=0.918, NFI=0.926, RFI=0.916, TLI=0.974, IFI=0.977, and RMSEA=0.038, indicating that the measurement model and observation data fit well (McDonald and Ho, 2002). The Average Variance Extracted (AVE) and Construct Reliability (CR) of each dimension of the scales are as below: proactive personality AVE=0.310, CR=0.777; social capital AVE=0.680, CR=0.895; human capital AVE=0.668, CR=0.909; and entrepreneurial intention AVE=0.589, CR=0.896, where in the minimum of AVE is above 0.36, and CR is more than the standard of 0.6 (Fornell and Larcker, 1981), indicating that all dimensions have acceptable convergent validity.

Common Method Variation

Multi-factor CFA and single-factor CFA were used for comparing the fit between the two and performing the CMV verification between the variables (Podsakoff and Organ, 1986). The results, which are listed in Table 2, revealed that the multi-factor model fitted well, with its χ^2 being much lower than the single-factor model ($p<0.001$), which implied that the two models were significantly different. Therefore, it was inferred that the common method bias was not serious in the present study.

Descriptive Statistics and Correlation Analysis

This research used formal test data to perform Pearson correlation analysis to observe the correlation between variables. Table 3 shows that proactive personality and social capital have a significant and positive correlation ($r=0.614$, $p<0.001$); proactive personality and human capital have a significant and positive correlation

($r=0.740$, $p<0.001$); proactive personality and entrepreneurial intention have a significant and positive correlation ($r=0.724$, $p<0.001$); social capital and human capital have a significant and positive correlation ($r=0.638$, $p<0.001$); social capital and entrepreneurial intention have a significant and positive correlation ($r=0.665$, $p<0.001$); and human capital and entrepreneurial intention have a significant and positive correlation ($r=0.738$, $p<0.001$). The above correlation coefficients may be highly and moderately related, so it is necessary to test discrimination validity. The results are shown in Table 3. The number of the square root of AVE of each dimension greater than the correlation coefficient of each variables accounts for more than 75%, which meets the criteria for evaluation discriminant validity (Fornell and Larcker, 1981).

Structural Model

In this research, *t*-test and ANOVA analysis result show that gender ($t=1.785$, $p>0.050$) and major ($F=2.166$, $p>0.050$) have no significant difference in college students' entrepreneurial intentions. Also, all college students that participated in this questionnaire survey took the innovation and entrepreneurship courses or entrepreneurship training activities in the college. Therefore, this research does not control the impact on entrepreneurial intention of gender, major, and whether participated in entrepreneurship courses or entrepreneurship training activities.

This research hypothesized proactive personality as the predictive variable, entrepreneurial intention as the dependent variable, and social capital and human capital as the mediating variable of the relation between proactive personality and entrepreneurial intention, and adopted Structural Equation Modeling (SEM) to explore the mediating effect of social capital and human capital. Based on the test procedures for mediating effect developed by previous researchers (Judd and Kenny, 1981; Baron and Kenny, 1986), firstly, the influence of proactive personality on entrepreneurial intention was explored. Second, both social capital and human capital were added as the mediating variables between proactive personality and entrepreneurial intention. If the path coefficient of the impact of proactive personality on entrepreneurial intention decreases, it demonstrates social capital and human capital play a partial mediating role. If the path coefficient of the impact of proactive personality on entrepreneurial intention is not significant, it demonstrates social capital and human capital play a complete mediating role.

First, this research adopted SEM to construct the main effect model of the impact of proactive personality on entrepreneurial intention (as in Figure 2), and the model fitness index is: $\chi^2=104.547$, $df=76$, $\chi^2/df=1.376$, CFI=0.983, GFI=0.952, NFI=0.939, RFI=0.927, TLI=0.979, IFI=0.983, and RMSEA=0.035. According to the research result, proactive personality can significantly predict college students' entrepreneurial intentions ($\beta=0.901$, $p<0.001$), and proactive personality can explain 81.1% of the entrepreneurial intention, so H1 is supported.

Second, this research adopted SEM to construct the chain mediation model (as in Figure 3). The model analysis results were as follows: $\chi^2=318.657$, $df=224$, $\chi^2/df=1.423$, CFI=0.977,

GFI=0.918, NFI=0.926, RFI=0.916, TLI=0.974, IFI=0.977, and RMSEA=0.038, indicating the chain mediating model fits well (McDonald and Ho, 2002).

In the path of proactive personality→social capital→human capital→entrepreneurial intention (see Table 4; Figure 3), proactive personality has a significant and positive impact on entrepreneurial intention ($\beta=0.343$, $p<0.010$); proactive personality has a significant and positive impact on social capital ($\beta=0.785$, $p<0.001$); social capital has a significant and positive impact on entrepreneurial intention ($\beta=0.216$, $p<0.010$); proactive personality has a significant and positive impact on human capital ($\beta=0.524$, $p<0.001$); human capital has a significant and positive impact on entrepreneurial intention ($\beta=0.442$, $p<0.001$); social capital has a significant and positive impact on human capital ($\beta=0.454$, $p<0.001$). It can be seen that after adding social capital and human capital as the mediating variables between proactive personality and entrepreneurial intention, the path coefficient of the impact of proactive personality on entrepreneurial intention decreased from 0.901 to 0.343, which is still significant. This indicates that social capital and human capital play a partial mediating role between proactive personality and entrepreneurial intention, which also preliminarily verifies that social capital and human capital have a chain mediation effect in the relationship between proactive personality and entrepreneurial intention.

According to the suggestion of Nevitt and Hancock (2001), the method of Bootstrapping can be further used to test the stability of the mediating model. As an intensive computer-based statistical technique, the method of Bootstrapping reconstructs new samples representing the distribution of maternal samples by repeated sampling on limited sample data (Zhu, 1997). In order to test the chain mediation effect of proactive personality on entrepreneurial intention in college students, the present study employed Bootstrapping method which randomly repeated sampling 5,000 times. The results of this study should improve the accuracy of statistical estimates. Table 5 shows the analysis result of the chain mediating model

using Bootstrapping method. Figure 3 shows the chain mediating model's path diagram and effect size. It can be seen from Table 5 that the total indirect effect was 0.559. The total indirect effect was made up of three effects: indirect effect path 1: proactive personality→social capital→entrepreneurial intention (Indirect effect 1=0.170, LLCI=0.340, and ULCI=0.744), indirect effect path 2: proactive personality→human capital→entrepreneurial intention (Indirect effect 2=0.232, LLCI=0.085, and ULCI=0.410), indirect effect path 3: proactive personality→social capital→human capital→entrepreneurial intention (Indirect effect 3=0.157, LLCI=0.033, ULCI=0.291). The CIs of the above indirect effect exclude 0, showed that the three indirect effects all significant; moreover, proactive personality had a significant and positive prediction effect on entrepreneurial intention (Direct effect=0.343, LLCI=0.150, ULCI=0.615). It showed that social capital had a partial mediation effect on the influence of proactive personality on entrepreneurial intention, human capital had a partial mediation effect in the influence of proactive personality on entrepreneurial intention, social capital and human capital had a chain mediating role in the influence of proactive personality on entrepreneurial intention. Therefore, H2–H4 of this research was once again confirmed.

DISCUSSION

According to H1, the result of this research shows that college students' proactive personality has a significant and positive impact on their entrepreneurial intentions, which is similar to the previous research result, indicating that the higher level of proactive personality is, the higher degree of entrepreneurial intentions will be (Zareieshamsabadi et al., 2010; Paul and Shrivatava, 2016). This is also similar to the research result in the educational field, which is that as college students' proactive personality improves, their entrepreneurial intentions will increase, too (Basar, 2017; Zeb et al., 2019; Hossain and Asheq, 2020). Tan et al. (2021) noted six types of entrepreneurs' personality traits: the need for achievement, risk-taking propensity, innovativeness, proactiveness, empathy, and moral obligation, and only four of them influence social entrepreneurial intention: proactiveness, innovativeness, empathy, and moral obligation. Differing from the study of Tan et al. (2021), the present study aimed to explore the influence of proactive personality on college students' entrepreneurial intention and contributed to entrepreneurship research. Therefore, this research reveals this positive relationship under higher education background, which corresponds to the

TABLE 2 | Comparison between the single-factor model and the multi-factor model.

Model	χ^2	df	$\Delta\chi^2$	Δdf	<i>p</i>
Single-factor model	507.641	230	188.984	6	0.000
Multi-factor model	318.657	224			

TABLE 3 | Summary of the descriptive statistics and correlation analysis.

Variable	<i>M</i>	<i>SD</i>	Proactive personality	Social capital	Human capital	Entrepreneurial intention
Proactive personality	5.276	0.756	0.557			
Social capital	4.937	1.143	0.614***	0.825		
Human capital	4.581	1.075	0.740***	0.638***	0.817	
Entrepreneurial intention	4.181	1.047	0.724***	0.665***	0.738***	0.767

*** $p<0.001$.

Bolded fonts are AVE root values.

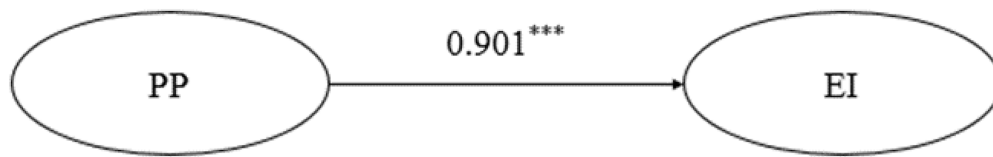


FIGURE 2 | Main effect of the PP on EI. *** $p < 0.001$; PP, Proactive Personality; EI, Entrepreneurial Intention.

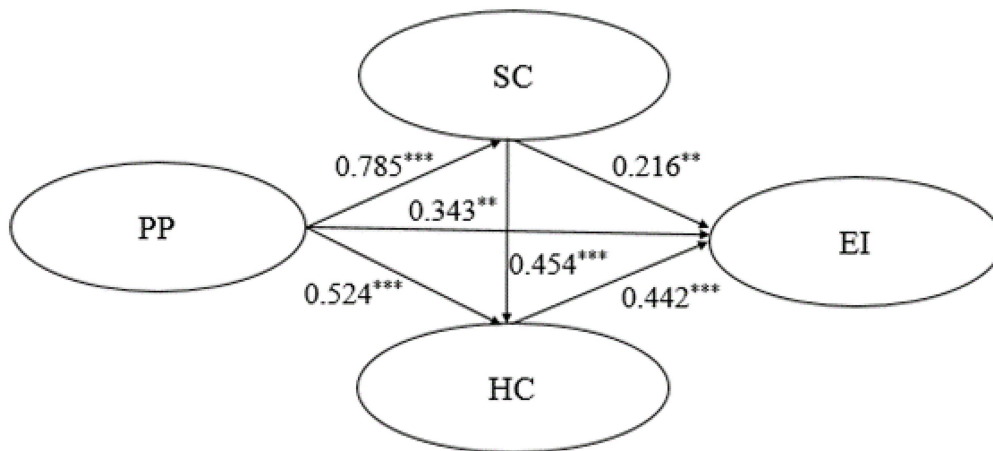


FIGURE 3 | The chain mediation model. ** $p < 0.01$; *** $p < 0.001$; PP, Proactive Personality; EI, Entrepreneurial Intention; SC, Social Capital; and HC, Human Capital.

former research result. It is because college students with a higher level of proactive personality are more willing to take the initiative to change and chose to start their own business when they encounter unsatisfactory employment or working conditions. In contrast, college students with a lower level of proactive personality will only choose to adapt to the environment passively instead of entrepreneurship (Campbell, 2000). It can be seen that college students with a higher level of proactive personality, more spontaneity, and better ability to deal with changes and focus on the future will have higher entrepreneurial intentions.

According to H2, social capital has a partial mediation effect on the relationship between college students' proactive personality and their entrepreneurial intentions. This result is the same as that of previous research, which is that the higher level of the proactive personality will cause more social capital (Thompson, 2005; Yang et al., 2011), and an increase in social capital will enhance the formation of entrepreneurial intention (Lee et al., 2014; Mahfud et al., 2020). Therefore, social capital plays an important mediating role between proactive personality and entrepreneurial intention. It is because that entrepreneurship requires support from the social network (Bian and Ang, 1997), and college students with a higher level of proactive personality are more likely to ask for others' help to enlarge their social capital (Zhang et al., 2021) and thus enhance their entrepreneurial intentions. College students with a higher level of proactive personality can improve their entrepreneurial intentions by increasing social capital (Subramaniam and Youndt, 2005).

According to H3, this research confirms that human capital has a partial mediating role between college students' proactive personality and entrepreneurial intentions, consistent with previous studies' findings. It was demonstrated that the higher the level of proactive personality, the richer is the human capital (Seibert et al., 1999; Demirtas et al., 2017). The increased inhuman capital would, in turn, promote the development of entrepreneurial intention (Moradi et al., 2014; Miao et al., 2015). Therefore, human capital plays an important mediating role between proactive personality and entrepreneurial intention. It is because that this research believes that entrepreneurship requires a high level of knowledge and skills (Markman and Baron, 2003), and college students with a higher level of proactive personality are more likely to take the initiative to accumulate skills, experience, and knowledge (Subramaniam and Youndt, 2005). This will help solve complex problems during the entrepreneurial process (Gao et al., 2020) and increase their entrepreneurial intentions.

According to H4, this research further discovered the chain mediating role of social capital and human capital in the relationship between college students' proactive personality and entrepreneurial intentions. This research result is similar to that of previous research, which is that social capital and human capital both have an important mediation effect on personality traits and entrepreneurship (Hsiao et al., 2016). Moreover, social capital improves entrepreneurial intention through human capital (Wang, 2021). This research result also verifies the view that social capital has a significant influence on the human capital

TABLE 4 | SEM analysis results.

Path	β	SE	C. R.
Proactive personality→entrepreneurial intention	0.343**	0.201	3.207
Proactive personality → social capital	0.785***	0.200	7.850
Social capital→entrepreneurial intention	0.216**	0.074	2.757
Proactive personality →human capital	0.524***	0.199	5.490
Human capital→entrepreneurial intention	0.442***	0.110	3.626
Social capital → human capital	0.454***	0.080	5.906

** $p < 0.01$; *** $p < 0.001$.

β , standardized coefficients; SE, standard error; and C. R., critical ratio.

TABLE 5 | Mediation effects with bootstrapping.

Path	Effect	SE	95% LLCI	95% ULCI
Direct effect	0.343	0.040	0.150	0.615
Total indirect effect	0.559	0.101	0.340	0.744
Indirect effect 1	0.170	0.077	0.022	0.326
Indirect effect 2	0.232	0.085	0.085	0.410
Indirect effect 3	0.157	0.067	0.033	0.291

Bootstrapping random sampling 5,000 times; SE, standard error; LLCI, Lower limit of confidence interval; ULCI, Upper limit of confidence interval; Indirect effect 1, proactive personality→social capital→entrepreneurial intention; Indirect effect 2, proactive personality→human capital→entrepreneurial intention; and Indirect effect 3, proactive personality→social capital→human capital→entrepreneurial intention.

formation (Coleman, 1988). Social capital is a drawing force, contributing to the creation and accumulation of human capital (Leana and Pil, 2006). Social capital is good for acquiring, transferring, or sharing human capital (Hansen, 1999). A high level of social capital will cause more frequent interaction among social members, which is beneficial to the generation of new human capital (Suseno et al., 2020). In this view, Chinese college students with more social capital will have more human capital. Also, the entrepreneurial intentions of Chinese college students with a higher level of proactive personality will be promoted by the chain mediation effect of social capital and human capital. Based on China's cultural background, "Guan xi" is important, unique, and common in Chinese society (Zhang, 2006). "Chinese-style relationship," such as relatives or acquaintances, plays an important role in personal career development and job search process (Bian, 1997; Farh et al., 1998; Chen and Chen, 2004; Zhang, 2006). Therefore, this research believes that Chinese college students' social capital will significantly influence their human capital. The higher level of Chinese college students' proactive personality will better increase their social capital and promote the accumulation of their human capital, enhancing their entrepreneurial intentions. In other words, college students with a higher level of proactive personality will have more

social capital and human capital, facilitating the generation of their entrepreneurial intentions.

THEORETICAL CONTRIBUTIONS

This research result provides certain theoretical contributions to higher education literature. First, college students' proactive personality has a significant and positive influence on entrepreneurial intentions. Second, social capital and human capital both have a partial mediation effect on college students' proactive personality and entrepreneurial intentions. Third, social capital and human capital play a chain mediating role in the relationship between proactive personality and entrepreneurial intention. Although previous research has confirmed that proactive personality has a significant and positive impact on entrepreneurial intention (Zareieshamsabadi et al., 2010; Paul and Shrivatava, 2016), and the empirical research result exploring college students' proactive personality and entrepreneurial intentions have been widely supported (Zeb et al., 2019; Hossain and Asheq, 2020), there were still a few discussion on the influence of proactive personality on the mediating mechanism of entrepreneurial intention. Although some previous empirical research took social capital theory and human capital theory as theoretical background at the same time, discussing the mediating role of social capital and human capital between employees' internal control personality and entrepreneurship, and had obtained verification (Hsiao et al., 2016). The empirical research taking Chinese college students as research objects and exploring the mediating mechanism of proactive personality on entrepreneurial intention is still to be further discussed. Therefore, the contributions of this research lie in that it discovers that Chinese college students with a higher level of proactive personality will show more entrepreneurial intentions. Further, social capital and human capital can play an effective mediating variable effect between proactive personality and entrepreneurial intention. This research result enriches the relationship between college students' proactive personality and entrepreneurial intentions under higher education background, which also promotes the application value of social capital theory and human capital theory in higher education.

PRACTICAL CONTRIBUTIONS

This research result also provides some useful, practical suggestions. First, since college students' proactive personality has a significant and positive impact on their entrepreneurial intentions, there are several ways in terms of specific practices: colleges can conduct an assessment of proactive personality and promote college students' active consciousness; colleges can carry out psychological quality training classes by introducing situational teaching to strengthen students' willing, and increase college students' proactive personality level.

Second, since college students' social capital has a partial mediation effect between proactive personality and entrepreneurial

intentions, increasing college students' social capital cannot be ignored. Therefore, colleges can take measures from the following aspects: organize various club activities to provide support for college students on their interpersonal relationship; colleges can establish entrepreneurial information platforms so that college students' entrepreneurial relationships can gradually form, which will be convenient for college students to find suitable partners or entrepreneurial mentor rapidly; it is also strongly recommended that colleges establish cooperation relationship with enterprises of different industries in various fields *via* integration of college and enterprises and in the mode of integration of industry and education, to promote college students' social capital.

Third, this research result also shows that college students' human capital partially mediates between proactive personality and entrepreneurial intentions. Therefore, it is suggested to take the following measures: at the same time opening entrepreneurship courses, colleges should also focus on developing entrepreneurship guidance and practice to increase students' entrepreneurial knowledge and skills. Colleges can invite entrepreneurs and college students to deliver lectures to share entrepreneurial experiences with college students. Colleges can hold activities such as entrepreneurship simulation and entrepreneurship competition to train college students' ability to solve problems related to entrepreneurship by allowing them to participate the simulation of real entrepreneurial issues to promote college students' level of human capital.

Finally, this research reveals that college students' social capital and human capital play a significant chain mediating role in the relationship between proactive personality and entrepreneurial intentions. Therefore, if colleges wish to ensure college students' high level of proactive personality to acquire more entrepreneurial intentions, it is necessary to increase college students' social capital and human capital. Social capital can positively influence human capital, and a higher level of human capital can help college students generate more entrepreneurial ideas to promote their entrepreneurial intentions. The chain mediating model of this research has a certain degree of practical contributions.

LIMITATIONS AND FUTURE DIRECTION

There are still several limitations in this research. First, only students in a college in Hebei, China were involved as volunteers of this research, limiting the result's universality. Future research should expand the sample scope and explore college students from various cultural backgrounds from different countries. Second,

this research only discusses social and human capital as mediating variables between college students' proactive personality and entrepreneurial intentions. It still needs further exploration in the future whether there are more mediating variables in the process of influence or whether other variables moderate mediating variables. Furthermore, this research cannot make causal inferences of the nature of cross-section data, so it is suggested that future research adopt longitudinal study, time series cross-lag analysis, or rigorous quasi-experimental design to understand further the dynamic process of changing relationships between variables.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hengshui University. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

Y-FL conceived the study idea, edited the data, performed the analysis and interpretation, drafted the skeleton of the manuscript, and critically reviewed the manuscript. JH contributed to constructing the model, interpretation of model results, and intensively editing the language of the manuscript. SG participated in the revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Impacts of Entrepreneurial Openness and Creativity on Company Growth

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Entrepreneurs as individuals are the main drivers of entrepreneurship and possess distinct personality characteristics. The study focused on entrepreneurial openness and creativity on the entrepreneurial level relative to business growth. Hypotheses were developed and empirically tested in structural equation models using survey data obtained from SMEs' entrepreneurs in three countries. This study adds to what is known about entrepreneurship and small business management in terms of normative research on firm growth by empirically examining the relationships between the entrepreneurial openness, creative personality, and creativity of the entrepreneur and growth of the company. Moreover, the study develops refined internationally comparable measures of entrepreneurial openness, entrepreneur creativity, and a creative personality. An entrepreneur's openness and creative personality may be essential for their creativity. The entrepreneur's creativity may be a vital element of company growth in some countries.

Keywords: entrepreneurial openness, creativity, entrepreneur, personality, growth, entrepreneurship, SMEs

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INTRODUCTION

Entrepreneurs as individuals are the main drivers of entrepreneurship. The personality characteristics of entrepreneurs mean they can make a difference in how their companies perform (Antončič et al., 2018). Despite the notion that variations in performance among companies can be explained by distinct differences among those individuals who lead companies, there is not much research in this area (Mollick, 2012), except for studies that consider individual differences while studying firm performance, like studies investigating managers (Lieberson and O'Connor, 1972; Bertrand and Schoar, 2003; Crossland and Hambrick, 2011; Mollick, 2012) or entrepreneurs (Gimeno et al., 1997; Johnson, 2007; Antončič et al., 2018).

Much research in the entrepreneurship field relies on the assumption that entrepreneurs have distinct personality characteristics that can be identified (Cooper and Dunkelberg, 1987). Personality traits constitutes a broad field attracting intensive research, where it is shown they are able to influence organizations. For example, Ruzzier et al. (2007) state that entrepreneurs draw on their human capital (knowledge, skills, values) to advance the interests of their organization.

Researchers have considered a range of determinants that affect entrepreneurial behavior, such as creativity (Shalley, 1991; Ward, 2004; DiLiello and Houghton, 2006) and the Big Five personality factors (extraversion, agreeableness, conscientiousness, neuroticism, openness to experience; Ciavarella et al., 2004; Zhao et al., 2010; Antončič et al., 2015). It makes sense to examine how entrepreneurial openness affects creativity on the level of the individual—the entrepreneur. Openness to experience is a typical element of entrepreneurship (Singh and DeNoble, 2003). Individuals possessing a high level of openness to experience are tolerant of

ambiguity and able to create distant and unusual associations (McCrae, 2007), which may help in discovering entrepreneurial ideas. We study the construct of entrepreneurial openness, which is a specialized measure of openness in this area of study and thus suitable for consideration. The construct of entrepreneurial openness was developed by Slavec et al. (2017) and helps to understand the impact an entrepreneur's personality has on the performance of their SMEs. In this article, we are interested in whether entrepreneurial openness influences creativity on the level of entrepreneurs such that they can successfully generate useful ideas and solutions and thereby influence the growth of their business. This study intends to fill a gap in the research on creativity and firm-level performance given that only a few studies have assessed this relationship (for example, Von Nordenflycht, 2007; Weinzimmer et al., 2011; Khedhaouria et al., 2015), but without taking account of the entrepreneur's creativity, creative personality and entrepreneurial openness together in a model.

Edwards-Schachter et al. (2015) note that while creativity, innovation, and entrepreneurship are recognized as key ingredients for fostering an entrepreneurial culture, their relationship to a skills-based approach remains insufficiently understood. Creativity is the premise of individual geniuses (Perry-Smith and Mannucci, 2015), while creativity and entrepreneurship are closely connected (Tiwari and Verma, 2020). Creativity may be understood as the creation of new ideas and innovations as well as the commercialization of new ideas (Basadur, 2004), which promotes an entrepreneurial culture (Edwards-Schachter et al., 2015), meaning it is reasonable to explore whether an individual entrepreneur's creativity affects the growth of their company. In summary, this study concentrated on entrepreneurial openness and creativity on the entrepreneurial level relative to business growth.

THEORY AND HYPOTHESES

Growth of the company may be regarded as a key concept in entrepreneurship because entrepreneurship can be growth and growth can be entrepreneurship (Davidsson et al., 2006). The growth of a company has two main connotations: (1) an increase in the amount (of its output, exports and/or sales) and (2) an increase in its size or an improvement in quality of its operations/products/services due a development process (Penrose, 1959, in Davidsson et al., 2010). Company growth typically indicates entrepreneurial success (Gupta et al., 2013) and is essential for economic development and the creation of wealth and employment, being best assessed in both absolute and relative terms (Davidsson and Wiklund, 2006). Growth of the company (including growth in employee numbers, sales and in market share) is often considered an important element of the company's performance (Antončič and Hisrich, 2001). Sales growth may be an appropriate measure of growth in the company's performance because it reflects stronger demand for the company's products/services (Wiklund, 1999).

The right set of entrepreneurial characteristics can boost the results of entrepreneurial activities (for example, Zhao

et al., 2010; Obschonka et al., 2013; Antončič et al., 2018). For instance, Ayala and Manzano (2014) note that three dimensions of entrepreneurial flexibility (courage, ingenuity, optimism) help predict entrepreneurial success, which might prove to be important for this study because flexibility is associated with creativity (Tasan-Kok, 2008). From the point of view of psychology, the constructs selected on the entrepreneurial level to be used in models of growth of the company are well connected and upgraded, one on top of the other.

One may conclude that entrepreneurs express quite considerable entrepreneurial openness that ensures their long-run success; entrepreneurs must be open to new things that can help them do business. Slavec et al. (2017) state that entrepreneurial openness consists of three categories: openness to learning, which directs entrepreneurs to learn about new ways of marketing and management approaches; openness to newness, which is crucial during the processes of innovation adoption; and openness to feedback, since entrepreneurs actively seek feedback to gain a competitive advantage, creatively solve problems, and reshape ideas to make them more relevant to market needs. Accordingly, we study how entrepreneurial openness, which we consider as an independent variable, affects the entrepreneur's creativity.

Creativity is a very complex concept that can be defined, understood and applied in various ways. This means the term must be properly defined for this study's purposes, relying on originality, usefulness, flexibility and mobility as the main criteria for creativity (Štemberger, 2013), whereas the focus is on creativity on the level of the individual entrepreneur. A creative-person approach is therefore used as it seeks to define general and specific abilities, motives and characteristics that describe an individual who makes creative products (Gough, 1979; Carroll, 1993; Eysenck, 1993; Batey and Furnham, 2006), while creativity will be treated as a personal characteristic.

Entrepreneurial creativity is considered in this study as both a dependent variable and partly as an independent one. Creativity is what distinguishes humans from other species, which probably explains this great interest in studying it on a general level (Ko and Butler, 2007). Creativity is directly related to entrepreneurship and entrepreneurs because when change is constant one must continually look for creative solutions to the current challenges. Entrepreneurs are creative in their work due to what is required or expected of them (Antonio et al., 2014). An increase in openness to experience can affect the relationship between quantity of ideas and creativity (Friis-Olivarius and Christensen, 2019). Shi et al. (2016) found positive relationships between openness to experience, intelligence and creative thinking in children in China. McCrae and Costa (1997) note that, on one hand, employees with a high level of openness to experience have access to different approaches and perspectives, and that entrepreneurial openness is a positive personality strength that includes characteristics like acquiring new skills, themes, and bodies of knowledge; discovering new and productive ways of doing things; and contemplating and studying things from all aspects (Slavec et al., 2017). We thus propose hypothesis 1, as follows:

Hypothesis 1: Entrepreneurial openness has a positive effect on the entrepreneur's creativity.

The entrepreneur's creativity may have another antecedent—a creative personality. A creative personality (Kaufman and Baer, 2004) entails general creativity on the level of the individual, whereas the creativity on the level of an entrepreneur (Puhakka, 2005) is more specific to the domain of entrepreneurship. Kaufman et al. (2009) developed the hierarchical creativity construct and found that its most reflective domains were performance and artistic/visual, with its much less reflective domains being math/science and problem-solving. Key items were identified (Kaufman et al., 2009) for each creativity domain: the entrepreneur domain (the most reflective items: advertising and business); the performance domain (acting and film); the math/science domain (life sciences and chemistry); the artistic/visual domain (painting and crafts); the problem-solving domain (mechanical and logic); the interpersonal domain (personal problems and interacting with one's family); and the artistic/verbal one (writing fiction and writing nonfiction). Kaufman et al. (2009) state the question of whether creativity is general (a creative individual) or domain-specific (for example, a creative poet, a creative mathematician, a creative architect) is sometimes left unanswered or ignored. In this study, we include both aspects and hypothesize that people with a higher level of general creativity are more likely to develop a specific form of creativity in entrepreneurship:

Hypothesis 2: A creative personality has a positive effect on the entrepreneur's creativity.

According to one definition, creativity is the imaginative recombination of elements from the past into new configurations needed in the present (Torrance, 1988). Kampylis et al. (2009) define creativity as an activity (both mental and physical) that occurs in a particular time, spatial, social and cultural context and leads to original tangible/intangible outcomes that are useful, ethical and desirable, if not for others then at least for the creator. This knowledge constitutes a scientific challenge on the level of entrepreneurship and thus in this study we explore how the creativity of entrepreneurs affects the growth of their companies. Trstenjak (1981) argued that creativity is built on two starting points in the relationship between the individual and society: the individual in cooperation with society, and vice versa when society encourages the individual.

Innovation (or innovativeness) is a defining ingredient of entrepreneurship (for example, Schumpeter, 1934, 1942) and is crucial for firm performance (for example, Antončič et al., 2007; Antončič and Prodan, 2008). Innovativeness is not included in this study, yet it must be distinguished from creativity. For the purposes of separating the constructs of creativity and innovation on the entrepreneurial level, we note the rationale given by Gurteen (1998) who states that a more useful definition of creativity is the process of generating ideas, while innovation should be seen as a treatment, improvement and, more critically, the implementation of these ideas. Gurteen (1998) listed several differences: creativity refers to divergent thinking, innovation

refers to convergent thinking; creativity refers to generating ideas, innovation puts ideas into action. Being creative means seeing the same things as everyone else, but thinking about something other than what everyone else does (Krueger and Brazeal, 1994).

The relationship between digital creativity and individual academic performance of adolescents can be positive and mediated by parenting styles (Pérez-Fuentes et al., 2019). Peljko et al. (2017) examined the relationship between the entrepreneur's creative abilities and firm growth and obtained mixed results (a positive relationship in a combined sample from Slovenia and the United States of America, yet no relationship in Serbia). Wdowiak et al. (2012) suggest that entrepreneurial behavior can be improved by developing values of the individual like creativity, striving for a challenging life, or autonomy, through the early life of individuals in education and in the family, based on the finding of positive relationships between values held by the individual and entrepreneurial skills in Austria, Poland and Slovenia. Entrepreneurs constantly deal with questions/challenges for which they have no answer. Here, the essence of creativity lies in inventing new and better ways to do things and address certain risks since new ideas can ensure delivery of the planned positive results (Zhou and George, 2001). Creativity is important for organizations' competitiveness and success (Çekmecelioğlu and Özbağ, 2016) as well as entrepreneurial success (Tiwari and Verma, 2020). We thus posit the following hypothesis:

Hypothesis 3: The creativity of the entrepreneur has a positive effect on the growth of their company.

The structural model discussed and verified in this research and reflected in hypotheses H1, H2 and H3 presented in the section above is shown in **Figure 1**.

RESEARCH METHODS

Participants

Data for this study were obtained through an online survey questionnaire. The survey questionnaire was sent in each country (Slovenia, Serbia and Latvia) to a random sample of companies (SMEs) with up to 250 employees by e-mail with a request the questionnaire be filled out by entrepreneurs (owners and/or founders) online or returned by e-mail. Contact e-mails of SMEs were selected from available databases of all companies in each country. Then a probability sampling procedure yielded a smaller number of e-mails, to which the request to fill out the questionnaire was sent in each country. The sample yielded 851 usable responses from entrepreneurs of SMEs with up to 250 employees in three countries: Slovenia ($n=359$), Serbia ($n=154$) and Latvia ($n=338$). Characteristics of the sample are presented in **Table 1**.

The surveyed SMEs were found to be sufficiently representative after comparing the size structure of companies with up to 250 employees in each country between the total population and the sample. The sample firms were generally small (up to 50

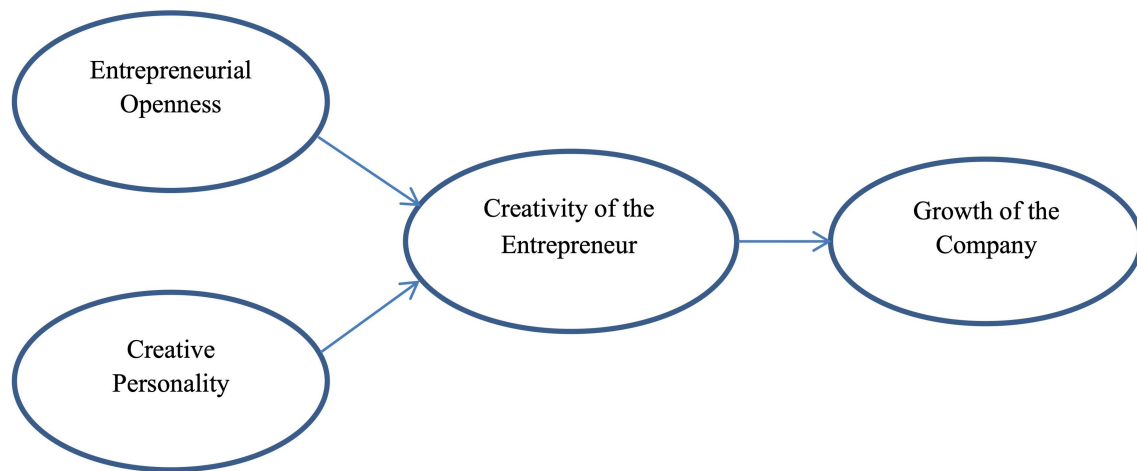


FIGURE 1 | The model of entrepreneurial openness, creativity of the entrepreneur, and growth of the company.

TABLE 1 | Characteristics of the sample.

Characteristics of the sample (<i>n</i> = 851)	Group (<i>n</i>)
Country	Slovenia (359) Serbia (154) Latvia (338)
Gender	Male (387) Female (464)
Age	Younger—over 20–50 years (507) Older—over 50 years (344)
Education	Up to undergraduate (599) Graduate degree (252)
Founder or co-founder	Yes (564) No (287)
Owner or co-owner	Yes (640) No (211)
Industry	Manufacturing (149) Services (702)
Firm age	0–10 years (329) 11 or more years (522)
Size	0–10 employees (631) 11–250 employees (220)
Stage in the life cycle	Start-up—growth (312) Maturity and later (539)

employees: Slovenia 96%, Serbia 97%, Latvia 98%; up to EUR 4 million in annual sales: Slovenia 92%, Serbia 97%, Latvia 96%) and medium-aged (operating in business between 11 and 50 years in Slovenia and Serbia and between 6 and 20 years in Latvia) from various industries (with services prevailing). The sample entrepreneurs were well represented in terms of gender and age (a slight majority of females in Slovenia 63% and Latvia 51% and males 58% in Serbia; the majority over 40 years old: Slovenia 75%, Serbia 60%, Latvia 73%, younger ones also well represented).

Instrument

The survey included four measures (measurement items in Appendices in **Appendix 1–4**): (1) entrepreneurial openness

(Slavec et al., 2017; 11 questions); (2) creative personality (Kaufman and Baer, 2004; 10 questions), which covers general creativity on the level of the individual; (3) creativity on the level of the entrepreneur (Puhakka, 2005; five questions); and (4) growth of the company (Antončič and Hisrich, 2001; Antončič and Antončič, 2011; three items: growth in the number of employees, sales and market share). Control variables were also assessed: industry, company life cycle, gender, age, education, and questions about (co-)ownership and a (co-)founding role in the company.

Procedure

The data from Slovenia were used to develop the model, while the data from Serbia and Latvia were used to validate the models developed on the first sample. The constructs were analyzed for internal consistency and validity (Cronbach's alpha reliability analysis, exploratory and confirmatory factor analysis). SPSS and EQS were used to assess the constructs. The models and hypotheses were tested with structural equation modeling (EQS). EQS was selected because of its benefits (Bentler, 1995): structural modeling in EQS is made simple, consistent, technically advanced, and accurate. Control variables (e.g., industry: production and services; life cycle: early and late stages; gender: female and male) were used while assessing the model differences on the sub-samples.

EMPIRICAL RESULTS

Factor Analysis and Reliability Results

The entrepreneurial openness construct was first tested using exploratory factor analysis (method: ML, rotation: Oblimin) on the three samples (Slovenia, Serbia, Latvia), with the results being presented in **Table 2**. Four items were retained for the analysis based on the size of the communalities and their factor loadings. The appropriateness of factor analysis was ascertained by examining the correlation matrix, where Bartlett's test of sphericity was used

TABLE 2 | The entrepreneurial openness construct—factor analysis and reliability results.

Factor analysis			Sample					
Exploratory (method: ML, rotation: Oblimin)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
KMO			0.77		0.72		0.83	
Bartlett test			346.27		101.02		660.90	
Chi square			6		6		6	
df			0.000		0.000		0.000	
p			45.49%		37.43%		63.43%	
Total variance explained			0.77		0.69		0.87	
Reliability			Cronbach alpha		0.69		0.87	
Items			Communalities after extraction			Factor loadings		
Entrepreneurial openness			Slovenia		Serbia		Latvia	
Slovenia			Serbia		Latvia		Slovenia	
Serbia			Latvia		Slovenia		Serbia	
Latvia			Slovenia		Serbia		Latvia	
New marketing approaches			0.5		0.3		0.6	
Ideas for new products/services			0.5		0.3		0.6	
Examine changes			0.4		0.3		0.6	
An open mind			0.5		0.5		0.7	
Confirmatory (method: ERLS)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
Model			Chi square		3.66		1.86	
Chi square			26.30		3		3	
df			3		0.300		0.603	
p			0.99		0.98		0.97	
Goodness-of-fit			NFI		0.99		1.00	
NFI			0.99		1.00		0.97	
TLI (NNFI)			0.99		1.00		0.97	
IFI			0.03		0.00		0.15	
RMSEA			1.00		1.00		0.97	
CFI			0.77		0.69		0.87	
Composite reliability			RHO		0.76		0.70	
RHO			0.76		0.70		0.84	
Discriminant validity			Average variance extracted (AVE)		0.44		0.38	
Average variance extracted (AVE)			0.44		0.38		0.56	

Items (frequency of occurrence: 1 = never, 2 = very rarely, 3 = rarely, 4 = occasionally, 5 = often, 6 = very often, and 7 = always): I learn new marketing approaches. I look for ideas for new products or services. I carefully examine all changes proposed to me by others (for example, I search for additional information on how to introduce changes, etc.). In terms of business matters, I have an open mind (thinking outside of the box and evaluating all options).

for this purpose. Bartlett's test examines the presence of correlations among the principal variables. In all three countries under study, Bartlett's test was significant ($p < 0.001$), showing that the correlation matrix includes significant correlations. The KMO measure (Kaiser–Meyer–Olkin measure of sampling adequacy) also showed acceptable sampling adequacy results (0.77 in Slovenia, 0.72 in Serbia, 0.83 in Latvia). The Cronbach alpha reliability test results were very good (Slovenia 0.77, Serbia 0.69, Latvia 0.87).

Second, the entrepreneurial openness construct was tested using confirmatory factor analysis (method: ERLS) on the three samples (results in **Table 2**). The confirmatory factor analysis confirmed the results of the exploratory factor analysis. All items had high, positive and significant coefficients. The construct showed good internal consistency (Cronbach alpha reliability: Slovenia 0.77, Serbia 0.69, Latvia 0.87; RHO: Slovenia 0.76, Serbia 0.70, Latvia 0.84). The construct also showed good convergence (model goodness-of-fit indices: NFI: Slovenia 0.99, Serbia 0.98, Latvia 0.97; RMSEA: Slovenia 0.03, Serbia 0.00, Latvia 0.15; CFI: Slovenia 1.00, Serbia 1.00, Latvia 0.97). The construct showed good discriminant validity in Latvia [average variance extracted (AVE) over 0.50 in all three countries] and marginally acceptable in Slovenia and Serbia (AVE around 0.4 with composite reliability over 0.6, Lam, 2012).

The creativity of the entrepreneur construct was first tested using exploratory factor analysis (method: ML, rotation: Oblimin) on the three samples (Slovenia, Serbia, Latvia). The results are shown in **Table 3**. Four items were retained for the analysis based on the size of the communalities and their factor loadings.

In all three countries under examination, Bartlett's test was significant ($p < 0.001$), revealing that the correlation matrix includes significant correlations. The KMO measure (Kaiser–Meyer–Olkin measure of sampling adequacy) also showed acceptable sampling adequacy results (0.81 in Slovenia, 0.77 in Serbia, 0.75 in Latvia). The Cronbach alpha reliability test results were very good (Slovenia 0.85, Serbia 0.81, Latvia 0.80).

Second, the creativity of the entrepreneur construct was tested using confirmatory factor analysis (method: ERLS) on the three samples (results in **Table 3**). The confirmatory factor analysis corroborated the results of the exploratory factor analysis. All items had high, positive and significant coefficients. The construct showed good internal consistency (Cronbach alpha reliability: Slovenia 0.85, Serbia 0.81, Latvia 0.80; RHO: Slovenia 0.86, Serbia 0.80, Latvia 0.80). The construct also showed good convergence (model goodness-of-fit indices: NFI: Slovenia 1.00, Serbia 0.97, Latvia 0.98; RMSEA: Slovenia 0.00, Serbia 0.08, Latvia 0.07; CFI: Slovenia 1.00, Serbia 0.99, Latvia 0.99). The construct showed good discriminant validity (AVE over 0.50 in all three countries).

The creative personality construct was first tested using exploratory factor analysis (method: ML, rotation: Oblimin) on the three samples, with the results being presented in **Table 4**. Three items were retained for the analysis based on the size of the communalities and their factor loadings. In all three countries under study, Bartlett's test was significant ($p < 0.001$), revealing that the correlation matrix includes significant correlations. The KMO measure also showed acceptable

TABLE 3 | The creativity of the entrepreneur construct—factor analysis results.

Factor analysis			Sample					
Exploratory (method: ML, rotation: Oblimin)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
KMO			0.81		0.77		0.75	
Bartlett test			634.72		228.18		540.87	
Chi square			6		6		6	
df			0.000		0.000		0.000	
p			60.07%		55.15%		55.21%	
Total variance explained			0.85		0.81		0.80	
Reliability			Cronbach alpha					
Items			Communalities after extraction			Factor loadings		
Creativity of the entrepreneur			Slovenia		Serbia		Latvia	
Modifying			0.2		0.4		0.4	
New solutions			0.4		0.5		0.2	
Problems' solutions			0.6		0.7		1.0	
Plenty of ideas			0.7		0.6		0.5	
Confirmatory (method: ERLS)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
Model			Chi square		5.72		8.50	
			df		3		3	
			p		0.126		0.037	
Goodness-of-fit			NFI		0.97		0.98	
			TLI (NNFI)		0.97		0.98	
			IFI		0.99		0.99	
			RMSEA		0.08		0.07	
			CFI		0.99		0.99	
Composite reliability			Cronbach alpha		0.81		0.80	
			RHO		0.80		0.80	
Discriminant validity			Average variance extracted (AVE)		0.54		0.53	

Items (agreement with the statement: 1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = moderately agree, and 7 = strongly agree): I am good at modifying normal ways of doing things. New solutions come to my mind even if they are not especially needed. I come up with exceptional and surprising solutions to problems. I have plenty of ideas.

TABLE 4 | The creative personality construct—factor analysis results.

Factor analysis			Sample					
Exploratory (method: ML, rotation: Oblimin)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
KMO			0.60		0.67		0.64	
Bartlett test			257.96		138.00		446.86	
Chi square			3		3		3	
df			0.000		0.000		0.000	
p			50.99%		56.21%		65.59%	
Total variance explained			0.71		0.78		0.83	
Reliability			Cronbach alpha					
Items			Communalities after extraction			Factor loadings		
Creative personality			Slovenia		Serbia		Latvia	
Slovenia			Serbia		Latvia		Slovenia	
Serbia			Latvia		Slovenia		Serbia	
Latvia			Slovenia		Serbia		Latvia	
Do strange things			0.2		0.3		0.4	
Enjoy fantasy			0.8		0.6		1.0	
Love to daydream			0.5		0.6		0.5	
Confirmatory (method: ERLS)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
Model			Chi square		9.35		0.38	
df			1		1		2	
p			0.002		0.535		0.815	
Goodness-of-fit			NFI		0.96		1.00	
TLI (NNFI)			0.94		1.00		0.20	
IFI			0.97		1.00		0.60	
RMSEA			0.15		0.00		0.00	
CFI			0.96		1.00		1.00	
Composite reliability			Cronbach alpha		0.71		0.78	
RHO			0.79		0.78		0.85	
Discriminant validity			Average variance extracted (AVE)		0.56		0.55	

Items (agreement with the statement: 1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = moderately agree, and 7 = strongly agree): I do things that others find strange. I enjoy wild flights of fantasy. I love to daydream.

TABLE 5 | Firm growth construct—factor analysis results.

Factor analysis			Sample					
Exploratory (method: ML, rotation: Oblimin)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
KMO			0.66		0.64		0.58	
Bartlett test			204.50		85.85		198.63	
Chi square			3		3		3	
df			0.000		0.000		0.000	
p			46.01%		46.40%		50.09%	
Total variance explained			0.70		0.70		0.67	
Reliability			Cronbach alpha					
			0.70		0.70		0.67	
Items			Communalities after extraction			Factor loadings		
Growth			Slovenia		Serbia		Latvia	
			Slovenia		Serbia		Latvia	
No. of employees			0.3		0.3		0.2	
Sales			0.6		0.7		1.0	
Market share			0.4		0.4		0.3	
Confirmatory (method: ERLS)			Slovenia (n = 359)		Serbia (n = 154)		Latvia (n = 338)	
Model			Chi square		2.91		36.21	
			df		1		1	
			p		0.088		0.000	
Goodness-of-fit			NFI		0.96		0.97	
			TLI (NNFI)		0.90		0.94	
			IFI		0.97		0.98	
			RMSEA		0.13		0.11	
			CFI		0.97		0.98	
Composite reliability			Cronbach alpha		0.70		0.70	
			RHO		0.76		0.75	
Discriminant validity			Average variance extracted (AVE)		0.51		0.50	
							0.63	

Items: average annual growth in number of employees over the last 3 years (1 = less than 0%, 2 = 0%–4%, 3 = 5%–9%, 4 = 10%–19%, 5 = 20%–35%, 6 = more than 35%). Average annual growth in sales over the last 3 years (1 = less than 5%, 2 = 5%–9%, 3 = 10%–19%, 4 = 20%–34%, 5 = 35%–50%, 6 = more than 50%). Growth in market share over the last 3 years (the market share of your company is ... 1 = decreasing, 2 = holding its own, 3 = increasing slightly, 4 = increasing moderately, and 5 = increasing significantly).

sampling adequacy results (Slovenia 0.60, Serbia 0.67, Latvia 0.64). The Cronbach alpha reliability test results were moderate (Slovenia 0.71, Serbia 0.78, Latvia 0.83).

Second, the creative personality construct was tested using confirmatory factor analysis (method: ERLS) on the three samples (results in Table 4). The confirmatory factor analysis confirmed the results of the exploratory factor analysis. All items had high, positive and significant coefficients. The construct showed good internal consistency (Cronbach alpha reliability: Slovenia 0.71, Serbia 0.78, Latvia 0.83; RHO: Slovenia 0.79, Serbia 0.78, Latvia 0.85). The construct also showed good convergence (model goodness-of-fit indices: NFI: Slovenia 0.96, Serbia 1.00, Latvia 1.00; RMSEA: Slovenia 0.15, Serbia 0.00, Latvia 0.00; CFI: Slovenia 0.96, Serbia 1.00, Latvia 1.00). The construct showed good discriminant validity (AVE over 0.50 in all three countries).

The firm growth construct was initially tested using exploratory factor analysis (method: ML, rotation: Oblimin) on the three samples. The results are presented in Table 5. All three items were retained for the analysis based on the size of the communalities and their factor loadings. In all three countries under examination, Bartlett's test was significant ($p < 0.001$). The KMO measure also showed acceptable sampling adequacy results (Slovenia 0.66, Serbia 0.64, Latvia 0.58). The Cronbach alpha reliability test results were good (Slovenia 0.70, Serbia 0.70, Latvia 0.67).

The firm growth construct was then tested using confirmatory factor analysis (method: ERLS) on the three samples (results in Table 5). The confirmatory factor analysis supported the

results of the exploratory factor analysis. All items had high, positive and significant coefficients. The construct showed good internal consistency (Cronbach alpha reliability: Slovenia 0.70, Serbia 0.70, Latvia 0.67; RHO: Slovenia 0.76, Serbia 0.75, Latvia 0.84). The construct also showed good convergence in Slovenia and Serbia and somewhat less good convergence in Latvia (model goodness-of-fit indices: NFI: Slovenia 0.96, Serbia 0.97, Latvia 0.68; RMSEA: Slovenia 0.13, Serbia 0.11, Latvia 0.32; CFI: Slovenia 0.97, Serbia 0.98, Latvia 0.68). The construct showed good discriminant validity (AVE over 0.50 in all three countries).

Non-response Bias and Common Method Bias Tests

Non-response bias was tested by applying the approach of Armstrong and Overton (1977), who stated that late respondents can be more like non-respondents. All model items' means were compared for each country between these two groups (early respondents and late respondents), formed by using a median split based on the response time. Only for a few items in t-tests were significant mean differences found (the items "I enjoy wild flights of fantasy," "I love to daydream," and "growth in market share" in Slovenia, one item "new solutions come to my mind even if they are not especially needed" in Serbia, and no item in Latvia). These results indicate minimal response bias in this study.

Common method bias was tested using the approach of Harman (1976), for which Podsakoff and Organ (1986) suggested that common method bias can be assessed by applying the 50%

threshold of total variance extracted in the one-factor test. All model items were included for each country in factor analysis with one fixed factor by using the principal components method of extraction. The total variance explained by a single factor was found to be below the 50% threshold in all three countries (33.9% in Slovenia, 30.0% in Serbia, 24.1% in Latvia), therefore the common method bias was not found to be present in this study.

Structural Equation Modeling Results

The hypothesized relationships were tested in a model with structural equation modeling (method: ERLS) on both the overall data and the three samples (results shown in **Tables 6, 7**). The models were established to be appropriate both overall and in all three countries (model goodness-of-fit indices: NFI: overall 0.95, Slovenia 0.92, Serbia 0.90, Latvia 1.00; RMSEA: overall 0.06, Slovenia 0.07, Serbia 0.04, Latvia 0.03; CFI: overall 0.96, Slovenia 0.95, Serbia 0.98, Latvia 1.00; internal consistency: Cronbach alpha reliability: overall 0.79, Slovenia 0.83, Serbia 0.79, Latvia 0.74; RHO: overall 0.87, Slovenia 0.89, Serbia 0.86, Latvia 0.86).

Hypothesis 1 predicted a positive relationship between entrepreneurial openness and the creativity of the entrepreneur. Coefficients were found positive and significant overall and in all three countries (standardized coefficients: overall 0.39, Slovenia 0.64, Serbia 0.51, Latvia 0.14). These results act to support H1.

Hypothesis 2 predicted a positive relationship between a creative personality and the creativity of the entrepreneur. Coefficients were found positive and significant overall and in all three countries (standardized coefficients: overall 0.27, Slovenia 0.21, Serbia 0.34, Latvia 0.15). The results provide support for H2. Variance explained (R-squared) was found to be substantial overall (0.25), in Slovenia (0.54) and in Serbia (0.47), and lower in Latvia (0.04).

Hypothesis 3 predicted a positive relationship between the entrepreneur's creativity and the growth of the firm. Coefficients were found to be positive and significant overall and in two of the three countries (standardized coefficients: overall 0.13, Slovenia 0.23, Serbia 0.23). Variance explained (R-squared) was found to be low overall (0.02), in Slovenia (0.05) and in Serbia (0.05), and non-existent in Latvia (0.00). The results mostly lend support for H3, except for Latvia.

The variability of the structural model results was tested by splitting the overall sample by control variables (results shown in **Tables 8, 9**). The entrepreneurial openness–creativity of the entrepreneur relationship coefficient was positive and significant on all control variables' sub-samples, with one exception (positive and non-significant for the graduate education group), showing considerable support for H1. The creative personality–creativity of the entrepreneur relationship coefficient was positive and significant on all control variables' sub-samples, showing a high level of support for H2. The creativity of the entrepreneur–growth relationship coefficient was positive on all sub-samples and significant in the majority of sub-samples, which means good support for H3. In addition to direct effects, some smaller indirect effects were detected in the model for the indirect effect of entrepreneurial openness and creative personality on growth through the creativity of the entrepreneur.

DISCUSSION, CONTRIBUTIONS, AND IMPLICATIONS

A positive relationship between the entrepreneur's entrepreneurial openness and their creativity was found in all three countries under study. Based on their openness (e.g., to learn new marketing approaches, look for ideas for new products or services, carefully examine all changes proposed by others, think outside of the box, evaluate all options), individuals will tend to develop entrepreneurial creativity (e.g., to become good at modifying the normal ways of doing things, new solutions come to mind even if not especially needed, inventing exceptional and surprising solutions for problems, and having plenty of ideas). A positive relationship between the entrepreneur's creative personality and their creativity was established. The creative personality (e.g., doing things that others find strange, enjoying wild flights of fantasy, loving to daydream) can influence entrepreneurial creativity. We may conclude that entrepreneurial openness and creative personality may be important antecedents of the entrepreneur's creativity. A positive relationship between the creativity of the entrepreneur and firm growth was found in two of the three

TABLE 6 | Structural equation modeling results (standardized coefficients and variance explained).

Sample (n)	EO-CE	CP-CE	CE-GR	R2CE	R2GR
Total (851)	0.39***	0.27***	0.13**	0.25	0.02
Slovenia (359)	0.64***	0.21***	0.23***	0.54	0.05
Serbia (154)	0.51***	0.34***	0.23*	0.47	0.05
Latvia (338)	0.14*	0.15*	-0.03	0.04	0.00

EO-CE: the entrepreneurial openness–creativity of the entrepreneur relationship coefficient. CP-CE: the creative personality–creativity of the entrepreneur relationship coefficient. CE-GR: the creativity of the entrepreneur–growth relationship coefficient. R2CE: variance explained (R-squared) of the creativity of the entrepreneur. R2GR: variance explained (R-squared) of the firm's growth. * $p < 0.05$ (two-sided); ** $p < 0.01$ (two-sided); *** $p < 0.001$ (two-sided).

TABLE 7 | Structural equation modeling results (goodness-of-fit and reliability).

Sample (n)	Chi	df	Sig.	NFI	RMSEA	CFI	RHO	Cronbach alpha
Total (851)	266.28	75	0.000	0.95	0.06	0.96	0.87	0.79
Slovenia (359)	219.45	75	0.000	0.92	0.07	0.95	0.89	0.83
Serbia (154)	96.59	75	0.047	0.90	0.04	0.98	0.86	0.79
Latvia (338)	105.48	77	0.017	1.00	0.03	1.00	0.86	0.74

TABLE 8 | Structural equation modeling results—controls (coefficients and variance explained).

Control group	(n)	EO-CE	CP-CE	CE-GR	R2CE	R2GR
Gender	Male (387)	0.22*	0.35*	0.14*	0.19	0.02
	Female (464)	0.50*	0.23*	0.11•	0.16	0.01
Age	Younger—over 20–50 years (507)	0.42*	0.25*	0.19*	0.28	0.01
	Older—over 50 years (344)	0.34*	0.31*	0.15*	0.24	0.02
Education	Up to undergraduate (599)	0.51*	0.26*	0.17*	0.38	0.03
	Graduate degree (252)	0.11	0.20*	0.03	0.06	0.00
Founder or co-founder	Yes (564)	0.45*	0.24*	0.19*	0.31	0.03
	No (287)	0.30*	0.28*	0.03	0.18	0.00
Owner or co-owner	Yes (640)	0.42*	0.26*	0.14*	0.28	0.02
	No (211)	0.33*	0.31*	0.09	0.22	0.01
Industry	Manufacturing (149)	0.32*	0.28*	0.18•	0.23	0.03
	Services (702)	0.40*	0.28*	0.11*	0.26	0.01
Firm age	0–10 years (329)	0.40*	0.22*	0.10	0.22	0.01
	11 or more years (522)	0.37*	0.30*	0.13*	0.27	0.02
Size	0–10 employees (631)	0.33*	0.26*	0.08	0.21	0.01
	11–250 employees (220)	0.50*	0.29*	0.17•	0.42	0.03
Stage in the life cycle	Start-up-growth (312)	0.47*	0.29*	0.20*	0.35	0.04
	Maturity and later (539)	0.33*	0.26*	0.06	0.20	0.00

EO-CE: the entrepreneurial openness–creativity of the entrepreneur relationship coefficient. CP-CE: the creative personality–creativity of the entrepreneur relationship coefficient. CE-GR: the creativity of the entrepreneur–growth relationship coefficient. R2CE: variance explained (R-squared) of the creativity of the entrepreneur. R2GR: the variance explained (R-squared) of the firm's growth. * $p < 0.05$ (two-sided); • $p < 0.10$ (two-sided).

TABLE 9 | Structural equation modeling results—controls (goodness-of-fit and reliability).

Control group	(n)	Chi	df	Sig.	NFI	RMSEA	CFI	RHO	Cronbach alpha
Gender	Male (387)	157.78	75	0.000	0.93	0.05	0.96	0.86	0.78
	Female (464)	190.72	75	0.000	0.94	0.06	0.96	0.87	0.80
Age	Younger—over 20–50 years (507)	194.47	75	0.000	0.94	0.06	0.96	0.86	0.79
	Older—over 50 years (344)	153.38	75	0.000	0.93	0.05	0.96	0.87	0.79
Education	Up to undergraduate (599)	224.74	75	0.000	0.95	0.06	0.96	0.88	0.81
	Graduate degree (252)	103.92	75	0.015	0.92	0.04	0.97	0.83	0.73
Founder or co-founder	Yes (564)	219.18	75	0.000	0.94	0.06	0.96	0.87	0.81
	No (287)	145.51	75	0.000	0.92	0.06	0.96	0.85	0.75
Owner or co-owner	Yes (640)	225.19	75	0.000	0.94	0.06	0.96	0.87	0.80
	No (211)	121.49	75	0.001	0.90	0.05	0.96	0.85	0.76
Industry	Manufacturing (149)	102.92	75	0.018	0.89	0.05	0.97	0.86	0.78
	Services (702)	230.08	75	0.000	0.95	0.05	0.96	0.87	0.79
Firm age	0–10 years (329)	167.91	75	0.000	0.92	0.06	0.95	0.86	0.79
	11 or more years (522)	172.61	75	0.000	0.94	0.05	0.97	0.87	0.79
Size	0–10 employees (631)	200.88	75	0.000	0.95	0.05	0.97	0.87	0.78
	11–250 employees (220)	137.67	75	0.000	0.90	0.06	0.95	0.86	0.80
Stage in the life cycle	Start-up-growth (312)	156.35	75	0.000	0.93	0.06	0.96	0.87	0.81
	Maturity and later (539)	191.09	75	0.000	0.94	0.05	0.96	0.86	0.77

countries (Slovenia and Serbia, but not in Latvia). The entrepreneur's creativity can be an influential driver of their firm's growth (growth in the number of employees, sales growth, growth in market share) in some countries (in Slovenia and Serbia in our study) and not in others (Latvia in our study). This might reflect differences in culture among the three countries in this study because national culture and its individual elements can influence entrepreneurial growth intentions (Leković and Berber, 2019).

The contribution to science made by this study is the conceptually developed and empirically tested model of entrepreneurial openness, creativity, and growth. This study makes a theoretical contribution by showing that the entrepreneur's openness and possession of a creative personality

may be important for the entrepreneur's creativity and that this very creativity may be important for the growth of their firm. These results were found on samples of entrepreneurs from three European countries (Slovenia, Serbia, Latvia), except for the entrepreneurial creativity–growth relationship in Latvia. The empirical results based on the model of entrepreneurial openness, creativity, and firm growth contribute to the normative research on firm growth (for instance, research on creativity and firm performance: Von Nordenflycht, 2007; Weinzimmer et al., 2011; Khedhaouria et al., 2015) by revealing the importance of entrepreneurial openness and a creative personality for predicting the entrepreneur's creativity, and the importance of the entrepreneur's creativity for their firm's growth.

The findings from this study extend research on entrepreneurial personality (e.g., Gimeno et al., 1997; Johnson, 2007; Antončič et al., 2018) and research on creativity and success (e.g., Çekmecelioğlu and Özbağ, 2016; Peljko et al., 2017; Tiwari and Verma, 2020) by adding constructs of entrepreneurial openness and creative personality in the model. The study confirms previous findings on the relationship between entrepreneurial openness and creativity (e.g., Shi et al., 2016; Friis-Olivarius and Christensen, 2019). The study clarifies the structure of constructs of entrepreneurial openness (Slavec et al., 2017), creative personality (Kaufman and Baer, 2004) and entrepreneur's creativity (Puhakka, 2005) by testing the constructs on data from three countries.

This study contributes to comparative international entrepreneurship research because it involves a multi-country study of entrepreneurial activity that includes the four levels classified by Terjesen et al. (2016): individual, firm, industry and country. These levels were embodied in the following:

1. The individual level: characteristics of entrepreneurs related to entrepreneurial openness, creativity of the entrepreneur, a creative personality, and the individual controls of gender, age, education, a (co-)ownership and a (co-)founding role in the company.
2. The firm level: growth of the company and the company controls of size, age and life cycle.
3. The industry level: a control variable industry (production and services).
4. The country level: three different countries (Slovenia, Serbia, and Latvia).

The study also makes an empirical contribution by refining or retesting measures of entrepreneurial openness (Slavec et al., 2017), the entrepreneur's creativity (Puhakka, 2005), and a creative personality (Kaufman and Baer, 2004) in three countries and revealing the key internationally comparable (etic) items:

1. Entrepreneurial openness items: I learn new marketing approaches. I look for ideas for new products or services. I carefully examine all changes proposed to me by others (for example, I search for additional information on how to introduce changes, etc.). In terms of business matters, I have an open mind (thinking outside of the box and evaluating all options).
2. Creativity of the entrepreneur items: I am good at modifying normally used ways of doing things. New solutions come to my mind even if they are not especially needed. I come up with exceptional and surprising solutions to problems. I have plenty of ideas.
3. Creative personality items: I do things that others find strange. I enjoy wild flights of fantasy. I love to daydream.

This study holds implications for theory, research and practice. Theory can better focus on entrepreneurial openness and creativity on the level of the entrepreneur in the prediction of firm growth. On one hand, company growth can depend on creative entrepreneurs who can spot opportunities for growth. Creativity may be connected to entrepreneurship because creativity stimulates the recognizing of new

opportunities (for example, Shane, 2003; Gielnik et al., 2012). On the other hand, growth might not be about creativity but more about imitating or copying others (for example, Schmitz, 1989; Segerstrom, 1991; Szulanski and Jensen, 2008). With this study we have added some evidence to help resolve this controversy (creativity vs. copying) by focusing on creativity and showing that growth of the company can depend on creative entrepreneurs in Slovenia and Serbia and on copying or other factors in Latvia.

Researchers can use the three cross-nationally comparable measures (openness of the entrepreneur, creative personality, and creativity of the entrepreneur) in their research. Practitioners and policymakers must take into account that the personality of the entrepreneur as concerns their openness and creativity might be important for the growth of their company (growth in employee numbers, sales, and market share), meaning that education and training for companies and students must focus more strongly on developing the openness and creativity of individuals in order to improve business results (growth). Education and training should concentrate on developing entrepreneurial openness (in terms of learning new marketing approaches, searching for ideas for new products/services, searching for information on how to introduce changes, and thinking outside of the box), entrepreneurial creativity (in terms of encouraging numerous ideas, modifying the normal ways of doing things, searching for new solutions even if they are not needed, and coming up with exceptional and surprising solutions to problems), and a creative personality (in terms of encouraging wild fantasizing, daydreaming, and doing things that others find strange).

LIMITATIONS AND FUTURE RESEARCH POSSIBILITIES

This study is not without its limitations. The main limitations are: (1) the model which is developed is a partial model in that only some psychological constructs of the entrepreneur were considered; for example, the creativity of the entrepreneur could have other antecedents: self-efficacy, internal locus of control, achievement, and materialism (Nisula and Olander, 2020), whereas growth of the company could have other antecedents: firm strategy factors (for example, customer orientation, competitor orientation, relationship coordination) and industry characteristics (for example, industry growth; Leischnig et al., 2016). (2) The use of closed-ended questions and perceptual measures in the questionnaire. (3) The possible indications (NFI = 1; RMSEA = 0.000) of saturations of some of the structural models. (4) Data were collected in the same time period and thus inferences about causality in the hypotheses were developed based on the literature and not directly verified. (5) Data from SMEs' entrepreneurs were collected in three European countries and thus the results might not be fully relevant to all countries around the world.

For future research, we suggest: (1) the relationships between the constructs entrepreneurial openness, creative personality and

creativity of the entrepreneur on the individual level and the growth construct (firm level) could be further examined in other countries, perhaps by adding some other variables and/or constructs. (2) The cross-country comparable measures employed in this study could be upgraded in future research. (3) Qualitative research techniques like in-depth interviews might improve knowledge about the content and functioning of the conversions of personal-level activities and aspirations (related to openness and creativity) to firm-level business results (growth).

CONCLUSION

This study contributes to knowledge about entrepreneurship and small business management in terms of normative research on firm growth by empirically examining the relationships between the entrepreneurial openness, creative personality, and creativity of the entrepreneur and growth of their company. Further, the study developed refined cross-nationally comparable measures of entrepreneurial openness, creativity of the entrepreneur, and creative personality. The entrepreneur's openness and creative personality may be essential for their creativity. The entrepreneur's creativity may be vital for the growth of their company in some countries.

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DATA AVAILABILITY STATEMENT

The datasets presented in this article will be made available by the authors upon request. Requests to access the datasets should be directed to ziga.peljko@kd-group.si; jasna.auer@fm-kp.si.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

ŽP and JA developed the research project, carried out the data collection, and revised the manuscript. ŽP carried out the data analysis and wrote the first draft. All authors contributed to the article and approved the submitted version.

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APPENDIX

Appendix 1 | Entrepreneurial openness items (Slavec et al., 2017).

	Frequency of occurrence: 1 = never, 2 = very rarely, 3 = rarely, 4 = occasionally, 5 = often, 6 = very often, 7 = always						
I follow successful entrepreneurs to learn something from them (I watch TV shows about successful entrepreneurs and/or attend their lectures and/or read articles about them).	1	2	3	4	5	6	7
I learn new marketing approaches.	1	2	3	4	5	6	7
I learn new approaches about managing the business.	1	2	3	4	5	6	7
I look for ideas for new products or services.	1	2	3	4	5	6	7
I look for new markets.	1	2	3	4	5	6	7
I look for new business partners.	1	2	3	4	5	6	7
I search for information about introducing my firm into new geographic markets.	1	2	3	4	5	6	7
I carefully examine all changes proposed to me by others (for example, I search for additional information on how to introduce changes, etc.).	1	2	3	4	5	6	7
I ask employees for their opinion on which improvements could be introduced.	1	2	3	4	5	6	7
In terms of business matters, I have an open mind (thinking outside of the box and evaluating all options).	1	2	3	4	5	6	7
In business, I search for creative solutions.	1	2	3	4	5	6	7

Appendix 2 | Creative personality items (Kaufman and Baer, 2004).

	Accuracy of the statement: 1 = very inaccurate, 2 = inaccurate, 3 = moderately inaccurate, 4 = neither inaccurate nor accurate, 5 = moderately accurate, 6 = accurate, 7 = very accurate						
1. I do things that others find strange.	1	2	3	4	5	6	7
2. I like to get lost in thought.	1	2	3	4	5	6	7
3. I enjoy wild flights of fantasy.	1	2	3	4	5	6	7
4. I do things by the book.	1	2	3	4	5	6	7
5. I love to daydream.	1	2	3	4	5	6	7
6. I swim against the current.	1	2	3	4	5	6	7
7. I like to solve complex problems.	1	2	3	4	5	6	7
8. I am not interested in abstract ideas.	1	2	3	4	5	6	7
9. I love to read challenging material.	1	2	3	4	5	6	7
10. I have a vivid imagination.	1	2	3	4	5	6	7

Appendix 3 | Creativity of the entrepreneur items (Puhakka, 2005).

	Agreement with the statement: 1 = strongly disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = moderately agree, 7 = strongly agree						
1. I am good at modifying normally used ways of doing things.	1	2	3	4	5	6	7
2. I'm sensitive to seeing problems that others do not see.	1	2	3	4	5	6	7
3. New solutions come to my mind even if they are not especially needed.	1	2	3	4	5	6	7
4. I come up with exceptional and surprising solutions to problems.	1	2	3	4	5	6	7
5. I have plenty of ideas.	1	2	3	4	5	6	7

Appendix 4 | Growth of the company items (Antončič and Hisrich, 2001; Antončič and Antončič, 2011).

Growth of your company		
1. Average annual growth in number of employees over the last 3 years:		
Less than 0%	0%–4%	5%–9%
10%–19%	20%–35%	More than 35%
2. Average annual growth in sales over the last 3 years:		
Less than 5%	5%–9%	10%–19%
20%–34%	35%–50%	More than 50%
3. Growth in market share over the last 3 years: the market share of your company is...		
Decreasing	Holding its own	Increasing slightly
Increasing moderately	Increasing significantly	



Interactive Association of Negative Creative Thinking and Malevolent Creative Thinking

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With the existing research available on negative and malevolent creativity, this paper proposes a more narrowly defined concept: the bi-directional relationship between negative and malevolent creative thinking, which is intended to clarify the way forward for research in the area of negative and malevolent creativity. This paper uses qualitative research to identify and correlate an individual's concept of negative and malevolent creativity and uses a Inductive reasoning methodology to outline a preliminary theory. Following this, the preliminary theory was returned to the primary sources for validation, continuous optimization, and presentation. To better demonstrate the bidirectional linkage mechanism of thinking between the two types, this paper constructed a model to describe the relationships between the variables. This study concludes that negative creative thinking is a kind of native thinking based on personal interests that are developed to emphasize the benefits of an individual's interests, while malevolent creative thinking is a kind of native thinking based on the value-added of personal interests and is deliberately harmful. Both types of thinking share a value orientation, environmental stimulation, and subjective motivation. However, they differ in terms of value goals, ways of thinking, and the scale of the subject. It is concluded from the intrinsic thinking logic of individual thinking as well as the temporal dimension of the individual creative process that value-added and intentions to exploit others are factors that drive the transformation of negative creative thinking into malevolent creative thinking, and personal intention is a vital factor for establishing a linkage between negative and malevolent creative thinking.

Keywords: negative creative thinking, malevolent creative thinking, linkage model, value-add, linkage

INTRODUCTION

In the field of education there is a consensus almost unanimously that creativity can be taught (Cropley, 1992; Runco and Chand, 1995; Amabile et al., 1996; Wilson, 2005; Baer and Kaufman, 2006; Kaufman and Beghetto, 2009). Creativity education consists of two main aspects. The first aspect is about teaching and learning, that is, how to provide creative and innovative educational practices that stimulate higher-level thinking and opportunities to explore multiple alternative solutions (Cropley, 1992; Fryer, 1996; Lin, 2011). The second aspect is the creation of a supportive environment, which can stimulate learners' motivation and creative behavior (Torrance, 1995; Collins and Amabile, 1999; Hennessey, 2007; Lin, 2011). In creativity education, it is largely the teacher who guides students through the creative process.

Scholarly research on creativity has mostly focused on the forms of creation and its originality and appropriateness (Runco and Jaeger, 2012). In other words, it is the study of the positive side of creativity (Cropley et al., 2014). However, creativity does not always lead to positive outcomes (Clark and James, 1999; Cropley and Cropley, 2011; Harris and Reiter-Palmon, 2015; Ligon et al., 2017), and Carl (1954) illustrates the existence of another side of creativity. Identifying the connotations of negative creative thinking and malevolent creative thinking as well as clarifying the differences and connections between the two types of thinking will help rationalize the relevant academic discourse system and standardize our research; at the same time, it will also help researchers to think more accurately about the thinking cultivation paths in the creative process and thus further promote the development of creative education. Therefore, this paper will separately discuss the core connotations of negative creative thinking and malevolent creative thinking, identify the similarities and differences in connotations between them, and propose a linkage model of negative creative thinking and malevolent creative thinking to remove conceptual barriers for the development of thinking research and provide a foundation for further research on the interaction mechanism between negative creative thinking and malevolent creative thinking.

METHODOLOGY

Through qualitative research, this paper aims to inductively advance negative, malevolent creativity. This study was conducted using the Inductive reasoning method. Initially, a multistage data collection process was conducted to distill key information to be able to introduce new models from known theories (Strauss and Corbin, 1990, 1998; Polkowski, 2011). In the next step, a comparative analysis of the information that continues to emerge utilizes the concepts of negative and malevolent creativity, compares these concepts, considers the differences and similarities that exist between them, and ties these differences and similarities together. The preliminary hypothesis is: that there is an interactive association between the two types of thinking. It is then returned to the original source for validation and the existing theory is continuously optimized to make it more precise. Finally, the theory is explained, layer by layer, by describing the relationship between the two thinkings, as an answer to the research question. For better display of the linkage relationship, it is proposed to be presented in the form of visual images.

CONCEPTS DEFINITION

The Connotation of Malevolent Creative Thinking

Malevolent creative thinking is the creation of products that cause harm to humans and society and is therefore defined as creativity that intentionally leads to harmful or unethical outcomes (Ning and Jing, 2016). Malevolent creative thinking is not only associated with terrorism and crime (Cropley et al., 2008; Gill et al., 2013), but ordinary people also

generate malevolent creative thinking. That is caused by a number of situational factors (Barbot et al., 2020). For example, dissatisfaction with society (Clark and James, 1999; Harris and Reiter-Palmon, 2015; Gutworth et al., 2016; Kapoor and Khan, 2019). Second, low emotional intelligence (EI) can also produce malevolent creative thinking (Harris et al., 2013). In addition, negative personality traits can also contribute to malevolent creative thinking, for example, trait physical aggression (Lee and Dow, 2011), implicit aggression, low pre-mediation (Harris and Reiter-Palmon, 2015), and low emotional intelligence (Harris et al., 2013). Malevolent creative thinking is characterized by intentional harm (Cropley et al., 2008).

The Connotations of Negative Creative Thinking

Negative creative thinking is associated with narcissism, mental illness, and Machiavellianism (Hansika, 2015). Negative creative thinking is an intersection of originality and value as well, and is the use of creative processes to achieve negative goals, but without the intention of intentional harm (Clark and James, 1999; James et al., 1999; Kapoor, 2018). This behavior prioritizes self-service.

Identifying the Connotation of Negative Creative Thinking and Malevolent Creative Thinking

Common Ground

There are high similarities between the two in the following 3 areas: First, the value orientation converges (Value). Both Malevolent Creative Thinking and Negative Creative Thinking are at the highest level of higher-order thinking and are usually closely linked to design thinking, analytical thinking, and critical thinking to achieve personal goals through the act of problem-solving. The intersection of originality and value is the value orientation of both malevolent creative thinking and negative creative thinking. The second is environmental stimulation (Environment). Kapoor and Khan (2019) provide an explanation for the situational variable that individuals are more willing to think malicious or negative creative thoughts in response to negative or unjust situations (Clark and James, 1999; Harris and Reiter-Palmon, 2015; Gutworth et al., 2016; Kapoor and Khan, 2019). The third is subjective motivation (Motivation). Both types of thinking are conscious and purposeful, and both require the support of personal intention factors (Mueller et al., 2012; Gutworth et al., 2016). When an individual's creative potential and tendency to react maliciously are controlled, the probability of malicious or negative thoughts being generated is reduced (Xu et al., 2021, 2022; Wang et al., 2022).

Connotation Differences

Different Value Goals

There is a threshold between malevolent creative thinking and negative creative thinking, which is the balance between individual and social interests (Mueller et al., 2012; Gutworth et al., 2016). Malevolent creative thinking intentionally causes harm to others and society in order to maximize personal

interests (Eisenberger and Shanock, 2003; Cerasoli et al., 2014; Bochkova and Meshkova, 2019). While negative creative thinking seeks to achieve negative self-centered goals by creating new pathways that do not harm others and do not involve intentional destruction of the public good. While personal interest is the core of both types of thinking, whether or not one intends to harm others is the key to defining them (Cropley et al., 2008; Ning and Jing, 2016). The transformation process from negative creative thinking to malevolent creative thinking involves many elements, such as risk-taking.

Thinking Styles

Negative creative thinking is the generation of negative ideas and the development of ideas to achieve personal negative ideas and purposes (Clark and James, 1999; James et al., 1999; Kapoor, 2018); malevolent creative thinking is the creative approach to achieve maximum value-added for self-interest and is deliberately harmful in nature. Malevolence covers the highest level of negative expression. Negative creativity is the satisfaction of an individual's expected benefits, and its thought process includes solving problems as well as achieving some practical utility (James et al., 1999; Kapoor, 2018). In contrast, malevolent creation is the infinite amplification of value in spite of everything and based on negative creative thinking, it includes the idea of intentionally harming others to satisfy one's own malicious psychological achievements (Cropley et al., 2008; Runco, 2010; Ning and Jing, 2016). It can be seen that negative creative thinking is the original conception to achieve the personal benefit, and malevolent creative thinking is the original conception to add value and satisfy evil psychological fulfillment. Generally speaking, malice begins when higher added value emerges and has a motivation for change.

Different Subject Sizes

The process of negative creation is mostly based on a single creative subject; while the process of malicious creation is logically individual-based, but actually focuses on other aspects because of its nature of intentional harm (Hunter et al., 2022). Malevolent creation and negative creation are both systematic creations, relying on individuals to complete the process of transformation from creation to value. However, the process of value calculation and evaluation is more important in the development of malevolent creative thinking than negative creative thinking and contains more factors (Hunter et al., 2022). For example, making explicit and structuring unclear values as well as psychological satisfaction from intentional harm to the individual. As a result, malevolent creative thinking requires more consideration of collaboration with other factors and a larger scale of thinking subjects.

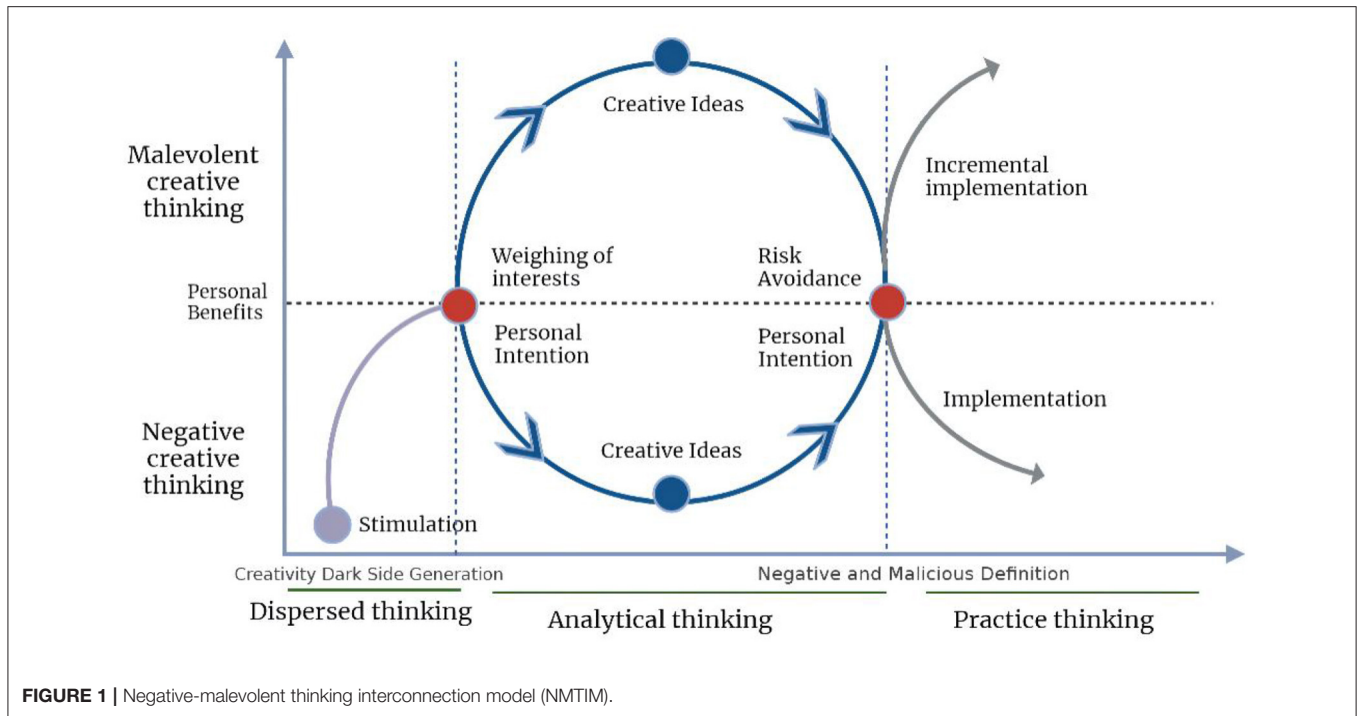
The preceding concepts of negative and malevolent creativity revealed considerable disparities in the conceptual definitions of negative and malevolent creative thinking. Negative creative thinking is a sort of original thinking that is founded on personal interests and then develops to emphasize the benefits of individual self-interest; malevolent creative thinking is original thinking that is based on the value-added of personal interests and has the nature of purposeful harm. In terms of value

orientation, contextual stimulation, and subjective motivation, the two styles of thinking overlap. They differ, however, in terms of value goals, thinking styles, and subject size. We propose a more narrowly defined concept: the bi-directional linkage mechanism of negative-malevolent creative thinking, based on the intrinsic thinking logic of individual thinking and the temporal dimension of the individual creative process, which will contribute to the growth of meaningful research.

THINKING LINKAGE

Gutworth et al. (2016) argued that the nature of the goal and the instructions for satisfying stated goals explain whether individuals produce malevolent creativity. Malevolent creative thinking is the creation of products that cause harm to humans and society and is therefore defined as creativity that intentionally leads to harmful or unethical outcomes (Ning and Jing, 2016). Negative creative thinking is the use of creative processes to achieve negative goals but without the intention of intentional harm (Clark and James, 1999; James et al., 1999; Kapoor, 2018). The two are closely related to the process of thought generation. From the above-mentioned common ground and connotational differences, negative creative thinking and malevolent creative thinking have an important linkage, namely value-added. Value is a linkage node in the transformation of negative creative thinking to malevolent creative thinking. Value is, on the one hand, the outcome of creative thinking generation and, on the other hand, the base point for negative and malevolent assessment. Therefore, personal intention toward value is a key stage in the linkage of negative creative thinking to malevolent creative thinking. Before this stage, negative creative thinking is dominant and ideas are highly individualized and self-serving, while after this stage, thinking needs to include risk-averse elements and make choices after considering multiple factors to form the final creative outcome (Mumford and Hunter, 2005; Mueller et al., 2012; Blank, 2013). The path from negative creative thinking to malevolent thinking is not unidirectional. In the process of thinking transformation, value is used as the linkage node between the two types of thinking, and personal intention is used as the determining factor leading to the mutual transformation between negative creative thinking and malevolent creative thinking.

Creation is an evolving thought process (Zehui et al., 2019). Logic deduced the relationship between the variables of negative-malevolent creative thought based on the temporal dimension of the creative process and the findings of previous investigations. We built a model of linkage between individual negative creative thought and malevolent creative thinking to better show the linkage relationship (Figure 1). In the chronological dimension of individual development, the interconnection model of negative and malevolent thinking is not abrupt and discontinuous, but rather a continuous spectrum with different emphases. In the initial stage of creative stimulation, the environment stimulates creative drive (Hennessey, 2007; Lin, 2011). Changes in situational variables, such as unjust environments (Harris and Reiter-Palmon, 2015; Gutworth et al.,



2016; Kapoor and Khan, 2019), and environments with violent elements (Malik et al., 2020), can cause individuals' creative motivation to shift, resulting in the emergence of negative creative thinking (De Jesus et al., 2013). Malevolent thinking is further stimulated by calculations and reevaluations of personal interests, or by failed responses to creative stimulation events and conflict resolution. As a result, negative creative thinking is gradually transformed into malicious creative thinking. Of course, not all links between negative and malevolent creative thought develop gradually from negative creative thinking. There is evidence that exposure to or experiencing violence enhances a person's likelihood of committing violence in the future (McFall et al., 1999; Ferrajão and Oliveira, 2016; Hunter et al., 2022). That is, victims of violence are more likely to be directly driven to generate maliciously. This, however, is a rare occurrence, and this research concentrates on the bi-directional connection mechanisms of negative-malevolent creative thinking in most general groups. In the idea stimulation stage, the critical point for the linkage of the two types of thinking is whether it is value-added to the ultimate goal of personal intention, and whether they will exploit people to further their own goals (i.e., Machiavellianism) (Bochkova and Meshkova, 2019).

During the creative phase, analytical thinking predominates because negative emotions impair the individual's reassessment skills, resulting in less use of problem-oriented thinking (Perchtold-Stefan et al., 2021). When the creation is complete, the individual will again value the created product. At this stage, the individual considers the possible risks and the threats they pose to their own interests, weighs the risks against the benefits, and ponders whether to harm others in order to satisfy inner desires. Due to risk aversion and a low level of inner desire to harm others, creative thinking results that are originally malicious will be

impaired in the execution stage to ensure the preservation of their own interests and become negative creative results (Mumford and Hunter, 2005; Mueller et al., 2012; Blank, 2013; Murray et al., 2017, 2018; Persson et al., 2018). Conversely, negative creative thinking outcomes can also be transformed into malevolent creative outcomes through value-added execution. Therefore, in the stage of practicing creative outcomes, the individual's intention, i.e., whether to undertake risk and whether to harm others; and whether to value-add execution to maximize benefits, are the key nodes in the linkage of the two types of thinking in that stage.

DISCUSSION

Malevolent creativity, according to Hao et al. (2016), maybe a component of regular employment. Negative creativity can also be seen in schooling (Meshkova et al., 2021). Terrorism, crime, theft, and espionage are examples of malevolent or negative innovation in their broadest sense (Cropley et al., 2008; Gill et al., 2013). Cheating, lying, retribution, and disinformation are examples of malevolent or negative creativity on a smaller scale (Gill et al., 2013; Harris and Reiter-Palmon, 2015; Hao et al., 2016). Based on this model, we will elaborate the linkage between negative and malevolent creativity in education from both micro and macro perspectives.

The Linkage Model of Negative Creative Thinking and Malevolent Creative Thinking From the Micro Perspective

From a micro perspective, we consider how a course can be designed to detect and intervene with the production of negative

and malevolent creative thinking in time. In the context of educational learning, the creative thinking training process is divided into three stages: idea stimulation, analysis and creation, and presentation and promotion (Zehui et al., 2019). The starting point for negative creative thinking is in the creative stimulation stage. Teachers create specific situations for students based on projects to elicit questions for inquiry; assist students in decomposing problems and goals, transforming structures and contexts, working to find multiple solutions, experimenting with multiple solutions, reverse thinking, and negotiating constructs; and dispersing and activating ideas through questioning, exploring, imagining, and expanding (Zehui et al., 2019). At this stage, teachers should pay more attention to individual creativity while focusing on group creativity, and promptly identify individual negative emotions as well as the generation of malicious motives. It has been demonstrated that expertise is a crucial driver of idea production and refinement (Hunter et al., 2022), and that people with great cognitive abilities may explore and improve ideas more successfully than those who do not have such abilities (Jaarsveld et al., 2015). Individuals create negative feelings when their own abilities do not drive the development and implementation of creative ideas, which may lead to the production of negative creative thinking (Perchtold-Stefan et al., 2021). Especially in the process of thought dispersion and decision aggregation, and group negotiation construction, Hunter et al. (2022) suggested that group influence may also be a factor in the generation of negative, malevolent creative thinking in individuals. Therefore, teachers should pay attention to individual student's emotional state and potential value orientation, and making positive guidance and care can curb negative and malevolent creative motivation in the cradle.

In the analytic creation stage, negative creative thinking and malevolent creative thinking are iteratively intertwined. The main points of this stage of thinking are design and utility analysis, which involve the integrated use of design and analytical thinking, learning from experience, integration of existing knowledge, skills, and resources, and estimation of the value of creative products. People that are creative are more prone to be dishonest (De Dreu and Nijstad, 2008; Beaussart et al., 2010; Gino and Ariely, 2012). When considering personal goals, creativity can also be dubious (Mueller et al., 2012; Gutworth et al., 2016). When an individual's creative capacity and desire to react cruelly are controlled for, positive personality traits are favorably associated with creativity (Xu et al., 2021, 2022; Wang et al., 2022). At this point, we must concentrate on guiding students' ideology and morality (Hansika, 2015; Jonason et al., 2015; Meshkova et al., 2021; Kapoor and Kaufman, 2022) in order to avoid the formation of Machiavellianism (Bochkova and Meshkova, 2019). Teachers need to provide students with relevant reference cases and learning materials according to the specific situation of the task and guide them to improve their creativity in the previous stage. Interfering with and curbing the production of negative or malevolent creative thinking in the creative stimulation stage does not mean that negative or malevolent creativity will not be produced in the analytical creation stage. Negative and malevolent creative thinking at this stage sprouts between balance and trade-offs between originality

and practicality of the product orientation. Negative creative thinking (e.g., imitation, plagiarism) and malevolent creative thinking (e.g., unscrupulous destruction of others' creative results) can still occur in order to be different, and negative or malevolent creative thinking can also occur in order to highlight the value of creative products. The creation stage is an important part of the initial determination and linkage between the preliminary creative ideas and the later creative results presentation and promotion, and it is also the key to the linkage between negative and malevolent creative thinking. Therefore, multiple levels of thinking training can be done at this stage in the implementation of creative ideas and iterative adjustment of creative solutions, so as to detect students' negative and malevolent motives at different levels. Furthermore, those with higher levels of malevolent or negative creativity are less self-aware (Kapoor and Khan, 2019). As a result, teachers need to pay special attention to less self-aware kids.

Display and promotion stage teachers organize appropriate communication or display activities, and students present and share their creative results. During the display process, students and teachers will make value judgments on other works, which is one of the assessment indexes for judging the creative teaching results. Prejudice, discrimination, and anger all stimulate the production of negative, malevolent creative thinking (Kirkpatrick, 1993; Cropley et al., 2014). At this point, when the individual predicted value is not equal to the value judged by others, a negative reaction will occur. In most current creator or STEM education, the aspect of presentation and promotion is often neglected or partially missing. Many maker education stops at making a good product or simply displaying it without considering the psychological condition of the individual student, which is the key to the creation of negative and malevolent creative thinking.

A Linkage Model of Negative and Malevolent Creative Thinking in a Macro Perspective

To look beyond the micro-framework of curriculum design, the discovery and intervention for the linkage of negative and malevolent creative thinking in the temporal dimension of individual development is not disconnected but should be a continuous spectrum with different emphases. In the primary education stage, provide students with as many opportunities as possible to experiment, to go through a process of accumulating experience, creating products, trial, and error, and gradually approaching success, and from which they learn to negotiate, cooperate, and develop non-intellectual qualities such as integrity, responsibility, strength, and fear of setbacks (Zehui et al., 2019). Students are given sufficient self-regulation to regulate their own negative emotions or motivations that may arise during the creative process. With the growth of age and school level, exposing students to a more social environment and considering more the social significance of the creative outcome in the creative process is conducive to dovetailing with innovation education at the higher education level and is conducive to helping students shape correct moral values and

better help them recognize the negative and malicious creation in the creative process.

Based on the consideration of the environment, it is particularly important to build an educational ecosystem intervention means of negative—malevolent creative thinking linkage. Creativity education is not only limited to the classroom, but through the linkage of many parties, such as school and society, it helps to collaboratively cultivate students' creativity, as well as to discover students' negative creative thinking and malevolent creative thinking in different contexts, and fully support students' positive creativity and transformation of results, effectively contributing to the creativity education.

CONCLUSION

Negative creative thinking and malevolent creative thinking are different in their core categories. The two types of thinking have something in common in terms of value orientation, environmental stimulation, and subjective motivation; however, they differ in terms of value goals, thinking styles, and subject size. The identification of such differences helps to think about and study the paths of the two types of thinking more comprehensively. Negative creative thinking may be transformed into malevolent creative thinking after it is generated out of the weighing of personal interests and the realization of ultimate intentions, or it may remain negative creative thinking. Malevolent creative thinking may also become negative or malevolent creative outcomes after it is stimulated, due to risk avoidance and the value choices it ultimately practices. The value-added is the stimulus for the conversion of negative creative thinking to malevolent creative thinking, and personal intention is the key stage in the linkage of negative creative thinking to malevolent creative thinking.

From a pedagogical perspective, our creative education usually emphasizes the cultivation of creative thinking (Wilson, 2005; Baer and Kaufman, 2006; Kaufman and Beghetto, 2009; Zehui et al., 2019; Dou et al., 2021) and does not extend to the avoidance of negative and malevolent creative thinking. In the context of the current creative society, the cultivation of creative talents should consider both intervention and avoidance of negative and malevolent creative thinking. The NMTIM model proposed in this paper can be used to distinguish the difference between the two types of thinking, but it is also a conceptual prototype for the linkage model of the two types of thinking. Negative creative thinking and malevolent creative

thinking are iterative in the whole creation process. There is a close interplay between the three stages of inspiration, creation, and practice. Having clarified the distinctions and connections between the two types of thinking, it is necessary to make further in-depth discussions in the following directions: (1) The linkage of negative and malevolent creative thinking in education. In the process of thinking development, we should also pay attention to students' potential negative creative thinking and make timely interventions. (2) Linking negative creative thinking and malevolent creative thinking with technological support. Technology in the age of intelligence is changing rapidly, and new technology itself is a product of creativity and a great motivation to promote creative thinking education. In particular, artificial intelligence has the potential to be “disruptive” in terms of speed, breadth, and depth. The linkage of negative creative thinking and malevolent creative thinking with technological support will become one of the important directions for the next research.

LIMITATION AND FUTURE RESEARCH DIRECTIONS

There are certain limitations to the research effort presented in this study. First, this study addresses a wide range of individual behaviors associated with negative creative thinking and malevolent creative thought, providing a complete understanding of the topic. We acknowledge that the linking model is purposely broad to maximize the model's accessibility and usefulness. Second, the bidirectional linkage described in this research focuses on the individual's internal thinking logic and does not involve any influencing factor variables. According to Hunter et al. (2022), social and group influences may also be factors in the generation of negative, malevolent creative thinking in individuals. As a result, future research could include extrinsic influence factors. Third, after discussing individual negative-malevolent creative thinking interconnections, the study might be expanded to include group negative-malevolent creative thinking relationships.

AUTHOR CONTRIBUTIONS

XinyuD was responsible for the writing of the article. XinyanD was responsible for the creation of the model. LJ was responsible for reviewing. All authors contributed to the article and approved the submitted version.

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The Impact of Resource Bricolage on Entrepreneurial Orientation in Start-ups: The Moderating Roles of TMT Heterogeneity and TMT Behavioral Integration

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Prior studies demonstrate the role of resources in shaping a firm's entrepreneurial orientation from the resource-based view. We expand this line of research by theorising and testing the impact of resource bricolage on entrepreneurial orientation. Based on the data of 295 start-ups, we find that when start-ups face resource constraints, the strategy of resource bricolage has a significant positive effect on entrepreneurial orientation, and the relationship is positively moderated by top management team (TMT) heterogeneity. Meanwhile, the relationship is negatively moderated by TMT behavioral integration. The results are expected to provide theoretical guidance for start-ups to overcome resource constraints and achieve smooth survival and growth.

Keywords: start-ups, resource bricolage, entrepreneurial orientation, TMT heterogeneity, TMT behavioral integration

INTRODUCTION

Start-ups usually face a higher risk of entrepreneurial failure than mature enterprises. Start-ups face high levels of technological and market uncertainty due to liability or weakness caused by newness (Elfring and Hulsink, 2003). The lack of performance records and information asymmetry hinders the evaluation of resource owners, making it difficult for start-ups to obtain external resources (Xiumei and Yupeng, 2010). Previous studies have shown that cultivating entrepreneurial orientation can effectively promote dynamic capability orientation and firm performance and enterprise development (Wiklund and Shepherd, 2003) in uncertain environment. It can be seen that entrepreneurship orientation is very important for start-ups. Entrepreneurial orientation is a mental model of firms in pursuit of new business and in response to environmental change (Srivastava and Lee, 2005). Firms with a high entrepreneurial orientation are more likely to innovate continuously and actively defeat competitors perceived as more entrepreneurial (Miller, 1983; Anderson et al., 2015). There are few studies on the antecedent variables of entrepreneurship orientation. Although researchers have recognized the importance of resources for entrepreneurial orientation and established a framework involving firms' internal resources, competitive advantages and innovation capability, most research efforts of entrepreneurial orientation are limited to the entrepreneurial resources

themselves. Therefore, these studies cannot yet provide an effective answer to the problem of resource scarcity (Jingkun and Jian, 2019).

The key to the survival and development of start-ups facing fierce market competition lies in their creative reorganization of resources (Sirmon et al., 2011). Resources are the foundation of entrepreneurial activity (Barney, 1991). When firms have the resources to match their (Miller, 1983) entrepreneurial behavior and innovation, they tend to succeed. Most firms face massive resource constraints (Wiklund and Shepherd, 2005), while start-ups face even more severe resource constraints. Resource bricolage is an action strategy for entrepreneurs to meet new entrepreneurial opportunities or challenges by adapting and leveraging existing resources (Baker and Nelson, 2005). Successful bricolage enables start-ups to cope better with market uncertainty, survive in resource constraints, and perhaps even thrive (Lomborg et al., 2017). How does bricolage affect entrepreneurial orientation? The mechanism remains to be explored.

The other key to deepening research on the relationship between resource bricolage and entrepreneurial orientation lies in the introduction of related organizational factors. Entrepreneurial behavior is rooted in a certain resource environment, and TMT of each firm is the decision-maker and executor of the corporate strategy and plays a key role in the enterprise innovation activities (Hambrick and Mason, 1984). The theoretical extension based on the upper echelons theory proves that the characteristics of TMT (such as age, career path, other professional experience, education, socioeconomic basis, economic status, group characteristics, etc.) are important organizational factors that affect entrepreneurial orientation (Bantel and Jackson, 1989; Yang and Wang, 2014). However, there are still considerable differences in the empirical research conclusions on the relationship between TMT and entrepreneurial orientation. Start-ups usually face unstructured and creative problems, and heterogeneous teams are often better able to cope with them due to their different cognitive and resource bases (Gang and Chao, 2017). TMT behavioral integration is defined as the degree of team members' participation and interaction in thought and action, which holds the key to the effectiveness of strategic decision-making and execution (Carmeli and Schaubroeck, 2006). The demographic differences of TMT members and their behavioral integration influence the decision-making and implementation of corporate strategy, which can explain the group phenomenon (Alexiev et al., 2010).

Our study focuses on the impact of resource bricolage on entrepreneurial orientation in start-ups, effectively combining the entrepreneurial resource view and entrepreneurial opportunity view to provide a new entrepreneurial research perspective. That is, when start-ups cannot control all the resources, bricolage behavior helps the entrepreneur use the existing resources optimally and avoid resource restrictions. Therefore, resource bricolage is an effective solution to overcome the resource-constraint dilemma, providing an effective way for enterprises to carry out entrepreneurial activities. In addition, resource bricolage results from TMT's decisions, so

it does not independently affect entrepreneurial orientation. Analysis of this TMT dual role can explain why some start-ups with similar resource bases succeed and others fail. By considering this view, we provide a new way of thinking and a feasible path for start-ups to overcome the resource dilemma (Mehrabian et al., 2021). It also deepens the research content of the perspective of resource bricolage and upper echelons theory.

THEORY AND HYPOTHESES

The positive effect of entrepreneurial orientation on performance through various ways has been gradually confirmed (Li et al., 2009; Lomborg et al., 2017). Thus, entrepreneurs and scholars began to focus on what can be done to make the most of entrepreneurial orientation (Wangbin and Yuli, 2012). Following the conceptual structure of entrepreneurial orientation proposed by Lumpkin and Dess (1996), scholars study the impact of environmental factors, strategic factors, and internal factors on entrepreneurial orientation. The entrepreneurial behavior of firms is regarded as a process of integrating internal and external resources. Therefore, resources are the foundation of entrepreneurial activity and the key to its success (Barney, 1991). The quantity and quality of resources play a key role in the performance, survival, and development of entrepreneurial firms (Guohong and Lan, 2018).

Prior studies focused on the important role of resources for firms to build and maintain strategic advantages from the resource-based view (Covin et al., 2006; Jian, 2012), and most concluded that competitive advantage and high performance of firms come from a unique and heterogeneous resource portfolio (Wales et al., 2011). The view highlights that advantageous resources must have three characteristics simultaneously: they can create value, cannot be copied by competitors, and can be continuously possessed. The resource-based view discusses the source of competitive advantage from the perspective of internal enterprise resources, but scholars gradually realized that the formation and accumulation of competitive resources is a long-term process (Shijian and Minghui, 2013). It is difficult for start-ups to achieve this in the early stages. Moreover, the view does not extend to research on how to obtain advantageous resources and the abilities needed by firms to obtain resources.

When it is difficult for start-ups to obtain advantageous resources or they even face the problem of insufficient resources, integrating and utilizing existing resources are effective ways to address the problem (Yuli and Xin, 2009). The problem is acute for start-ups, which typically need many resources in the start-up and growth stages. Scarcity is the most striking feature of entrepreneurial resources (Liang and Heng, 2017). Due to the lack of internal accumulation, such a firm often does not have all the resources needed to develop its opportunities (Senyard et al., 2014). Therefore, one of the important tasks of entrepreneurs in the entrepreneurial process is to access and utilize resources (Newbert and Tomikoski, 2012). The concept of resource bricolage, proposed by Baker

and Nelson (2005), provides a new thinking style and a new action strategy to solve resource problems. Following the principle of “make the best use of everything,” firms make do with their existing, accessible resources to explore opportunities and meet challenges. When start-ups are unable to pay for standardized resources that have a high degree of matching needs, strong applicability, and high efficiency, the original purpose can be achieved by using the resources currently at hand (Hongxia and Hongjia, 2016).

Resource Bricolage and Entrepreneurial Orientation

Scholars proposed the logic of potential advantages of resource constraints, that is, the effects of resource constraints are not all negative (Gibbert et al., 2007). The more severe the resource constraint of a start-up, the more efficient the start-up will be in using resources. They tend to work harder to find resources in competitive markets, partly reflecting greater entrepreneurial intention. Resource bricolage includes three core elements, namely the resource at hand, making do, and combining resources for new purposes (Miller, 1983). The first element, “resource at hand,” relates to entrepreneurial orientation because firms pay attention to the use and exploration of resources that are immediately available, especially resources that exist in new firms or the existing market but have not been explored or neglected (Covin and Slevin, 1989). Using existing idle resources, which not only reduces resource costs and saves search time, but also obtains income from investment, which greatly improves the ability of firms to take entrepreneurial risks (Xiue and Kun, 2018). Similarly, through the creative use of inexpensive resources, firms can bring more net cash inflow with minimal cost, achieving survival and development (Hooi et al., 2016). In addition, firms may inadvertently create new resources by using many piecemeal resources; the process helps firms market new products, provide new services, and achieve innovation (Lu et al., 2019).

The second core element listed above, “making do,” relates to entrepreneurial orientation as follows. This form of bricolage refers to the effective performance of an entrepreneur who faces resource constraints and uses existing resources to deal with new challenges or opportunities (Baker and Nelson, 2005). On the one hand, “making do” helps firms creatively solve the problems they face and quickly create targeted products, services, or business models, thereby making more room for the firms to develop (Jingqin and Jingjing, 2017). On the other hand, “making do” is advantageous to seize the fleeting opportunity to take the lead in breaking into new markets and thus gain a first-mover advantage (Zahra and Covin, 1995).

The third core element, “combination of resources for new purposes,” relates to entrepreneurial orientation because entrepreneurs frequently integrate resources that were previously used for other purposes to achieve new goals (Liang and Xinglu, 2016). It means that start-ups often use resources that were otherwise used for other purposes to achieve goals and capture market opportunities. This is an extension of the use of resources, and is an important manifestation of bricolage (Desa, 2012).

The new service attribute is developed by the firm based on the original use attribute of the resource, which helps the firm to get out of the difficulty of obtaining the standard resource in time, and to simultaneously improve stability in the existence and development of the organization.

Resource bricolage is an important way for firms to obtain available resources by exerting their subjective initiative. Although the literature contains no direct research showing that resource bricolage impacts the entrepreneurial orientation of enterprises, scholars have verified the relationship between resource bricolage and innovation performance through empirical research, which reflects the innovation and risk-taking ability of enterprises. Based on this, we consider the following hypothesis:

H1: A firm's resource bricolage positively relates to its entrepreneurial orientation.

The Moderating Effect of Top Management Team Characteristics

When studying resource strategies, one should not neglect examination of the subject of decision-making, that is, TMT. According to the upper echelons theory, there are two main viewpoints (Hambrick and Mason, 1984). Firstly, when faced with the same organizational environment and strategic information, different managers make different strategic choices and interpret the information diversely (Carpenter et al., 2004). Scholars have studied the impact of entrepreneurial enthusiasm on entrepreneurial behavior and received positive responses (Li et al., 2020). Secondly, the differences arise from the past experiences, values, perceptions, and personal characteristics of the top managers. Based on the above two main points, Hambrick and Mason further suggest that to understand why a firm makes one choice rather than another, it is necessary to have a deep understanding of its top managers. The theory effectively explains why enterprises with similar resource constraints may have completely different survival and growth capabilities (Knight et al., 2015).

The TMT background characteristics are closely related to key activities such as the formulation and execution of strategic decisions (Xinming and Huan, 2021) because a TMT is usually made up of key managers responsible for strategy formulation, planning, and implementation. They are responsible for the operation and management of the entire organization and have decision-making and control rights (Hambrick, 2007). Therefore, the TMT decision-making process will impact the firm resource allocation and change. Therefore, considering the integrity of the research model, the current study combines TMT heterogeneity and TMT behavioral integration into the same research framework. The theoretical model can further deepen and expand the upper echelons theory and the perspective of resource bricolage.

The Moderating Effect of Top Management Team Heterogeneity

TMT heterogeneity reflects the differences of TMT in demographic characteristics, important cognitions, values, and

experiences, which can be divided into demographic background variables and latent variables (Mehrabi et al., 2021). Often, heterogeneous teams are better suited to deal with unstructured, creative problems (Alexiev et al., 2010). Therefore, when the diversity among TMT members is large, the team has diversified knowledge, skills, experience. Moreover, diversity means that the team has a wide social network and a broad interpersonal base, which can provide more diverse resources and capabilities for the growth of the venture (Heyden et al., 2013). Conversely, when the level of TMT heterogeneity is low, it is often difficult to have sufficient external contacts to access strategic resources.

The background characteristics of top managers determine their problem-solving ways and thus influence their strategic decisions (Richard et al., 2019). Therefore, the influence of TMT characteristics in the study of the relationship between resource bricolage and entrepreneurial orientation should not be ignored. On the one hand, highly heterogeneous teams have a wide variety of information and insights and a broader perspective, which allows them to identify more potentially available resources (Bantel and Jackson, 1989). When the use of resources is broadened, the team's ability to solve problems is enhanced. On the other hand, high heterogeneity means that the team has more extensive social capital and network relationships, which can improve the firm's ability to access both tangible and intangible resources. For both reasons, TMT member heterogeneity is helpful for start-up firms to cope with resource constraints and achieve high growth. Based on this, the following hypothesis is made:

H2: TMT heterogeneity positively moderates the relationship between resource bricolage and entrepreneurial orientation; the higher the degree of TMT heterogeneity, the greater the positive impact of resource bricolage on entrepreneurial orientation.

The Moderating Effect of Top Management Team Behavioral Integration

Based on the upper echelons theory, Hambrick found through field research that it is not enough to rely on static indicators such as demographic characteristics to predict the results of firms, and TMT behavioral interaction are also important. If TMT members cannot effectively integrate their existing knowledge and skills, it is often difficult to find new opportunities. The solidification of knowledge and experience is easy to form cognitive bias, which will lead to the solidification of the existing strategy and affect the innovation behavior of the enterprise. In 1994, the concept of "TMT behavioral integration" was first put forward and the term can be used to describe the essence of the specific operation process of the team. As a meta-concept of the TMT executive process, TMT behavioral integration is the process of TMT members sharing information, resources, and decision; these three aspects reflect the team's integrating capacity.

After 1994, follow-up study based on the upper echelons theory showed that the integration of group behavior is an important contingent factor that influences the strategic behavior

of firms (Hambrick, 2007), and thus impacts the relationship between resource bricolage and entrepreneurial orientation. For two reasons, this study suggests that TMT behavioral integration may weaken the positive relationship between resource bricolage and entrepreneurial orientation. Firstly, a high level of TMT behavioral integration indicates frequent information exchange among team members, but this often leads to the disadvantage that the members have the same decision-making basis, so they have similar access to resources (Simsek et al., 2005). In such a situation, it is difficult to use resources creatively. In contrast, a low level of behavioral integration means that team members' unique vision of how to acquire resources can play a positive role. Second, joint decision-making is an important criterion for TMT behavioral integration. However, joint decision-making is often based on risk reduction, so teams tend to form a conservative consensus. Such a team ignores abandoned or idle resources, which is not conducive to the discovery, utilization, and accumulation of resources. Based on this, the following hypothesis is made:

H3: TMT behavioral integration negatively moderates the relationship between resource bricolage and entrepreneurial orientation; the higher the degree of TMT behavioral integration, the weaker the positive effect of resource bricolage on entrepreneurial orientation.

MATERIALS AND METHODS

Sample and Data Collection

A questionnaire survey was employed to collect data to test our hypotheses. Since this study focuses on firms in the early stages of formation or growth, we use the standards within the Global Entrepreneurship Monitor (GEM) report to investigate firms that have been established for at most 42 months. Considering that the CEO and senior management team members are located at the top of the organizational structure, they play an active role in the strategic decision-making of the enterprise. Meanwhile, they are familiar with the overall operation of the enterprise and can more accurately reflect the real situation (Yong and Rui, 2019). We first sent a questionnaire to CEOs to measure their perceptions of entrepreneurial orientation. At the same time, we sent a questionnaire to the top management team members to gauge their views on the firm's resource bricolage. To improve the response rate, our questionnaire was distributed by a professional team in China, a leader in Chinese market research. Specifically, the team uses a data platform dedicated to providing large-scale research, data collection, modeling, analysis, and business applications solutions for research institutions, businesses, and individuals.

A small-scale sample survey confirmed the reliability and factor structure of our measurements. Then, with a good understanding of our research purpose and requirements, the group recruited respondents in a rigorous manner to form a high-quality, representative sample. Samples came from 21 provinces, autonomous regions, and municipalities directly under the central government in China, covering the four

TABLE 1 | Sample feature distribution (*N* = 295).

Item		<i>N</i>	Percentage	Item		<i>N</i>	Percentage
Gender	Male	184	62.37	Major work experience	finance	77	26.55
	Female	111	37.63		marketing	26	8.81
Age	≤30	127	43.05		manufacturing	17	5.76
	31–40	152	51.53		technology	36	12.20
	>40	16	5.42		administration	68	23.05
					law	30	10.17
Education	Junior college or below	34	11.53	TMT Numbers	other	41	13.90
	Bachelor	206	69.83		≤5	27	9.15
	Master degree or above	55	18.64		6–10	145	49.15
				Firm Scale	>10	123	41.70
					≤50	17	5.76
					51–100	43	14.58
					101–250	54	18.31
					251–500	68	23.05
					501–1,000	61	20.68
					>1,000	52	17.63

major economic regions: the northeast region (e.g., Heilongjiang Province, Jilin Province and Liaoning Province), the eastern region (e.g., Zhejiang Province, Shanghai, Jiangsu Province), the central region (e.g., Anhui Province, Shanxi Province, Jiangxi Province) and the west area (e.g., Chongqing, Sichuan Province, Guangxi).

We chose to conduct our research in China for two main reasons. On the one hand, with the concept of “Mass entrepreneurship and innovation,” China has formed a new wave of entrepreneurship (Jun and Yuli, 2020). As a result, the number of start-ups is huge, and research on entrepreneurship is of great significance to the country. However, as a developing country, China is at a disadvantage in the international transfer of resources, so it needs to focus on internal and limited resources. On the other hand, as the world’s second-largest economy, China’s enterprise development faces a severe domestic and international environment. Therefore, Chinese companies must mold a competitive advantage in a fierce market environment, and the role of their top management teams cannot be underestimated. Top managers are the right people to fill out the questionnaire, this happens because we need to consider the TMT characteristics in our study. More importantly, top managers are at the top of the organizational structure, playing an active role in making strategic decisions, and they are very familiar with the overall operating situation of the firm.

Common Method Bias

In this study, we avoid the influence of common method bias by means of program control. Firstly, in the questionnaire design phase, we changed the order of items while keeping the same basic information to avoid reflecting bias. At the same time, the questionnaire uses a reverse item and a repeated item to identify invalid samples, which can help us quickly check whether the interviewee answered the question seriously. Secondly, before the respondents filled out the questionnaire, we informed them that the responses would be anonymous and the data would be used for scientific research only; all

response information would be kept strictly confidential so it would not affect their work in any way. The team used IP address checking to ensure that each person could only answer once, and we ended up with 350 complete samples. Finally, by comparing the results of the polygraph item and the repeated item, the data of those who did not answer seriously were deleted, leaving 295 samples and an effective recovery rate of 84.29%. **Table 1** shows the demographic details of the 295 respondents.

Measures

We adopted mature scales from the literature to measure, and we ensured the equivalence of language through translation and back-translation. Firstly, we translated the original scale from English into Chinese, and then translated the Chinese scale into English. Then, we invited two native English speakers to check the translated English scale. We repeated the operation until the new scale was consistent with the original scale in content, semantics, format, and application, after which we regarded it as a valid scale for distribution. After team discussion and feedback, we revised several ambiguous items and formed the final questionnaire. In addition to the control variables, all items were measured with 5-point Likert scales, ranging from “Strongly disagree” (1) to “Strongly agree” (5).

Resource Bricolage. We measured resource bricolage using eight items adapted from the work of Senyard et al. (2014), which includes three dimensions. Resources at hand refers to resources that exist in the market but have not yet been found or exploited for alternative uses; such resources are often obtained at a lower cost than standard alternatives. Making do means that the firm is quick to seize opportunities based on satisfaction rather than optimization. Combination of resources for new purposes refers to the reorganization of resources in order to achieve new goals. The internal consistency of resource bricolage was 0.828. The results of confirmatory factor analysis (CFA) show that the data represents the true characteristics of the measured objects ($X^2 = 33.324$, $df = 20$, $X^2/df = 1.666$, $p = 0.031$, RMSEA = 0.048[0.014, 0.075], GFI = 0.973,

NFI=0.948, IFI=0.978, TLI=0.969, CFI=0.978). These results show that the scale had good aggregation validity.

TMT heterogeneity. We measured TMT heterogeneity using four items adapted from the work of Heyden et al. (2013). The scale measures professional knowledge field, experience, functional background, and complementarity. The internal consistency of TMT heterogeneity is 0.644, and the results of CFA are as follows: $X^2=14.876$, $df=2$, $X^2/df=7.438$, $p=0.001$, GFI=0.978, NFI=0.902, IFI=0.914, CFI=0.911. These results indicate that the aggregation validity of the scale is good.

TMT behavioral integration. We measured TMT behavioral integration using nine items adapted from the work of Simsek et al. (2005), which include three dimensions. *Information exchange* reflects the initiative consciousness and the importance of the information exchanged in decision-making. *Collaborative behavior* measures how much the top managers work together and whether the boundaries of their rights and responsibilities are clear. Whether the firm's important decisions are made through inter-team discussion is mainly used to measure *joint decision-making*. The internal consistency of TMT behavioral integration is 0.795 and the results of CFA are as follows: $X^2=41.107$, $df=27$, $X^2/df=1.522$, $p=0.040$, RMSEA=0.042[0.009, 0.067], GFI=0.969, NFI=0.931, IFI=0.975, TLI=0.966, CFI=0.975. These results show that the aggregation validity of the scale is excellent.

Entrepreneurial orientation. We use the scale developed by Covin and Slevin (1989), which includes three dimensions, with a total of nine items. Innovativeness refers to the firm having new ideas in terms of products, service, and technology. For example, since the firm was established, new products and new services have been developed, and there is a trend of sustainable development. Risk taking refers to the firm daring to face, undertake, or engage in behavior with a certain amount of danger; that is, the firm is more inclined to try rather than give up in the face of an uncertain environment. Proactiveness refers to the tendency of the firm to develop and market new products and services before other firms in the industry. The internal consistency of entrepreneurial orientation is 0.845. The results of CFA are as follows: $X^2=80.791$, $df=27$, $X^2/df=2.992$, $p=0.000$, GFI=0.941, NFI=0.902, IFI=0.933, TLI=0.909, CFI=0.932. These results show that the scale has good convergent validity.

Control variables. This study selects several variables which may affect the entrepreneurial orientation from the entrepreneur, the top management team and the start-ups level. Firstly, we control the gender of entrepreneur, because it makes differences in the degree of entrepreneurial inclination. According to the questionnaire, the entrepreneur's age and education level were controlled by the ordinal classification variables. Different work experience results in different entrepreneurial intention, therefore, the main work experience is divided into seven categories, such as finance and accounting, marketing, production and manufacturing, technology research and development, administration, Discipline inspection and law. Second, from the perspective of entrepreneurial team, the number of team to measure the size of the TMT. Finally, the start-up scale is measured by the total number of enterprises at the enterprise level.

RESULTS

Descriptive Statistics and Correlation Analysis

Table 2 presents the means, standard deviations, and correlations. The results show that resource bricolage correlates positively with entrepreneurial orientation ($r=0.71$, $p<0.01$). Resource bricolage also correlates positively with TMT heterogeneity ($r=0.61$, $p<0.01$), and TMT heterogeneity correlates positively with entrepreneurial orientation ($r=0.59$, $p<0.01$). Resource bricolage also correlates positively with TMT behavioral integration ($r=0.65$, $p<0.01$), and TMT behavioral integration correlates positively with entrepreneurial orientation ($r=0.71$, $p<0.01$).

Variance inflation factor (VIF) test was carried out in this study, and the result was 1.025, close to 1, indicating that multicollinearity is not serious. In order to ensure the reliability of regression results and reduce statistical errors, this study conducted mean-centered processing on data before regression analysis.

Hypothesis Testing

Main Effect Test

First, the regression analysis showed that resource bricolage has a significant positive effect on entrepreneurial orientation ($\beta=0.83$, $SE=0.05$, $p<0.001$). Hypothesis 1 is verified.

Moderating Effect Test

The PROCESS 3.5 procedure (Model 1) of SPSS23.0 was used to test the moderating effect of TMT heterogeneity. The second hypothesized moderator was tested similarly. **Table 3** shows that the moderating effect of TMT heterogeneity on the relationship between resource bricolage and entrepreneurial orientation was not significant ($\beta=0.04$, $t=0.03$, 95% CI [-0.025, 0.110]). Moreover, **Table 4** examines the moderating effect of behavioral integration on the relationship between resource bricolage and entrepreneurial orientation was not significant ($\beta=-0.03$, $t=-0.03$, 95% CI [-0.084, 0.038]).

Finally, we examine the dual-moderating effects of TMT heterogeneity and TMT behavioral integration. Using Model 2 in the PROCESS 3.5 plug-in, we obtain the results shown in **Table 5**. The moderating effect analysis showed that TMT heterogeneity had a significant moderating effect on the relationship between resource bricolage and entrepreneurial orientation ($\beta=0.08$, $t=2.01$, $p<0.05$, 95% CI [0.002, 0.166]), which was positive. Under the same conditions, the relationship between resource bricolage and entrepreneurial orientation was significantly mediated by TMT behavioral integration ($\beta=-0.09$, $t=-2.01$, $p<0.05$, 95% CI [-0.161, -0.002]), which was negative. Thus, Hypotheses 2 and 3 are verified.

To explore the moderating effect of different degrees of heterogeneity, the resource bricolage and heterogeneity results were divided into three groups according to the average value plus or minus one standard deviation. Through the analysis of the following data and make moderating effect slope chart in **Figure 1**. The TMT behavioral integration is shown in **Figure 2**.

TABLE 2 | Descriptive statistics and correlation coefficients.

S. No.	Variables	M	SD	1	2	3	4	5	6	7	8	9	10
1.	Resource bricolage	4.23	0.45	—									
2.	TMT heterogeneity	4.29	0.45	0.61**	—								
3.	TMT behavioral integration	4.14	0.45	0.65**	0.64**	—							
4.	EO	4.05	0.53	0.71**	0.59**	0.71**	—						
5.	Gender	1.38	0.49	0.00	0.07	0.02	0.00	—					
6.	Age	1.63	0.61	0.01	0.05	-0.03	-0.05	-0.15	—				
7.	Education	2.07	0.55	-0.02	-0.02	0.00	0.05	-0.06	-0.05	—			
8.	Work experience	1.16	0.37	-0.06	-0.14	-0.06	-0.06	-0.03	0.04	-0.02	—		
9.	TMT Numbers	2.33	0.64	-0.05	-0.06	-0.09	-0.06	0.10	0.00	-0.11	0.00	—	
10.	Firm Scale	3.91	1.48	0.02	0.05	-0.04	0.01	-0.08	-0.03	0.10	-0.63	0.00	—

Gender, 1 = male, 2 = female. ** $p < 0.01$.

The simple slope is the most significant when the heterogeneity value is 1.02, and the behavioral integration value is -0.81 . In other words, under the effect of high heterogeneity and low behavioral integration, the resource bricolage can influence entrepreneurial orientation positively, which can promote entrepreneurial orientation.

DISCUSSION AND CONCLUSION

Based on resource bricolage theory, this study proposes and tests the impact model of 295 start-ups' resource bricolage on entrepreneurial orientation. Previous studies have verified that resource bricolage has a positive impact on enterprise innovation and other outcome variables (Desa and Basu, 2013; Senyard et al., 2014), and also verified that resource integration positively influences firm entrepreneurship through innovation capability (Ling et al., 2020). However, there are no direct research shows that resource bricolage has an impact on entrepreneurial orientation. This study fully considers the resource environment of start-ups and expands the result effect of resource bricolage. We found that the higher the degree of resource bricolage, the stronger the entrepreneurial orientation of start-ups.

As the study showed, start-ups often face the dilemma of resource constraints and the need for innovation, which forces the firm to make full use of existing resources to create value and build capability (Zhenduo and Xinchun, 2016). This view provides a good explanation of why some start-ups stand firm in the entrepreneurial wave and bear market risks effectively: their success stems mainly from their reorganization and utilization of existing resources. When start-ups have more bricolage behaviors, they can use existing low-cost resources to provide more resource options through a quick assessment of the market environment, thus improving their ability to withstand risk, and the combination of new options is more conducive to enterprise innovation. The study has shown to some extent that resource bricolage constitutes an important base on which new firms can implement their entrepreneurship orientation. Start-ups need to pay attention to the accumulation and effective use of existing resources, strive to maintain flexibility in their problem solving, and lay a solid foundation for their entrepreneurship orientation and subsequent entrepreneurial activities from the perspective of resource bricolage.

Based on upper echelons theory, the current paper considers TMT heterogeneity and TMT behavioral integration from static and dynamic dimensions to explore the moderating effect between resource bricolage and entrepreneurial orientation. In terms of entrepreneurial team construction, most scholars study the impact of TMT heterogeneity on enterprise innovation, enterprise growth, resource acquisition and performance (Chowdhury, 2005; Zhou and Rosini, 2015) by upper echelons theory. Previous studies focused on the impact of TMT behavioral integration on entrepreneurial performance and firm innovation (Baoshan and Zhaorui, 2019), but did not form a unified opinion. This paper builds a research framework based on start-ups, and incorporates the resource pooling and entrepreneurial orientation of enterprises into the research, which is an important supplement to existing research. The study shows that TMT Heterogeneity and TMT Behavioral Integration have a significant dual-moderating effect

TABLE 3 | The moderating effect of TMT heterogeneity.

Regression equation		Significance of overall equation		Significance of regression coefficient	
Outcome variable	Predictor variables	R^2	F	β	95%CI
EO	Constant	0.74	39.84***	0.02	[-0.761, 0.797]
	Resource bricolage			0.56***	[0.458, 0.656]
	TMT heterogeneity			0.27***	[0.173, 0.375]
	Resource bricolage * TMT heterogeneity			0.04	[-0.025, 0.110]
	Gender			-0.05	[-0.220, 0.110]
	Age			-0.11	[-0.240, 0.020]
	Education			0.12	[-0.026, 0.262]
	Work experience			0.03	[-0.253, 0.303]
	TMT Numbers			-0.02	[-0.142, 0.105]
	Firm Scale			-0.01	[-0.075, 0.064]

*** $p < 0.001$.**TABLE 4** | The moderating effect of TMT behavioral integration.

Regression equation		Significance of overall equation		Significance of regression coefficient	
Outcome variable	Predictor variables	R^2	F	β	95%CI
EO	constant	0.78	92.42***	-0.15	[-0.874, 0.567]
	Resource bricolage			0.43***	[0.338, 0.526]
	Behavioral integration			0.43***	[0.330, 0.522]
	Resource bricolage * behavioral integration			-0.02	[-0.084, 0.038]
	Gender			-0.02	[-0.176, 0.128]
	Age			-0.06	[-0.178, 0.062]
	Education			0.10	[-0.033, 0.235]
	Work experience			0.02	[-0.235, 0.277]
	TMT Numbers			0.01	[-0.110, 0.120]
	Firm Scale			0.01	[-0.051, 0.077]

*** $p < 0.001$.**TABLE 5** | Double regulation effect.

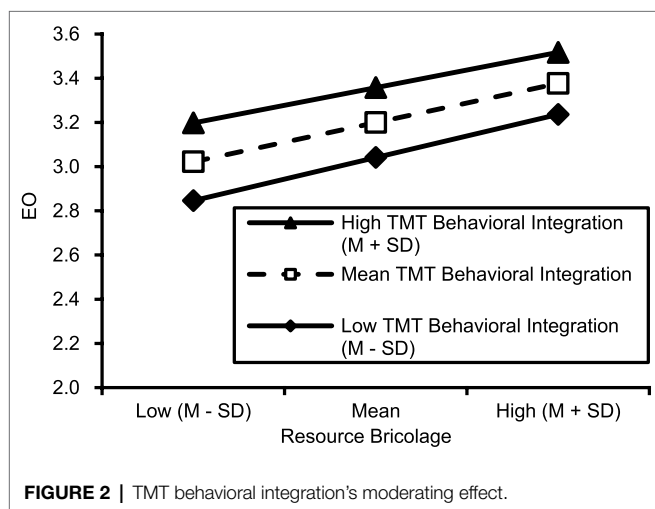
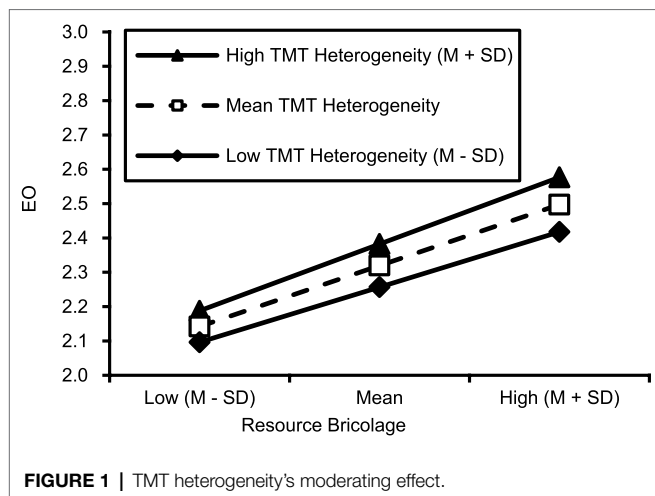
Regression equation		Significance of overall equation		Significance of regression coefficient	
Outcome variable	Predictor variables	R^2	F	β	95%CI
EO	Constant	0.79	44.14***	-0.20	[-0.918, 0.514]
	Resource bricolage			0.40***	[0.299, 0.498]
	TMT heterogeneity			0.14**	[0.040, 0.249]
	Resource bricolage * TMT heterogeneity			0.08*	[0.002, 0.166]
	Behavioral integration			0.35***	[0.244, 0.459]
	Resource bricolage * behavioral integration			-0.09*	[-0.161, -0.002]
	Gender			-0.05	[-0.202, 0.100]
	Age			-0.07	[-0.184, 0.054]
	Education			0.09	[-0.033, 0.232]
	Work experience			0.01	[-0.191, 0.200]
	TMT Numbers			0.15	[-0.099, 0.129]
	Firm Scale			0.02	[-0.046, 0.082]

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

on the relationship between resource bricolage and entrepreneurial orientation. That is, TMT heterogeneity strengthens the positive relationship between resource bricolage and entrepreneurial orientation, while TMT behavioral integration weakens the positive relationship between resource bricolage and entrepreneurial orientation. Therefore, when the degree of TMT heterogeneity

is high and the degree of TMT behavioral integration is low, resource bricolage can significantly enhance entrepreneurial orientation.

Among the key driving factors for organizational innovation, the differences in age, knowledge, and abilities of top management team members often affect the generation of innovative ideas and



the implementation of innovative behaviors, which in turn affect decision-making results (Fuping and Xiaochuan, 2010). Therefore, TMT building should combine the principles of differentiation and diversity to select and appoint team members. When forming a team, it is necessary to consider not only the differences in structural characteristics, but also the diversity of the social relationship network characteristics of top management members. The negative moderating effect of TMT behavioral integration shows that for the acquisition of resources and the realization of entrepreneurial goals, mere information sharing is not sufficient because similar cognitive foundations will form similar problem-solving modes. Similarly, joint decision-making should be done while paying attention to the expression of individual opinions of members and respecting the differences between members, so as to avoid the phenomenon that effective opinions are not expressed and the decision-making body conforms to the crowd.

Research Contributions

The study findings have theoretical value. Through quantitative analysis, this paper confirms the influence mechanism of resource

bricolage on EO in start-ups. Resource constraint is the primary obstacle faced by start-ups, and even becomes an important reason for the low success rate and short duration of start-ups. Resource bricolage is an effective solution to overcome resource constraints of start-ups, and provides an effective way for start-ups to carry out entrepreneurial activities and create economic value. Bricolage can help entrepreneurs make optimal use of existing resources and circumvent resource constraints when start-ups cannot control all resources. From this point of view, this paper provides a new idea and feasible path for start-ups to overcome the resource dilemma, and the research conclusions enrich the research topics in the field of entrepreneurship.

The study findings also have practical implications. Entrepreneurs must be clearly aware of the importance of innovative strategy, proactive strategy and risk-taking strategy to the survival and development of new ventures. Firstly, start-ups should pay attention to the market trend and grasp the market opportunity, in the new product creation and service mode and other aspects of new development. Secondly, start-ups should build a proactive strategic awareness to stay ahead of competitors from the start-up and management teams, and take a first-mover strategy to quickly capture the market and accumulate capital. Finally, to a certain extent, resource bricolage improves the utilization rate of resources, thus improving the risk bearing capacity of start-ups.

Limitations

Limitations in the study suggest the following research avenues. Firstly, the study only studies the effect of resource bricolage strategy on entrepreneurial orientation during the start-up period, and the conclusions are only applicable to new ventures. Future research could explore the impact of resource bricolage strategy on entrepreneurial orientation in other growth stages. Secondly, the study takes only one country's enterprises as samples. This suggests using international research in future to verify the conclusions with global data. Thirdly, one concern about the study is that readers may still be interested in the effect of entrepreneurial orientation on resource bricolage, although the study provides sufficient reasons to demonstrate the effect of resource bricolage on entrepreneurial orientation. It is a good thought process. People with low entrepreneurial orientation tend to take conservative action strategies in the face of insufficient resources, while people with high entrepreneurial orientation will reach their goals by bricolage, even though it is risky. In fact, our study pays more attention on the question of how start-ups thrive in resource-constrained situations. Resource bricolage can make full use of existing resources to improve the risk bearing capacity and enhance the innovation capacity of an enterprise. The study process is rigorous and the conclusions are credible. The future direction can be studied by studying the differences in the use of resource strategies among people with different degrees of entrepreneurial orientation. Fourthly, one question that needs to be explained is that in the study, the means of the key constructs are high and show little variation. When we set up the questionnaire to avoid ceiling effect and floor effect, it is necessary to explain the results to avoid misunderstanding. Firstly, we adopted mature scales and tested reliability and validity. Secondly, we carefully considered

the language of the questionnaire, and further improved the questionnaire by communicating with three CEOs of start-ups to ensure that the interviewees fully understood the questions. Finally, a small number of questionnaires were collected in the way of pre-survey to test whether the design of the scale was reasonable. Based on this, we believe that the data results of this study are real and accurate, and there is no ceiling effect. We measure the extent to which the independent variable can explain the variation of the dependent variable by R-square value. The result shows that the R-square value is 0.513, indicating a good fitting degree.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

PX guided and checked the topic selection and writing direction of the study. GR and SX are responsible for writing and revising

the main part of the study. ZJ is responsible for data collection. All authors contributed to the article and approved the submitted version.

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Using framing to foster creativity in learning: Reflective tool to analyze and discuss practice

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Several models have been devised in Iceland in recent years to analyze emerging pedagogies in practice. In this article we present a model that was developed and tested in research on innovation and entrepreneurial education in 2011 and subsequently applied in two participatory action research (PAR) projects with teachers in Iceland both focusing on creativity. The model draws on sociological concepts from Basil Bernstein's theories, such as "framing and classification" and "power and control" in school settings. Through multiple iterations, the model was converted into a practical analytical tool. The tool helps to reveal the range of elements that teachers can control or give students agency by applying different strengths of framing. When breaking down the elements we found that concepts such as freedom versus control can help to identify how these elements emerge and are applied in school practice and how they can support or hinder creativity. Working in the two PARs with subject teachers on four different school levels, we found out how the teachers used the tool to support their understanding of how to cultivate creativity in their students' learning. We found that the tool is useful for teachers at any school level and in any subject to identify and understand which elements they control in teaching and learning processes and how they can support students' creativity.

KEYWORDS

creativity, innovation and entrepreneurial education, entrepreneurship education, innovation education, participatory action research (PAR), framing, classification

Introduction

Creativity, innovation, and entrepreneurship have gained increased attention in recent decades as important competences in the modern world (Craft, 2000; Jónsdóttir and Gunnarsdóttir, 2017; Lilischkis et al., 2021). Creativity and innovation are not only important for constructive economic development but also to find solutions to social issues and environmental challenges (Weicht et al., 2020; Jónsson and Macdonald, 2021). UNESCO's report (UNESCO, 2021) on the future of education acknowledges the

power of education to bring about transformative change in the world, which requires both creativity and intelligence. Cross-curricular competencies such as problem-solving skills, creativity and curiosity are increasingly acknowledged as important for learners (OECD, 2020). Innovation and *action competence* are abilities that are important when dealing with the challenges of sustainable development (Pálsdóttir, 2014; Jónsdóttir and Gunnarsdóttir, 2017; Weicht et al., 2020). We use the definition of innovation as the generation, acceptance and implementation of new ideas, processes, products, or services (Shavinina and Seeratan, 2003). Action competence is the competence required for taking action, requiring willingness, knowledge, skills, and trust in one's influencing possibilities (Sass et al., 2020).

Innovation criteria and action competence have been taken up by many countries in Europe, but aspects of it have also often been misunderstood and how to deliver them in educational practice. To understand and analyze the pedagogy, the elements and nuances of how teachers work with students on inculcating these competences, we turn to Basil Bernstein's (2000) theories. Bernstein's central preoccupation is language, but not language as we know it day-to-day. For Bernstein, language is built on codes, criteria, and models. These in turn generate modalities of control based on rules, which themselves give rise to consequences and then function as hypotheses.

The research projects we describe were conducted in Iceland. A new version of the National Curriculum in Iceland was introduced in 2011. It includes a section on the visual and technical arts which has been translated into English and presents creativity as one of six fundamental concerns in the very much revised curriculum (Ministry of Education, Science and Culture, 2014). Guidance booklets were published to introduce the main policy for school curricula and make them accessible to most teachers. The many consequences of the new policy were brought to the attention of teachers and parents around the country in official booklets and ministerial documents, and similar booklets were produced for all the school subjects. Even so, it has been challenging for teachers to teach creativity to their students.

The purpose of this article is to show the utility of a model built on some of Bernstein's (2000) concepts, that teachers at any school level can use to identify which elements they control in teaching and learning processes and recognize how they can support students' creativity. The aim is, first to show how the model was initially developed and converted into a practical tool used to analyze pedagogy in innovation and entrepreneurial education and secondly how it was later used in two PAR projects to support student creativity.

In the next section we first present the background, relevant theories, and key concepts underlying this article. In section "Developing the model into a tool and using it in different educational contexts" we give an overview of the research behind the model and in section "Developing a model to analyze

creative pedagogy – The IEE research" how the model was developed as an analytical tool for curriculum in research on innovation education. We then describe in section "Further development and use of the model – Traditional subjects" how the tool was used later, in one PAR project with teachers working with traditional subjects. In section "Arts and crafts teachers using the analytical tool," we show how the tool was used in another PAR with technical, arts, and crafts teachers. These analytical exercises and descriptions allowed us to explore the nature and practice of pedagogy and the ways in which some of Bernstein's (2000) concepts challenge us to deepen our understanding. Finally, we discuss the main points presented in this article.

Background and influential theories

In this chapter we present the background for the design of the model and supporting theoretical foundations. First, we briefly discuss how we understand creativity and change in education and entrepreneurship education as a learning area that includes creativity and action competence.

Creativity and change

While creativity is a concept commonly used, it is nevertheless elusive, complex, and difficult to define. Creativity has been defined as "... a process of developing and expressing novel ideas for solving problems or satisfying needs" (Harvard Business Essentials, 2003, p. 82). Creativity is also defined as reasoning that produces imaginative new ideas and that creativity is an individual process, relating facts or ideas in new relationship and is discontinuous and divergent (Maravilhas and Martins, 2018). Craft (2000) identified possibility thinking as the core of creativity and that insight is a part of creativity. To harness creativity requires having "agency," defined as the control individuals have over their actions and lives that enables them to "actualize" their choices (Craft, 2000). Creativity is about applying "agency," the ability and capacity to act and work in order to come up with ideas or products that are original and innovative in their context (Jeffrey, 2005). However, creativity has also been described in relatively simple terms which we adopt here: creativity is the ability to flexibly produce work that is novel, high in quality, and useful (Sternberg and Lubart, 1999; Sternberg et al., 2003; Runco and Jaeger, 2012).

The importance of creativity and innovative competencies in modern societies has been increasingly acknowledged in recent decades, emerging as aims in many curricula internationally. In the Icelandic curriculum for compulsory schools (Ministry of Education, Science and Culture, 2014) creativity is said to involve "forming tasks and communicating

them, to make something, make something new or different from what the individual knows or has done before” (pg. 22). Implementing creativity in formal education makes demands on teachers, as they are key players in designing opportunities for learners to develop such skills. Classroom contexts matter and external pressures can limit student creativity (Tan et al., 2016). It can be challenging for teachers to apply the kinds of approaches that support learner creativity (Lin, 2014; Jónsdóttir, 2017). Creative work often involves risks and failures. To make students comfortable with open ended and ambiguous tasks, teachers need to be proactive in supporting them to self-regulate and be reflexive (Henriksen et al., 2021; Jónsdóttir and Guðjónsdóttir, 2021). Teachers need to be aware of the tendency to take conservative approaches when making changes in their teaching, especially if they intend to support creativity in student learning and go beyond rote learning (Leroy and Romero, 2021). A recent systematic review reveals certain features that are characteristic of creative pedagogical practice: generating and exploring ideas; encouraging autonomy and agency; playfulness; problem-solving; risk-taking; co-constructing and collaborating; and teacher creativity (Cremin and Chappell, 2021). The findings also indicate that documenting the complexities creative pedagogical practices is challenging. The authors recommend that practitioners join researchers as co-participants, to enable a more nuanced examination of the impact of creative pedagogies on student creativity (Cremin and Chappell, 2021). Such joint efforts can be seen in participatory action research (PAR) where researchers and practitioners work together in doing research. PAR can be an empowering way to deepen understanding of issues in education and directly influence practice. PAR offers a framework for generating knowledge centered on the belief that those who are most impacted by research should be leading in framing the questions, methods, and analysis (Torre and Fine, 2006).

Entrepreneurship education

Entrepreneurship education [In Iceland referred to as Innovation and Entrepreneurial Education (IEE)] is one area of teaching and learning that has offered valuable opportunities to foster and enhance creativity and competence for action (Jónsdóttir and Macdonald, 2013, 2019; Seikkula-Leino et al., 2021). A broad view of entrepreneurship education (EE) has been developed such that EE is not just about starting a new business, but about enhancing two of the core elements of such education: action competence and creativity. Creativity is a competence that is at the core of EE, as it is very much about problem-solving and action (Jónsdóttir and Gunnarsdóttir, 2017). EE is relevant for all levels of education, from kindergarten, through primary and secondary school, to vocational, higher and professional education (Lilischkis et al., 2021). We see EE as providing affordances that can be used

in different educational contexts to inculcate creativity and action competence.

The EntreComp report from the European Commission is meant to support the assessment and evaluation of the goals of EE. The report presents EE as learning framed around three overarching areas of competences: (1) *Ideas and opportunities* (including creativity), (2) *resources* (realizing what is needed), and (3) *into action* (getting things done) (Bacigalupo et al., 2016). Entrepreneurship education has been seen as a way to unleash human potential to tackle complex societal, economic, and environmental challenges (Lilischkis et al., 2021). It seems that the overall aims of EE are in line with what is needed to change education so it can empower learners to tackle challenges that sustainability education needs (Weicht and Jónsdóttir, 2021). Jónsson and Macdonald (2021) conclude that in order to develop practices that could support sustainability, the focus in education needs to shift from *what* to teach, to *how* to teach. Such a shift requires teachers to be aware of how they teach and to be ready to analyze different activities.

Developing the model into a tool and using it in different educational contexts

In the following sections we present how the model was developed and used (Developing and using a model to analyze creative pedagogy), how it was further developed and used in a two year PAR with teachers teaching traditional subjects (Further development and use of the model) and finally an example from a 2 year PAR with teachers teaching arts and crafts (Arts and crafts teachers using the tool) (see Table 1). We want to show with these cases how this model works and share examples of its use. Table 1 shows an overview of the researches behind the making of the model and how it was applied – and the role of each research for this article.

Developing a model to analyze creative pedagogy – The IEE research

The first study of the three, is a study where the model was first developed and used. This was a research project on the pedagogy of 13 IEE teachers, in which an analytical model was designed to code, interpret and record the interactions between teachers and students and among students in the classroom. Criteria based on Bernstein’s (2000) concepts of classification and framing enabled identifying the characteristics of the pedagogy the teachers applied working with IEE focusing on how they supported student creativity and action competence.

TABLE 1 The three research projects presented in the article.

Title of research	Description – role in article	Publications (different foci than in this article)
Section “Developing a model to analyze creative pedagogy – The IEE research.” The location of innovation education in Icelandic compulsory schools, 2006–2009	This study examined examples of IEE in compulsory schools in Iceland. The research built on qualitative case studies to determine how teachers were supported in developing IEE. Observations, interviews with teachers, principals and learners and school curricula and official texts were analyzed. Additionally, interviews were taken with seven teachers from other schools. Role in the article: To explain how the model was created and explain the data and the theories it is built on.	Jónsdóttir, 2011; Jónsdóttir and Macdonald, 2013; Jónsdóttir and Gunnarsdóttir, 2017
Section “Further development and use of the model – Traditional subjects.” Action research by eight teachers in traditional subjects, on four school levels, 2013–2015	An action research of eight teachers on four school levels aiming to understand and identify how they enhance the creative capacities of their students. The participants were one pre-school two secondary, two upper-secondary, and three university teachers. Role in the article: To show and explain the development of the model and an example of its use	Jónsdóttir, 2017
Section “Arts and crafts teachers using the analytical tool.” Action research of arts and vocational teachers at three school levels, 2016–2018	An action research project focusing on creativity in teaching and learning. Participants were eight arts and vocational teachers at three school levels. The teachers were three arts teachers, two textile teachers, two IT and vocational subjects (in Icelandic, <i>verkgreinar</i>) teachers, and one drama teacher. Role in the article: To show an example of the use of the model for teachers	“How can the ‘state bear become a quaint artifact’ Arts and vocational teachers at three school levels share narratives from their action research” [in Icelandic, long abstract in English] Jónsdóttir and Guðjónsdóttir, 2021

Adopting and adapting Bernstein’s concepts

To understand how Bernstein’s theories were used to lay the foundation for our model we explain here which of his concepts we used. Bernstein (2000) examined a series of rules internal to pedagogy and identified how these rules affect the knowledge chosen to be transmitted, as well as how those rules select those who can successfully acquire knowledge. Bernstein’s conceptual framework offers ways to recognize how knowledge is distributed and how it changes as it is recontextualized from one field into another. Bernstein introduced two concepts, classification and framing, that are important for this study. Classification and framing explain power and power relations and the forms they take in the control of relationships. *Classification* is a concept to categorize the construction of a social space; e.g., by school subjects or by roles such as teachers vs. learners and home vs. school (Bernstein, 2000). *Power* is fixed within a classified category, which can be strongly or weakly classified. The power of a school subject is reflected in the amount of time it is allocated and the space it gets in the curriculum. *Control* describes the establishment of legitimate forms of communication that are appropriate to different categories, such as who controls communication in the classroom and what forms are proper. This is important as supporting student creativity requires teachers to relinquish control in order to give students freedom and agency, which is often the opposite of traditional teaching (Jónsdóttir, 2017).

Framing refers to where control is located within a social context. Strong framing is when the transmitter has explicit control; in weak framing, the acquirer has more control (Bernstein, 2000). Strong framing indicates that control is located in a category that has power – for example, a teacher’s traditional role – whereas weak framing indicates that control is shared between categories, for example, between a teacher and a learner or among curricular subjects (Macdonald and Jóhannsdóttir, 2006). Framing regulates relations within a social context, referring to the relationship between transmitters and acquirers (Bernstein, 2000, p. 12). Framing is about who decides the location of work (in the classroom, the hallway, or outside; at school, at home, virtually, or out in nature), time restrictions, or social and emotional communication (unequal or equal roles; strict or relaxed communication) (Jónsdóttir, 2017).

Criteria using these concepts were developed into an analytical model to identify control in the classroom and how much freedom and agency learners were allocated in the research on the 13 IEE teachers’ practice. Bernstein’s theories are sensitive to context and can thus be applied in different settings to reveal how and where respect, power and responsibility are located in social interactions (Jónsdóttir, 2011). Curricular processes and the social interaction of teachers and learners in IEE have shown that supporting learner creativity needs a balance between *freedom* and *structure*. Applying the criteria in the model and using Bernstein’s concepts of classification and framing revealed three modes of pedagogy present among teachers working with IEE:

- *controlled*, where very strong framing is applied;
- *progressive*, where students have some control; and
- *emancipatory*, where students have ample agency and freedom to be creative and active and often are on equal footing with the teachers as they develop their own ideas (Jónsdóttir, 2011; Jónsdóttir and Gunnarsdóttir, 2017).

The teachers displayed different strengths of framing in IEE lessons, with an inherent tendency toward strong framing. From the data we designed a table with descriptors to identify different strengths of framing and classification. Bernstein's (2000) approach to coding the behavior and language of teachers and students enabled us as researchers to break down the interactions between the parties involved in order to form units that were the smallest category defined by Bernstein. Thus we created an analytical tool built on Bernstein's concepts and on the data from the IEE research (Table 2) to identify framing of interactions in the classroom and classification of power. Table 2 shows the elements using Bernstein's indicators, with some of them divided up in more detail than Bernstein did. The table shows explicatory texts that indicate who controls which elements and in what way.

Further development and use of the model – Traditional subjects

This example is from a PAR of eight teachers at four schools who collaborated in studying their own teaching to identify and analyze how they went about supporting their students' creativity (some findings in Jónsdóttir, 2017). The teachers taught traditional subjects – Icelandic and mathematics – and included a pre-school teacher and three university lecturers. The study was led by the first author; the group met once a month for 2 years (2013–2015) to share data and discuss and analyze the teachers' experiences.

Developing the model into an analytical tool

Using the framework from Table 2, the analytical tool *Who is in control?* was developed (Figure 1). It has empty spaces to fill in where teachers or researchers identify the strength of framing in teaching and learning that is to be scrutinized. One of the exercises of the teacher group was to apply the tool to examples of their own teaching, to help them become aware of power relations in the classroom. Bernstein's theories can help to identify and understand different forces that are at work and that are not visible until they are recognized and analyzed. The tool can help to identify different elements that can be controlled by the

teacher or the learner, or that can be negotiated between them. By looking at different elements of teaching and learning in the classroom, the teachers could identify who had power over each part.

The first element in the tool is *knowledge*, which can be a curricular subject, specific content, and/or a specific theme. Specific knowledge can comprise various topics and tasks. This was just one element with Bernstein but we found it important to split it up. We broke knowledge up into sub-elements such as themes and tasks. An important part of learning and creating is the *development of ideas* – who has a say in how they pan out and in what direction and can be a part of the student's knowledge creation. Is the teacher the specialist in the development of the student's creative idea, or is it actually the student who is the specialist, as is emphasized in IEE pedagogy (Jónsdóttir, 2011)? *Methods* of working in the classroom can differ. They can be fully controlled by the teacher (very strong framing) or the learner (very weak framing), but may fall somewhere between these two extremes. *Pacing* denotes how quickly work is finished in the classroom – another issue that can influence the creative process. The *sequence* of how to do processes in creative work also impacts outcomes – e.g., can the student decide what to work on first, and then move on to another part as they wish? Or does the teacher decide that students must start with a certain part, move on to the next, and end with a specific one? The *communication* in the classroom can be informal, with students and teachers interacting like colleagues – or it can be strictly formal, where the teacher is in total control and learners ask for permission to speak, stand up, or talk to each other (very strong framing)? Related to communication is the *location* of work – where can the learner work on tasks? Can they decide to sit on the floor, or work in the hallway? Or is location strictly determined by the teacher – e.g., students must sit at their own desks (strong framing)? Who chooses which *materials* to work with on tasks is also an issue that can restrict or support creativity? *Evaluation* of the schoolwork is important, but traditional knowledge assessment methods are not well-suited to creative work. It is interesting to find out how teachers go about evaluating learner creativity and whether the learners are included in that process.

Using the analytical tool

Well into the second year of study two, the PAR with the teachers in traditional subjects they used the tool to analyze their own teaching and scrutinize who had control in the classroom. This helped them understand how that framing influenced learners' autonomy and creativity. I (the first author) explained the tool (in the form of a table) and they each got an empty table (*Who is in control?* Figure 2) to mark their analysis of each of the elements in the table. The analysis helped to

TABLE 2 Developing the framing model.

Elements of lessons	Strong framing - teacher control		Weak framing – learner control	
Knowledge – content and themes	The teacher decides what is to be learned, content, themes, or issues to handle in the lessons with one set focus.	The teacher offers specific content, themes, or issues but accepts/allows learners' ideas to enrich the main focus.	The focus of the content is greatly influenced by learners' ideas and suggestions.	The focus and content of the theme or issue is set and developed around learners' ideas.
Topics	The teacher selects which topics to address.	The teacher offers a limited range of topics to address.	The learners suggest several topics and learners select which they want to address conferring with teacher.	The learner selects which topics to address.
Tasks – topics	The teacher selects tasks such as “make a 3D cube.”	The teacher offers a limited range of tasks and learners select from those. Learners choose how to develop them.	Learners suggest several tasks, the teacher offers a range of them, and learners select from those options.	The learner selects the task independently.
Direction of developing ideas	The teacher makes decisions in developing solutions.	The teacher suggests choices in development of ideas or influences learner choice.	The learner develops their idea with the teacher's support; the learner makes final choices.	The learner controls the development of their ideas, and the teacher provides support.
Direction of developing ideas	The teacher makes decisions in developing solutions.	The teacher suggests choices in development of ideas or influences learner choice.	The learner develops their idea with the teacher's support; the learner makes final choices.	The learner controls the development of their ideas, and the teacher provides support.
Methods	The teacher decides the method.	The teacher offers a limited range of methods.	The teacher and learners come up with a collection of methods and choose from them.	The learner selects the method independently.
Pacing	The teacher decides when each task is to be finished.	The teacher sets an overall time frame for when projects are to be finished.	The learner chooses their pace within a set but flexible time frame.	The learner sets the time frame and the pace of work.
Sequence	The teacher has a set sequence of tasks within projects or themes.	The teacher has a set sequence of some parts of projects or processes.	Learners can do some alterations to sequence of tasks or processes.	Learners can have any sequence of tasks that fits their object/goal.
Communication	The teacher controls all communication; learners ask permission to speak.	The teacher controls some of the communication; learners ask permission to speak to the teacher.	The teacher and learners freely communicate (atmosphere of a workshop); learners speak together.	Learners and teachers freely communicate and take on each other's roles; learners speak together and help each other.
Location of work	Location of work is fixed throughout the lesson as predetermined by the teacher.	Location of work is different according to different tasks – choices offered by teacher.	Location of work is negotiated between learner and teacher.	The learner selects location of work.
Materials	The choice of materials is decided by the teacher.	The teacher offers a limited range of materials to choose from.	Learners have a wide range of materials to choose from.	Learners may procure and use specific materials.
Evaluation	The teacher uses guidelines and criteria for evaluating learner achievements that are mainly built on the national curriculum.	The teacher offers guidelines and criteria for what is going to be formally evaluated and makes these explicit.	Goals and criteria for evaluation are negotiated between learner and teacher.	The learner sets goals and criteria for evaluation.
Roles	Learners have very limited agency and are receivers. The teacher is the specialist who transmits knowledge. The control in lessons is distinctly with the teacher.	The teacher controls most aspects of lessons and is the specialist. Learners have agency within certain well-defined areas.	Learners have agency in defined areas and are aspiring innovators and creators.	Learners have ample agency and are innovative, i.e., creative, and active. Learner and teacher roles are often flipped – learners become experts, and teachers learners.

identify in detail the kinds of learning spaces or opportunities for creative work the teachers had designed for their students (see Jónsdóttir, 2017). The findings indicated that the teachers became more aware of the opportunities for creativity they were offering their students in lessons and showed that the tool had helped them focus on when and how they offered learners control and agency over their creativity in their learning processes. The tool was thus one element in the research that helped them to analyze their own teaching and the opportunities for student creativity.

Arts and crafts teachers using the analytical tool

The third example we share is from a 2 year PAR of arts and crafts teachers. Arts and crafts teachers are expected to promote and cultivate creativity. It is expected that other educators can learn from their expertise to enhance creativity in their learners. In 2016–2018 eight technical, arts- and crafts teachers on three school levels (compulsory-, upper secondary- and university level) took part in a PAR lead by the first author focusing on how

Selection /control over Framing:	Teacher always ++ very strong	Teacher considerably + strong	Student considerably - weak	Student always -- very weak
Knowledge – content and themes				
Topics				
Tasks				
Development of ideas				
Methods - approach				
Pacing				
Sequence				
Communication				
Location of work				
Materials				
Evaluation				
<div> <div>Receiver/obedient/dependent</div> <div>Creative/free / independent</div> </div>				

FIGURE 1

The framing model as an analytical tool. Who is in control (Developed from Jónsdóttir, 2011).

they went about supporting learner creativity (study three). Of the five teaching at the compulsory level (5–16 years old), two were textile teachers, two taught information technology and crafts, and one visual arts. Two more teachers taught visual arts at the upper-secondary level, and one taught drama in teacher education. The data were analyzed in collaboration with the teachers and the research published with the support of a critical friend who also participated in certain aspects of the research process. The paper was published in Icelandic with an extended abstract in English covering the methods and main findings (Jónsdóttir and Guðjónsdóttir, 2021).

The teachers gathered different data about their teaching, keeping a journal on how they worked with students, focusing on creativity. They also gathered lesson plans and students' artifacts and work. Collaborative reflection meetings with the group were held once a month. At these meetings members of the group shared stories from the classroom and discussed challenges, issues, and benefits of arts and crafts education and how it worked in practice. The teachers interviewed one another to shed light on what kind of teachers they wanted to be. They also made collages to describe their professional working theories and interpreted them orally. Furthermore, they did an analytical exercise on a chosen part of their teaching using the framing tool "Who is in control?" where they identified what level of control they applied in their teaching.

Three examples from that exercise are presented here that have not been published before. The real names of the teachers are used with permission, as in other publications from this PAR.

Example from a textile teacher

All the teachers in the arts and crafts PAR used the framing tool to analyze a specific part of their teaching. The patterns of their entries into the framing table show how their students had influence on different elements of their learning. The teachers all explained their results using the tool. We present an example here from one of the textile teachers.

Erla Dís was a textile teacher with a master's degree and had only been teaching for 3 years. She was very ambitious in her teaching and found it helpful in a demanding job to keep a detailed journal about her teaching. Using the framing tool, she provided an example from her teaching about patterns and printing with a mixed age group of students in grade 8, 9, and 10 (14, 15, and 16 years old) (Figure 2).

Erla Dís felt that she sometimes had to locate the marks near the vertical lines in the tool (see Figure 2) or even on a line to indicate that it was not always either/or. Sometimes she chose to make two marks in the same line to indicate

Selection /control over Framing:	Teacher always ++ very strong	Teacher considerably + strong	Student considerably - weak	Student always -- very weak
Knowledge – content and themes	▶			
Tasks - topics	▶			
Methods		▶		
Development of ideas			▶	
Methods - approach				▶
Pacing				▶
Sequence	▶			
Communication		▶		▶
Location of work		▶	▶	
Materials			▶	
Evaluation		▶	▶	
<div> <div>Receiver/obedient/dependent</div> <div>Creative/free / independent</div> </div>				

FIGURE 2

Erla Dís – example – Teaching textiles: patterns and prints.

that sometimes she had a say and sometimes the student, depending on the negotiation between her and the students. The project she used as the unit of analysis is rather extensive and is the only one the students work on in this module. The module spans 10 weeks and students attend classes for 80 min each week. Erla Dís explained the lessons she analyzed in writing using the framing tool, and referenced framing in discussions during the research group meetings. The introduction to the module started with a general presentation on pattern-making followed by textile prints and basic methods for printing patterns. The knowledge or theme of learning is thus decided by the teacher (very strong). She described the process:

The part of patternmaking started with a short fieldtrip around the area near the school. During the fieldtrip the students are encouraged to scrutinize the environment and take note of details. I ask them to look up, look down and find forms and even patterns. Each student took five photographs during the trip.

On their return from the fieldtrip, Erla Dís gave a presentation with slides about pattern making. She presented

work of known designers and designer studios that use patterns in original ways (e.g., Timorous Beasties, Marimekko, and others) (strong framing of knowledge). Then the students scrutinized the photos they took during the field trip and chose one to work with (some teacher control). The textile printing portion of the project also began with a traditional teacher presentation supported by a slide show on printing methods from potato- and leaf-print to silk print. The students watched videos from different corners of the world displaying printing using different approaches.

The development of student ideas

The students chose one of five photos to work with as before and printed 10 copies. They performed their ideation and pattern design work on the copies and were encouraged to see forms and lines within the photos (weak framing).

Pacing and location of work

This project was taught over a period of 10 weeks. At the beginning, all students proceeded at the same pace, but later they were permitted to work at their own pace. The methods

and approaches students chose were different. The patterns they designed could be demanding on different levels and thus influence the progress of the project. Some students used up to three lessons (80 min each) to carve out their stencil. The work took place within the textile room, but the tables were sometimes moved to the sides so that students needing more space could spread their projects out on the floor.

Erla Dís described approaches, methods, materials, and communication:

The project is in fact very open and the methods that can be used to put patterns on textiles are manyfold, and the students learn about them right in the beginning. Students have considerable choice of materials (weak framing). Also, there is constant communication, conversation between me and each student (formative assessment) about the progress of their work. Often in such conversations good ideas are born. Students can choose a workplace within the textiles room and usually ask me (negotiation, strong to weak).

In the conversations Erla Dís had with her students, interesting ideas were born – what has been called “creative conversations” in some research (Chappell and Craft, 2011) – and she also used those words. She sometimes marked in two places in the table and explained that it was sometimes a negotiation between teacher and learner (Figure 2). She described the overall analysis of the project:

The project offers ample creativity and very independent work process and approaches. But students’ premises and interests certainly influence how this pans out. Some are insecure and do not manage independent work while others get lost in their own creative powers and even take the project further, do something unexpected, which is particularly pleasurable.

She described what she had found out by using the tool to evaluate the pedagogy for creativity she applied in practice:

For me as a teacher this is a great project among other reasons because the frame is clear, but the freedom is also within and that helps to make the student products so versatile. My experience is that I am offering a suitable balance of freedom and control.

Erla Dís’s example shows how the framing tool helped her become aware of the different elements of her pedagogy in practice, how control could be supportive, and when it was important to give students agency to be creative. If the first author were to plot her experience as a student in compulsory school and even in upper secondary school, the markings would be far to the left in most cases, displaying very strong framing.

Value of using the framing analytical tool

The other teachers in this PAR project showed different zig-zag patterns in their analysis of their practice. They were seldom far to the left (teacher control), and often near the middle or to the right side of the table (students significant control over some elements of their learning). Two other examples from the teachers in this PAR are presented next and can be seen in Figure 3.

The examples from Ása (Á), a drama teacher at the School of Education, at the University of Iceland, and from Sverrir (S), a crafts and information technology teacher at the compulsory level (5–16 year old students) are presented in Figure 3.

Sverrir analyzed a unit he taught in woodwork to 9-year-old students, where the task was to design and create a picture frame (Figure 3). The project and task are decided by the teacher and consider the aims for skills in the national curriculum for this age (mainly strong framing). Once the teacher has presented the project and tools that students might need as well as different types of frames, the students get a paper where they design the look they want for their frame (development of ideas, very weak framing). The methods are partially set, as students must follow a logical process, but they do have some influence on some of the steps and pace of their work (framing varies from considerably strong to weak). To get the teacher’s assistance, students take a clothespeg with their name on it and fasten it to a line by the teachers’ desk. The teacher can then see who is next and finds the student (strong framing of communication). The students each have their own workbench and can execute their projects there; alternatively, they can go over to a common space where they can paint, sitting or standing as they please (weak framing). The materials students can choose from are limited, although they are offered wood of varying thickness to choose from. The teacher evaluates various elements of the process such as whether the student can draw a design for a frame and transform an idea into a finished product. Students can influence one part of the evaluation process when they assess their own product and describe what they are pleased with and what not. This means that evaluation is mainly in the hands of the teacher (very strong to strong framing).

The unit Ása analyzed is a course called *From idea to play*. The students were a mixed group of in-service teachers and student teachers taking the course as an elective. Ása described the location of her marks in her table (Figure 3) and analyzed her unit of teaching as follows:

The knowledge, content and themes are usually chosen by me the teacher (strong framing) but sometimes I take into account students’ suggestions for tasks (strong to weak framing). The development of ideas and methods are often negotiated between me and the students (strong to weak































Selection /control over Framing:	Teacher always ++ very strong	Teacher considerably + strong	Student considerably - weak	Student always -- very weak
Knowledge – content and themes	 			
Topics				
Tasks		 		
Development of ideas				
Methods - approach			 	
Pacing				
Sequence				
Communication		 		
Location of work				
Materials		  		
Evaluation		 		
<div> <div>Receiver/obedient/dependent</div> <div>Creative/free / independent</div> </div>				

FIGURE 3
Ása Helga's and Sverri's examples.

framing) but the pacing and sequence is mainly decided by me (very strong to strong framing). Various materials to set up a play are offered and their choice often in the hands of the students or at my suggestion (strong to weak framing). There are no exams in the course and the evaluation is largely mine – however, students do a self-evaluation and give a peer review for each other (strong to weak framing).

Even though the teachers use of the tool revealed some differences, some similarities are also evident. They all marked certain parts of their practice as strongly framed or very strong – usually knowledge, topics, and tasks. Other elements varied a bit, but often tended toward weak or very weak framing. The purpose of using the tool was not to nail down precisely what kind of pedagogy was most successful in supporting student creativity, but rather to give the teachers a heuristic to look carefully at their own teaching to identify where they controlled student learning and creativity and where they gave them freedom and agency to be creative.

The teachers valued the tool as a supportive way to analyze and discuss their own teaching practice. They concluded that sometimes they needed to be in control, but also that they could sometimes give students more choice and freedom to support their creativity. The teachers also used other exercises during the 2-year research project to identify and analyze how they worked,

such as interviewing each other, making collages about their professional working theories, and relating stories about their practice. After using the tool, the stories they told were often related to how they used framing. They described examples of both strong and weak framing, and explained how they had become more aware of when they would like to give students more agency to be creative. All eight participating teachers wanted to give students more agency and control, and found ways to do so by analyzing the different elements in their lessons. However, they also realized that they had to offer some strong or even very strong framing for some elements of a project, and that it was important that the affordances of their specific subject could offer the students special knowledge and skills that were unique to the subject.

Discussion

In this project we built on a model developed in research on teaching innovation and entrepreneurial education and converted it into an analytical tool. The model was founded on Basil Bernstein's concepts, who was one of the more complicated sociologists of our time. The team brought very different fields of expertise to the development of the model. Figures 2, 3 cover concepts well known to those who use Bernstein's work,

for example we could cluster selection, pacing, sequence and development of ideas into what is known as the instructional discourse. The elements of the regulative discourse will benefit from a project similar to that described in [Figure 2](#). These include knowledge and criteria of knowledge, topics, and tasks. Finally, to complete the picture a workstation in a Bernstein fashion would house a group engaged in some of the other tasks such as communication and evaluation.

The studies reported here are diverse in nature but share a focus on creativity. We move from a discussion of a relatively new professional area in our description of entrepreneurial education. We hope it shows an interesting, challenging, and exciting area of teaching and learning. What the field needs now is more empirical research on entrepreneurship in different locations that call forth a variety of responses. There are opportunities for schools to offer entrepreneurial activities more often and with a clearer sense of mission. Innovation and entrepreneurship are not mirrors of each other but require a thorough understanding of the settings in which new work takes place and begins to understand what it faces ([Jónsdóttir and Macdonald, 2013, 2019](#)).

Several professionals in Iceland engage in entrepreneurial education in one way or the other. What we need are a wider range of topics and more cooperation with local enterprises, businesses and communities in order to motivate young people. COVID has taught us that we do not need to be on the spot to promote the cause we wish to champion. What is needed though is more focused discussion between adults and children with mutual respect. To achieve success those who work together will need to understand when the control is in the hands of the teacher and when it is possible for the student to take a leading role ([Jónsdóttir and Macdonald, 2019](#)). Also important is the regulative discourse in the district in which this project is situated where taking initiative is highly regarded.

The purpose of this article was to share a model that could help teachers to identify and analyze the elements they control in teaching and learning processes and recognize where and how they can support students' creativity. To achieve this, we discussed the model built on [Bernstein's \(2000\)](#) concepts, how it came about and how we used it as a tool in two PAR to help teachers discover how they could successfully support student creativity.

It can be challenging for teachers to break away from conservative approaches to teaching ([Leroy and Romero, 2021](#)). To bring creativity to the classroom requires that the role of the teacher shift from formal teaching to a more informal guidance. The model we have presented using [Bernstein's \(2000\)](#) concepts has helped teachers to allow students more creativity in their learning ([Jónsdóttir, 2017](#); [Jónsdóttir and Guðjónsdóttir, 2021](#)). The teachers in the two PAR, both the teachers in the study 2013 and 2016, were able to identify elements of their teaching that they could influence to enhance and support their students' creativity within their subjects by adjusting framing.

Thus, creativity became a focus of how they taught their subjects as they considered how they could give their students more ownership over their learning process. Teachers should be supported by administrators in considering and reflecting on factors and nuances of pedagogy and how they apply framing. They need opportunities to collaborate in a safe professional environment where they can discuss taking risks, share fears and uncertainties, and learn from failures in order to create a constructive professional culture ([Jónsdóttir, 2017](#); [Henriksen et al., 2021](#); [Jónsdóttir and Guðjónsdóttir, 2021](#)).

Creativity is emerging as a serious element in the contribution of the arts to knowledge. If [UNESCO's \(2021\)](#) ideals, as they are presented in the report *Reimagining our futures together: a new social contract for education*, are to be realized, teachers must execute them in practice. We certainly need creativity, perseverance, and hope in a world of increasing uncertainty and complexity, and entrepreneurship education offers a promising pathway to meet those needs ([Seikkula-Leino et al., 2021](#)). But for teachers to travel down that pathway, policy makers, researchers and teachers must find ways to support them in their demanding journey. Our argument is that the tool we presented is useful to help teachers in different subjects and at different school levels to identify and understand which elements they control in teaching and learning processes and how they can support students' creativity.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data are owned by the teachers conducting their action research. The data are in Icelandic. Requests to access these datasets should be directed to SJ, svanjons@hi.is.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent was not provided because this study is already conducted - those adhered to all required ethical standards. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SJ came up with the idea for the manuscript. SJ and MM developed and collaborated on writing the manuscript, have a long-standing collaboration starting with MM being SJ's

supervisor in the research described in the manuscript, and approved the submitted version.

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Effect of product-based pedagogy on students' project management skills, learning achievement, creativity, and innovative thinking in a high-school artificial intelligence course

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The purpose of this study is to explore the effectiveness of product-based pedagogy (PBP) on students' creativity and innovative thinking in artificial intelligence (AI) education. A seven-step model (i.e., phenomenon, problem, plan, prototype, product, presentation, price) in accordance with PBP was proposed, in which the key function of the product as a linkage between creativity and innovation was emphasized. A total of 209 students from a major high school in South China were randomly assigned to a treatment group with PBP and a control group with direct instruction. Results indicated no significant difference was found in students' learning performance; however, students in the treatment group performed significantly better than the control group in terms of students' project management skills, creativity, and innovative thinking. This research validates the feasibility and effectiveness of the PBP and highlights its advantages for high-school AI education, which indicates a new direction for cultivating creative and innovative talents.

KEYWORDS

product-based pedagogy, creativity, innovative thinking, 7P model, high school, introductory artificial intelligence course

Introduction

In recent years, the rapid development and the disruptive potential of artificial intelligence (AI) are a global trend and call on innovative talents in the future society. Various countries have issued corresponding education policies to actively welcome the opportunities and challenges brought by AI technologies and prepare for the arrival of the new era (Zhou et al., 2021). Despite this, there is a limited discussion of pedagogical approaches utilized in high school that are applicable to teaching AI courses.

There are inconsistent findings on the effects of different pedagogies in AI courses. According to the PISA report (OECD, 2016), teacher-directed instruction is significantly associated with improved science performance in schools. We were surprised to find that inquiry-based instruction was reported to be negatively related to students' learning performance in science and technology. However, opposite results were obtained in some empirical studies, which claimed that problem-based and inquiry-based learning is more conducive to helping students achieve better performance in these courses (Liu et al., 2018; Zhan et al., 2022).

Moreover, AI education at the high-school level emphasized the importance of cultivating creativity and innovation among students in order to keep up with future technological advancements. Notably, there are some differences between these two abilities: creativity involves curiosity, risk-taking, challenge, and imagination (Williams, 1980; Sternberg, 2006; Runco, 2014), emphasizing the generation of creative ideas and developing original conception of new things (Westwood and Sekine, 1988); innovation involves decision-making, feasibility, practicality, effectiveness, representing the market demand, and the value of the product (Fagerberg et al., 2005; Clydesdale, 2006; Schumpeter et al., 2017).

Both creativity and innovative thinking involve convergent and divergent thinking, and they are closely related to the process of generating ideas and interacting frequently. Given the aforementioned commonalities and differences in connotations, creativity and innovative thinking have an important connection: the creation of products through thinking. The product plays an essential role in the pedagogy, which triggered students to carry out meaningful creations according to social needs, starting from the problem to be solved and ending up in the form of products (Yulastri et al., 2017; Guo et al., 2020).

In AI courses, the product enables students to encounter real engineering problems and motivates them to develop original ideas and transform ideas to market value. Therefore, we try to propose a special kind of project-based learning, namely product-based pedagogy (PBP) in this study, regarding products as the connection between creativity and innovative thinking (Zhan et al., 2019), with market demand driving the process of product design, implementation, and promotion iteratively. In

PBP, products are the basis for the formation of market value by innovative thinking, which is also the result of creativity. The purpose of this paper is to propose a feasible PBP pedagogy and examine its effect on students' project management skills, learning achievement, creativity, and innovative thinking in a high-school AI course, in order to provide a model case and empirical evidence for adopting PBP in AI education.

Literature review

Creativity and innovative thinking

The concept of creativity encompasses core ideas such as “creating something new,” “expressing something in a novel way,” “finding new connections,” or “evoking pleasant surprises” (Maley, 2003; Lin et al., 2022). Creativity can be seen as the ability to create and the personality of being creative, which Krathwohl (2002) describes as “putting elements together to form a novel, coherent whole or to produce an original product.” According to Torrance (1974), creativity is the ability to think in innovative ways to solve problems and produce original, valuable ideas, which is a complex composition affected by both psychological and environmental factors. Sternberg (2006) argued that creativity is the result of the interaction of five psychological resources (i.e., intelligence, knowledge, thinking style, personality, and motivation). Later on, these factors were further proposed as three major elements (i.e., work motivation, domain skills, and related creative skills) (Amabile, 2011; Amabile and Pratt, 2016). In sociocultural definitions, creativity is the collaborative action of creating a product judged to be innovative, appropriate, useful, or valuable, whereas, in the individualistic definitions, it is the manifestation of a new psychological combination (Sawyer, 2011). Based on different theoretical frameworks, Runco and Jaeger (2012) proposed a standard definition (SD) that creativity requires both originality and effectiveness, which was regarded as a relatively static perspective. Later on, Corazza and Lubart (2020) proposed a definition claiming “Creativity is a context-embedded phenomenon requiring potential originality and effectiveness,” which emphasized the dynamic character of the creative process (Corazza and Lubart, 2021).

Scholars have also elaborated on the concept of creativity from the sociocultural and developmental perspectives. For example, Vygotsky (2004) believed that creativity is inherent to human beings. Gruber (2020) proposed an evolving systems perspective on creative lives that was developmental, interactive, and context-sensitive. With Clapp and Hanchett Hanson (2019)'s participatory framework, young people can effectively engage in creative activities that consider their interests and experiences. Glăveanu (2014) proposed a distributed creativity theory that stresses the dynamic, sociocultural, and

developmental nature of creativity. Csikszentmihalyi (2015) believed that creativity is never solely the result of individual activity, it is the combined effect of three main forces (i.e., social institutions, stable cultures, and individuals).

It is increasingly apparent that creativity is a necessary skill for the twenty-first century and that it can be incorporated into the curriculum from an early age (Vygotksy, 2004; Said-Metwaly et al., 2017; Beghetto, 2019). Generally, creativity is recognized as a cognitive and emotional endeavor (Fuchs et al., 2007; Ivcevic et al., 2007), and the discovery learning process enhances creative performance to help learners manipulate surroundings and generate new ideas (Munro, 2011; Carlsen and Välikangas, 2016). In cognitive neuroscience, creative thinking is thought to be a process in which cortical regions form and restore connections constantly (Zhang and Bai, 2006). Besides, the study of metacognition has been widely discussed and scholars believed that it is important to help students metacognitively understand the concept of creativity, thus increasing creative awareness and the quality of creative products (Davis, 1991; Hargrove and Nietfeld, 2015).

There are many ways to conceptualize creativity (e.g., approaches that focus on cognitive neuroscience, environmental factors, sociocultural processes, metacognition, learning theory, developmental psychology, etc.). In the field of AI, some scholars combined creativity with machine learning to emphasize the role of inventing new ideas to support the process of machine creation (Wendrich, 2020). It was found that the AI learning process mainly focused on clear reasoning but ignored the creative emergence of new ideas, especially the integration of AI technology in creativity (Wegerif et al., 2009). According to Park et al. (2021), creative problem-solving is one of the most essential competencies in engineering education. By applying entrepreneurship and innovation education to the construction of AI courses, creativity can provide a new understanding of the relationship between scenarios, goals, and solutions to problems (Tan, 2020).

Innovation is a terminology that dates back to the Greeks and the Romans in Western culture and is probably even older in Eastern culture (Saxena, 1993; Zambon, 2008; Godin, 2015). However, the formal appearance of “innovation” as an academic concept originated in Schumpeter’s “Theory of Economic Development,” which defined it as a change in the production function and recombination of existing resources (Schumpeter, 1912). Similarly, Westwood and Sekine (1988) regarded innovation as the process of converting an invention into a useful product or system. Roberts (1988) described it as invention and diffusion, in which invention refers to the attempts of creating new ideas, whereas diffusion refers to the development of these ideas, such as their application, transfer, and evaluation of success. Romer (1992), a representative of the new economic growth theory, asserted that innovation is essentially a mechanism that enables the generation and application of new designs or ideas.

Although the term “innovation” has been extended from the field of economics to various industries, its connotation remains to emphasize the process of generating new value, which can be either a new product or a new combination of factors. When a creation, a work, or an invention has market value, it becomes an innovation (Wang and Zheng, 2017). Therefore, innovation describes a process that is novel and provides a measurable economic benefit (Xie and Zhuang, 2006). In this vein, Jones (2015) regarded it as the first application of an invention or the first commercialization of scientific research outputs. Apart from this, innovation also emphasizes putting innovative ideas into action (Fagerberg et al., 2005). Innovative thinking is a cognitive process that leads to innovation (Lindfors and Hilmola, 2016; Keller-Bell and Short, 2019). It stimulates the realization and accomplishment of new ideas (Anderson et al., 2014; Barak and Usher, 2019).

A supportive environment and conducive conditions are essential to cultivating innovative thinking. According to the theory of innovation ecology, the link between the subjects and their environment is vital. By integrating the creative atmosphere in schools and the innovative environment of the enterprises and society, an effective mechanism of industry–university alliances can be developed, which is crucial to cultivating innovative talents (Lin, 2018; Mei et al., 2022).

Therefore, creativity pursues “novelty,” “original creation,” and the “unprecedented,” whereas innovation emphasizes commercial elements, with “feasibility,” “practicability,” “effectiveness,” and “decision-making.” From the aforementioned similarities and differences in connotation, it can be concluded that creativity and innovative thinking share a significant link, which is the creation of a product. As a carrier of the transformation from creativity to innovative thinking, the product is the result of creativity, but it also serves as a basis for innovative thinking to form market value. Therefore, product creation is a critical step in the creativity–innovative thinking linkage. Various factors need to be considered during the complex, diverse, and iterative process of the final product creation (Zhan et al., 2019; Lin et al., 2022). To summarize, although the concept of creativity varies widely, for this study, creativity will be defined as an intellectual quality that generates original, novel, and socially meaningful products, and innovative thinking will be defined as a cognitive level that enables the formulation, invention, and construction of products with sufficient market value.

Product-based pedagogy

Project-based pedagogy originated in the architectural and engineering education movement that emerged in Italy in the late sixteenth century (Knoll, 1997). Kilpatrick (1918) first mentioned PBL based on Dewey’s theory of experience. It is generally generated by a problem and leads to a project plan

to deal with the challenge (Blumenfeld et al., 1991). Compared to traditional instruction, PBL includes more autonomy, choice, and unsupervised working opportunity for students (Yousuf et al., 2010). Due to its features such as challenging students with real-world problems and giving students responsibility for learning, PBL has attracted tremendous attention around the world (Barrows, 1994; Frank and Barzilai, 2004).

PBP is an extension of PBL (Ragan et al., 2009), which emphasizes a tangible product as one of the project outputs, and potentially generates students' creativity and innovative thinking (Zhan et al., 2019). As Prince and Felder (2006) have pointed out, a final product is crucial to the achievement of learning goals. By focusing on product design and development to form solutions to the problems, PBP enables students to become active learners to achieve learning goals and promotes social interaction and meaningful learning.

Pedagogical models such as design thinking and maker education have gained increasing attention in recent years as inquiry-based approaches that bring insights to PBP. According to Carroll et al. (2010), design thinking is a way to develop students' creative confidence by encouraging them to participate in hands-on projects that enhance empathy, establish ideas, and promote positive problem-solving. Design thinking in education is also reflected in students' ability to recognize others' needs and respond when interacting with other students in the design process (Wells, 2013). Maker education aims to design, build, modify, and repurpose objects to produce a "product" that can be consumed, interacted with, or demonstrated by using traditional craft techniques or digital technologies (Veldhuis et al., 2021). In essence, maker education allows students to practice hands-on activities and encourages their creative realization and expression in the maker space. Comparatively, design thinking highlighted the application of empathy and the follow-up steps of defining, ideating, prototype, and testing (Wu et al., 2022); maker education focuses on the idea materialization and the iteration process (Goldman and Kabayadondo, 2016). Both pedagogies pay less attention to the market value of the product and neglect further integration of business expertise and marketing skills learning, which is crucial for innovative thinking training.

In Table 1, we compare PBP with the other pedagogies (i.e., direct instruction, PBL, design thinking, and maker education) from the perspectives of concept, feature, and steps, so as to sum up the features of PBP. As can be seen, PBP is different from the other pedagogies listed in the table. For example, "direct instruction" is a teacher-centered strategy in which the teacher is the primary source of information. Learning occurs when students interact directly with the ideas, skills, and information presented by the teacher, and teaching is effective when it involves the direct communication of facts, rules, and sequences of actions to students, which is different from PBP which encourages students to create products that meet real-world needs. Compared to PBL which generally

TABLE 1 Comparison of PBP and other pedagogies.

	Direct instruction	PBL	Design thinking	Makers education	PBP
Connotation	A teacher-centered pedagogy in which the teacher gives lectures or demonstrates exercises and presents the information in clear steps, then students follow the instructions to reinforce their knowledge and skills.	A general learner-centered pedagogy that organizes learning around projects and focuses on facilitating inquiry, problem-solving, and investigation around challenging problems	A pedagogy for meaningful and effective design through hands-on activities helps to build empathy, foster action, encourage ideas, and promote positive problem-solving	A pedagogy for generating a creative idea and materializing it by making tinkering, and emphasizing the construction, modification, and/or reuse of material objects applicable to craft techniques or digital technologies.	A pedagogy that focuses on product design and development to solve real-world problems and discover the market value, using products as a vehicle to promote creativity and innovative thinking
Features	<ol style="list-style-type: none"> 1. An explicit step-by-step strategy. 2. Development of mastery at each step in the process. 3. Strategy (or process) corrections for student errors. 4. Use adequate examples. 5. Teachers provide feedback and guidance. 	<ol style="list-style-type: none"> 1. Driving Questions 2. Situated Inquiry 3. Collaborations 4. Using Technology Tools To Support Learning 5. Creation Of Artifacts 	<ol style="list-style-type: none"> 1. User-centered, empathy-driven approach designed to create solutions 2. Based on a human-centered experience 3. Guided prototyping through a "test-and-learn" cycle 	<ol style="list-style-type: none"> 1. Advanced technical equipment support system 2. Open source, free, and sharing maker culture 3. Quasi-real situation learning mode 	<ol style="list-style-type: none"> 1. Emphasizing tangible products as the project outcome and as a carrier to promote students' creativity and innovative thinking 2. Motivate students with phenomena for problem identification and solving 3. Emphasize iteration and value assessment
Steps	Breaking instructional tasks into small steps through explicit teacher-led instruction	Four processes: planning, designing, producing, and revising	Five stages of action: empathy, definition, conceptualization, prototyping, and testing	Four fundamental phases: preparation, experimentation, prototyping, and integration feedback	7P: phenomenon, problem, plan, prototype, product, presentation, price

adopts a question or problem that serves to organize activities (Blumenfeld et al., 1991), PBP is inherently product-oriented and emphasizes the product as a creative and innovative learning outcome. Moreover, PBP integrates the advantages of design thinking and maker education. It integrates empathy into the problem discovery process from situated phenomena, allows students to think from others' perspectives, and facilitates cooperation around a shared vision of product design and utility analysis. Furthermore, PBP emphasizes the need to balance the current performance of products with their potential for the future, while considering the effects of product iteration and generation. The tangible product allows students to demonstrate the market phenomenon, discover the values, and transform creativity into innovative thinking.

Effect of product-based pedagogy on learning outcomes

It is believed that PBP offers a certain advantage for students' learning as it advocates student-centered activities and encourages learner-centered activities (Romero-Saritama, 2019). For example, it enables students to discover real engineering product problems (David and Larry, 2001) and seek solutions from the observed issues (Romero-Saritama, 2019), which is a learning outcome that meets social needs instead of simply memorizing basic knowledge (Hidayat, 2017). Besides, PBP was regarded as an active learning strategy (Rosales-Torres et al., 2020) and was reported to be effective in promoting student's creativity (Kaufman et al., 2017; Widyastuti and Utami, 2018; Zhou et al., 2021), innovative skill development (Cannon and Leifer, 2001), and learning performance (Jeprimansyah et al., 2018). Mardin et al. (2018) argued that PBP was conducive to increase students' learning achievement, involving the internalization of knowledge, skills, affections, and competencies through structured processes in science and technology education. Moreover, the previous study has reported that PBP offered a better opportunity for students to practice their project management skills (including time management skills, communication, and collaboration skills, etc.) during the problem-solving process (Shekar, 2007) and the creation of specific products, which can also be used as lesson examples to trigger students' creativity and innovative thinking (Zhan et al., 2019).

However, some previous research also pointed out that PBP is not always superior to direct instruction. For example, some teachers took products as the standard of learning outcomes, worrying that students' insufficient time management and self-management ability will affect the final shape of products, so they designed each project process in advance and gave students less choice (Wang, 2019). The student's product also has some problems such as one-time molding without sufficient revisions and iterations, and little connection with disciplines curriculum

standards (Condliffe, 2017). Another situation might be that PBP is not always applicable, because not all the projects could end up in the form of a product. For example, if the problem to be solved is a political or an ethical issue, it might not be suitable to generate a tangible product (Jia and Lin, 2014).

Given the debate that exists in literature, this study tried to establish a feasible model and adopt PBP in an AI course and examined its effect on students' project management skills, learning performance, creativity, and innovative thinking, which are variables mentioned in previous research that yielded inconsistent conclusions. Therefore, this study might provide a practical case and empirical evidence on the method of applying PBP in AI education and effectively develop a new approach for cultivating innovative talents.

Conceptual framework

A 7P model for product-based pedagogy

The goal of PBP is to create a final product that identifies the challenge that must be solved at the outset, allows students to actively participate in the process, and delivers social value. In this approach, students are motivated to learn by creating products that meet real-world needs while also integrating diverse and innovative ideas into the product creation process (Ragan et al., 2009). As a vehicle for linking creativity and innovative thinking, product creation helps students to think creatively, and understand the conditions necessary for innovative ideas to be realized and transformed into market value. While students engage in the process, they can reconstruct their knowledge, enhance their ability to work with others, and improve confidence and interest in the project, with the final product being a concentrated expression of the various competencies they may develop.

The product orientation in PBP is reflected in the clear outcome requirements, as well as the construction of the product creation process (7P), which outlines the steps involved in fulfilling the task and product presentation. By integrating fragmented knowledge into a systematic one, students can identify problems from phenomena and ultimately create innovative products that can solve problems through prototyping.

The products in PBP can be determined based on a problem-solving approach, including physical products, research reports, design solutions, etc. Conceptualization of a product does not occur all at once, and prototype construction is planned and completed through iterations. The process from prototype to product is then consciously tested, and opportunities are identified from idea generation to product creation. Ultimately, by analyzing the direction of the subsequent sustainable development of the product through the presentation, the

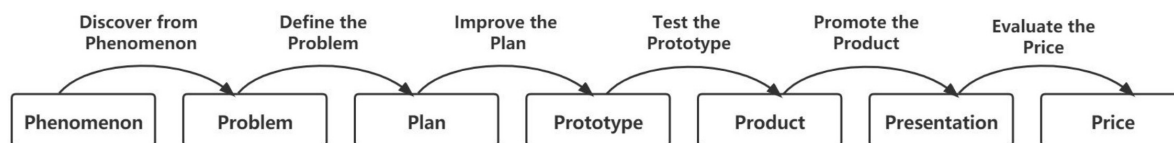


FIGURE 1
The 7P model of PBP.

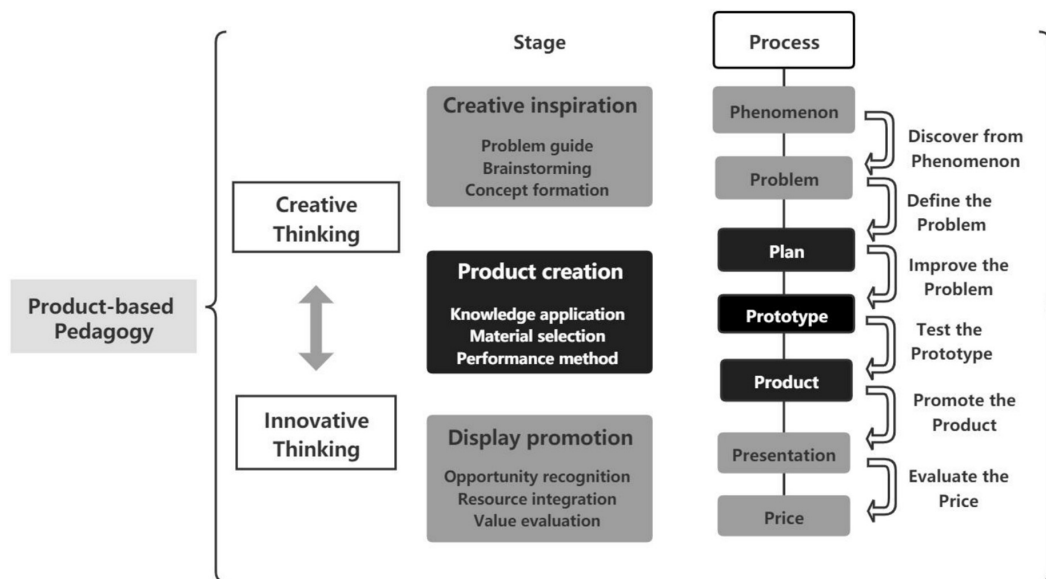


FIGURE 2
PBP in high-school AI education.

interactive and linkage cultivation of creativity and innovative thinking is realized.

As PBP emphasizes the organization of learning activities around product design, this study proposed a 7P model, consisting of seven steps starting with “P” (i.e., phenomenon, problem, plan, prototype, product, presentation, price). Using the 7P model, teachers should create the project situations based on real-life phenomena, so that students can pay attention to the actual situation rather than theoretical concepts, and then discover the core problems that need to be solved. Then, the students are guided to decompose the problems and explore potential directions for the solution, activating their ideas and creativity to develop a plan for the target product. According to the plan, the students collaboratively improve their ideas through practice and try to transform the idea into a conceptual prototype. After multiple iterations, the prototype is adjusted and finally leads to an entire product with a clear market value. Then after analyzing the unique feature and value of the product, students may illustrate the product in a simulated market environment through the presentation. Finally, based on the feedback from the presentation, students try to price the

product in conjunction with the estimation of its value, which allows them to grasp the rules of the market and the business model. **Figure 1** shows the 7P model of PBP.

Applying the 7P model in artificial intelligence education

The goals of AI education are to assist students in understanding the features of AI and the method of applying the technologies in daily life. In a certain sense, AI technology represents the frontier of information technology. Students can obtain knowledge by using AI technologies to create a product (Liu et al., 2018). With the development of society, the trend of integrating education, science, and technology and the economy is becoming stronger, driving the demand for creative and innovative talents. AI courses contribute to product innovation by integrating key technologies that facilitate the achievement of a complete innovation chain from idea to creation, then to application. In accordance with the characteristics of AI education, as well as the cognitive characteristics of high-school

students, this study proposes a 7P model in AI education, in which the PBP is divided into three stages as shown in [Figure 2](#).

The first stage is creative inspiration (phenomenon setting and problem discovery). Students are guided in discovering problems from phenomena in a specific problem situation, and relevant examples are presented, which not only include the standard pattern of the project output but the products made by the former students. Through examples, students can clarify the heterogeneous and complex issues that need to be explored. In addition, students are guided by the teacher to define the type of problem, structure, and direction of the solution. To activate ideas and creativity, students will need to negotiate within a group and solve the problem by questioning, imagination, and expansion.

The second stage is for product creation (plan, prototype, and product construction). In this stage, creativity and innovative thinking are iteratively blended. The product-oriented plan specifies how each group clarifies the situational problem, conducts further activities to advance the improvement, and develops the idea into a creative conceptual prototype. Based on the prototype, improvements and optimization links are constructed, and scheme adjustments and product tests are conducted with discussion. The process of optimization involves iterative adjustments of product solutions, analyses of the utility of prototypes arising from the inquiry activities, and timely discovery of their feasibility and effectiveness. After thorough testing and optimization, the final product is formed.

The third stage is display promotion (presentation and price). Through the integration of resources from various perspectives, students understand the product value of the market, society, and environment, so that they can present the product of the group's project in a unique way for business promotion. Then, identify the rules of the market and try to price the product. The learning of AI technology and principles ultimately serves application and practice. Therefore, when students are consciously taught to transform their creativity into innovative thinking, they will be able to accumulate experience, analyze goals, execute works, and eventually approach completion. As a result of project creation and design, students gain more knowledge about business and markets, as well as consider the value and social significance of their ideas, which is conducive to innovation and entrepreneurship education.

Research question and hypotheses

This paper tried to examine the effect of PBP in AI education. Specifically, we compared PBP with teacher-direct instruction and seek to find out whether PBP is more effective in promoting students' project management skills, learning performance creativity, and innovative thinking.

According to the research questions, four hypotheses were proposed as follows.

The first hypothesis was that PBP would promote students' project management skills in AI courses. This result was expected because project management skills emphasize teamwork and project output ([Birnberg, 1998](#); [van Rooij, 2009](#)), and PBP provides students with a product-oriented guide to the complete project planning and implementation process, which might develop basic project management skills with clear goals for the project.

The second hypothesis was that PBP would promote students' learning performance. This result was expected because PBP provides a specific target for students to create meaningful products, which might help students to understand AI knowledge and procedure more deeply so that they would probably learn better ([Despoina and Aikaterini, 2015](#)).

The third hypothesis is that PBP would enhance students' creativity. This result was expected because creativity emphasizes an intellectual quality that can produce novel, unique, socially meaningful, or personally valuable products ([Lin, 2018](#)); thus, students' creativity could be triggered in PBP.

The fourth hypothesis is that PBP can improve students' innovative thinking. This result was expected because innovative thinking is mostly characterized by the promotion of thinking outcomes, with emphasis on the feasibility of ideas or products ([Fagerberg et al., 2005](#); [Jones, 2015](#)). Therefore, students' innovative thinking is likely to be enhanced by value assessment and opportunity identification in PBP.

Materials and methods

Participants

The experiment was conducted in an information technology course of a high school in southeast China and lasted for 3 weeks. A total of 209 students in the tenth grade participated in the study. Among them, 107 students (i.e., 59 boys and 48 girls) were assigned to the treatment group with PBP pedagogy, and the other 102 students (i.e., 56 boys and 46 girls) were assigned to the control group with direct instruction. The participants took two sessions of AI courses each week, and they can go to the lab anytime by appointment to complete their products. Both groups of students had no previous experience in AI courses. According to the results of the pretest on students' creativity and innovative thinking, students in both groups have similar levels.

Research design

In order to investigate the effectiveness of PBP in AI courses, this study compared the effects of PBP with

those of direct instruction on four dependent variables (i.e., project management skills, learning achievement, creativity, and innovative thinking). Among these four dependent variables, the project management skills of the students were measured by a project evaluation scale containing five dimensions (i.e., topic, plan, tool, process, and product) from three-party perspectives (i.e., self-evaluation, peer evaluation, and teacher evaluation), which demonstrate how students improve project management through collaboration and inquiry. The learning achievement of the students was evaluated by the standard test offered in the textbook, which can be used to test students' AI knowledge. The creativity of the students was evaluated by Williams' Creativity Assessment Packet (Williams, 1980) based on four dimensions (i.e., curiosity, risk-taking, challenge, and imagination). The innovative thinking of students was evaluated by the General Innovation Skills Aptitude Test (General Innovation Skills Aptitude Test, 2000) with four dimensions (i.e., decision-making, feasibility, practicality, and validity). All of these instruments have been used in previous research and had good reliability.

Procedure

In the experiment, the content of the course was about *Data and Computing of Artificial Intelligence and Its Application*. The teacher in charge of this course was a qualified teacher with 7 years of teaching experience and strong motivation. Participants in both the treatment group and the control group were taught by the same teacher and teaching assistant, and they were learning the same contents from identical textbooks. The only difference between these two groups was the pedagogy adopted.

In the treatment group, the product of the PBP AI course is presented as an innovative application of product design solutions. With the phenomenon "AI technology empowers campus life," the teacher guides students to identify problems diversely such as inefficient manual temperature measurement at the school gate or crowded checkout at the canteen. Through group discussions and creative stimulation, teachers help students define and break down problems, explore AI technologies on the platforms, and enable creativity to grow. The students can experiment with multiple solutions to the same problem and negotiate the construction. For instance, a temperature measurement problem can be solved by using face recognition as the core and incorporating different technologies such as infrared temperature measurement or infrared thermal imaging. Through decision aggregation, the group stimulates ideas and creativity in product formation, which then leads to the determination of the final inquiry theme, and the development of the inquiry plan oriented toward the innovative application of the product. Students use examples of product solutions to improve their integrated ideas, ultimately developing a conceptual prototype of an innovative product

design solution. Research, practical investigation, and feasibility analysis lead to iteration and revision of the product design, so students can test its feasibility and effectiveness, and finally create a prototype. Based on the phenomenon, teachers organize activities such as "campus bid simulations," in which students present their product proposals from the perspectives of market, social and environmental values, reflecting the unique value of the product. Based on the feedback from other groups and the teacher, students priced their products considering the market rules and submitted a description of the product's price. Using a combination of the evaluation dimension, the teacher ranked the final product. **Figure 3** illustrates the specific implementation path of the PBP AI curriculum.

On the contrary, in the control group with direct instruction, students mainly learn through imitation, without emphasis on the creation of a product. Using the AI platform, the teacher explains how to use different AI technologies and conducts step-by-step demonstrations to enable students to master the corresponding theoretical and technical operations through imitation. For example, when teaching face recognition technology, the control group learned face recognition principles mainly by replicating the process: the teacher first explained the main component of the composition, and then students are guided to import photos for machine recognition and repeat the steps that are demonstrated by the teacher to experience and understand the face recognition technology.

Measure instrument

Project management skills

Project evaluation scales include self-evaluation and peer evaluation, whereas teachers score students' work based on the whole teaching session and the evaluation scale and finally use the average value of the three groups' evaluations as an evaluation of the learning group's output. The project evaluation scale contains five dimensions, such as topic selection (whether the topic has application value and innovative value), planning and design (whether it can accurately analyze the needs of the project), tools and methods (whether to carry out independent learning and collaborative learning around the project), steps and process (analyze whether the innovative application of artificial intelligence and its typical cases are complete), and the product and report (whether there is a correct understanding of the social impact of artificial intelligence). Using the reliability analysis, Cronbach's alpha was 0.812. Also, the KMO value of the questionnaire was 0.839.

Learning achievement

The test of AI knowledge adopts the chapter test questions based on the textbook, covering the development and application of information technology, intelligent processing,

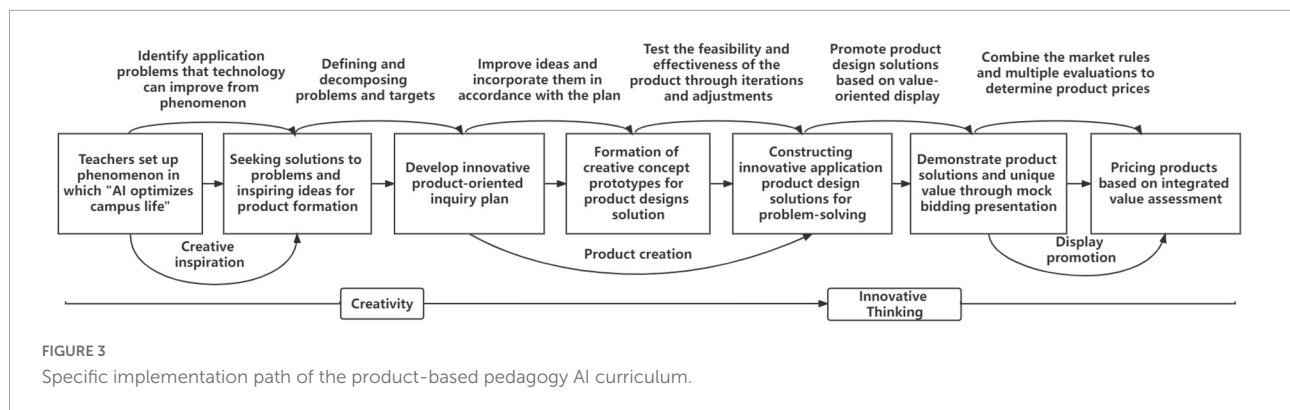


TABLE 2 Means and standard deviation of students' project management skills in treatment group and control group.

Dimension	Treatment group (N = 18) M (SD)	Control group (N = 18) M (SD)	t	p	df	Effect size
Self-evaluation	92.06 (2.127)	87.61 (1.819)	6.736	<0.001	34	0.419
Peer evaluation	88.33 (2.086)	83.28 (1.638)	8.086	<0.001	34	0.485
Teacher evaluation	89.06 (2.287)	83.72 (2.109)	7.273	<0.001	34	0.446
Product score	89.81 (2.678)	84.87 (2.685)	9.581	<0.001	106	0.549

AI applications, pattern recognition, the concept and characteristics of AI language, the impact of AI on human beings, the concept of AI, and other knowledge related to AI, through seven choice questions and three judgment questions to test students' mastery of AI knowledge in the project learning process. Questions cover the theory and development of artificial intelligence and the future, with one point for each. According to the reliability analysis, Cronbach's alpha was 0.797. The questionnaire had a KMO value of 0.784.

Creativity

Regarding the questionnaire on the creativity of students, this research is based on Williams' Creativity Assessment Packet (Williams, 1980). The measure yielded a total creativity score and four sub-scores: curiosity, imagination, challenge, and risk-taking, which were derived from student self-responses to the statements scored on a Likert-type scale. The CAP was chosen because the four dimensions of the scale are important thinking characteristics and personality traits in the development of human creativity, and it is often used as a predictor of a person's creative potential and level. CAP has some drawbacks; however, it cannot be recommended as an adequate assessment of the complex dimensions of creativity because its content validity is undermined by poor item and scoring definition. This study combined the four dimensions of the scale to revamp the pretest questionnaire for simplicity, ease, and validity, and 16 questions were revised. The response options range from 1 (non-conformance) to 3 (completely conforming). During and after the experiment, the same

survey was administered to all students; 209 questionnaires were collected in the experiment. According to the reliability analysis results, Cronbach's alpha for the new version of the questionnaire is 0.81. The KMO value is 0.785.

Innovative thinking

Based on the literature, it was found that the assessment of innovative thinking lacks a universally recognized evaluative tool. This study refers to the General Innovation Skills Aptitude Test (General Innovation Skills Aptitude Test, 2000), which combines four dimensions of decision-making, feasibility, practicality, and effectiveness. It improves awareness and understanding of the skills, attitudes, and behaviors that individuals and organizations need to innovate, as well as assessing the innovation skills needed by individuals and organizations to help them match innovation skills with their needs, and is therefore relevant in this study to test students' innovation skills in product design. However, GISAT is only used in some countries to test innovation skills and is not universally accepted by academia. In addition, the study refines the four directions of thinking definition and classification in the thinking linkage model (Zhan et al., 2019), including relationship building, innovative thinking, follow-up and implementation, and risk control, and revised the questionnaire on innovative thinking assessment by integrating the innovation tendency scale with a total of 16 questions, with response options ranging from 1 (not conforming) to 3 (completely conforming). Based on the reliability analysis

TABLE 3 Means and standard deviation of students' learning achievement.

Dimension		AI knowledge	<i>t</i>	<i>p</i>	<i>df</i>	Effect size
Control group (<i>N</i> = 102)	<i>M</i> (<i>SD</i>)	7.95 (0.705)	−1.082	0.281	205	0.075
Treatment group (<i>N</i> = 107)	<i>M</i> (<i>SD</i>)	7.84 (0.761)				

TABLE 4 Descriptive statistics of students' pretest and posttest scores and ANCOVA summary of creativity.

Factor	Group	Before treatment		After treatment		Univariate ANCOVA			
		Mean	SD	Mean	SD	Mean (adjusted)	SE	<i>F</i> -value	eta ²
Curiosity	Treatment	9.02	1.427	9.56	1.183	9.56	0.144	6.260*	0.029
	Control	9.57	1.193	9.05	1.748	9.04	0.147		
Risk-taking	Treatment	8.75	1.190	9.33	1.097	9.33	0.117	13.358*	0.061
	Control	8.61	1.329	8.73	1.329	8.71	0.120		
Challenge	Treatment	9.36	1.456	9.31	1.450	9.31	0.129	2.818	0.011
	Control	9.38	1.347	8.99	1.183	8.98	0.132		
Imagination	Treatment	8.86	1.751	10.17	1.444	10.16	0.170	26.887*	0.115
	Control	10.18	1.440	8.90	2.027	8.90	0.175		
Total score	Treatment	36.51	3.717	37.96	3.412	37.96	0.400	14.555*	0.066
	Control	38.12	3.341	35.77	4.788	35.77	0.410		

There were 107 students in the treatment group and 102 students in the control group. ANCOVA, analysis of covariance.

**p* < 0.05, significant *p*-value for ANCOVA and Bonferroni's multiple comparisons test; eta², effect size of ANCOVA (partial eta squared).

results, Cronbach's alpha was 0.859. The KMO value for the questionnaire was 0.756.

Data analysis

In this study, we took two steps to conduct data analysis by using SPSS. First, the normality statistics were calculated for the four dependent variables (i.e., project management skills, learning achievement, creativity, and innovative thinking). Then, two sets of independent-sample *t*-tests were used to test the learning effects of PBP by comparing the differences between the treatment group and control group on project management skills and learning achievement. Another two sets of ANCOVAs were employed to examine students' creativity and innovative thinking by using the pretest score as a covariate.

Results

Project management skills

Independent-sample *t*-tests were conducted on the experimental data of each dimension of project management skills. A significant difference existed between the treatment and control groups of product scores shown in Table 2, *t* = 9.581, *p* < 0.001, and the effect size (based on Cohen's *d*) was 0.549. In

the integrated multi-subject evaluation, the treatment group's scores are notably higher than those of the control group. The treatment group conducts product-oriented inquiry around artificial intelligence technology during learning activities to better meet product evaluation criteria.

Learning achievement

In the independent-sample *t*-tests on AI knowledge in Table 3, there were no significant differences between the treatment group and control group, indicating that direct instruction and PBP are probably equally effective in students' AI knowledge acquisition.

Creativity

Means (and SDs) for the students' creativity before and after the treatment are shown in Table 4. In order to examine the differences between the experimental and control groups in students' creativity, analysis of covariance (ANCOVA) was used, with pretest scores as a covariate. First, we checked whether the ANCOVA assumptions were met in the analysis of covariance using the Statistical Package for Social Sciences (SPSS version 26.0). The adjusted means (and SEs) for the two groups of creativity's dimensions and total score are shown in

TABLE 5 Descriptive statistics of students' pretest and posttest scores and ANCOVA summary of innovative thinking.

Factor	Group	Before treatment		After treatment		Univariate ANCOVA			
		Mean	SD	Mean	SD	Mean (adjusted)	SE	F-value	eta ²
Decision-making (relationship establishment)	Treatment	9.93	1.494	10.63	1.508	10.62	0.171	30.198*	0.128
	Control	9.81	1.612	9.27	2.001	9.27	0.175		
Feasibility (innovative ideas)	Treatment	8.87	1.756	10.14	1.610	10.13	0.165	55.249*	0.211
	Control	8.55	1.978	8.37	1.802	8.37	0.169		
Practicality (implementation)	Treatment	8.07	1.703	10.14	1.557	10.14	0.180	46.557*	0.184
	Control	8.28	2.022	8.39	2.126	8.38	0.184		
Effectiveness (risk control)	Treatment	9.33	1.682	10.36	1.538	10.365	0.167	40.092*	0.163
	Control	9.10	1.760	8.85	1.890	8.852	0.171		
Total score	Treatment	36.07	5.280	41.32	5.312	41.31	0.593	56.644*	0.216
	Control	35.75	5.767	34.92	6.863	34.92	0.607		

There were 107 students in the treatment group and 102 students in the control group. ANCOVA, analysis of covariance.

* $p < 0.05$, significant p-value for ANCOVA and Bonferroni's multiple comparisons test; eta², effect size of ANCOVA (partial eta squared).

Table 4 as well. It can be seen that in the experimental group, dimensions like curiosity ($F = 6.260$, $p < 0.05$, $\eta^2 = 0.029$), risk-taking ($F = 13.358$, $p < 0.001$, $\eta^2 = 0.061$), imagination ($F = 26.887$, $p < 0.001$, $\eta^2 = 0.115$), and the total score ($F = 14.555$, $p < 0.001$, $\eta^2 = 0.066$) are significantly higher than the control group. Results indicate that most creativity dimensions improved significantly under PBP except the challenge dimension.

Innovative thinking

Similarly, we use analysis of covariance (ANCOVA) to examine the innovative thinking between the experimental and control groups. SPSS was used to ensure that ANCOVA assumptions were met in the analysis of covariance. The means (and SDs) and the adjusted means for the two groups of students' innovative thinking are shown in **Table 5**. It is evident that the treatment group performed significantly better than the control group on the dimensions of decision-making ($F = 30.198$, $p < 0.001$, $\eta^2 = 0.128$), feasibility ($F = 55.249$, $p < 0.001$, $\eta^2 = 0.211$), practicality ($F = 46.557$, $p < 0.001$, $\eta^2 = 0.184$), effectiveness ($F = 40.092$, $p < 0.001$, $\eta^2 = 0.163$), and the total score ($F = 56.644$, $p < 0.001$, $\eta^2 = 0.216$). The results indicate a significant improvement in innovative thinking.

Discussion

Product-based pedagogy helps to promote students' project management skills

The first hypothesis that PBP would promote students' project management skills was supported. As PBP is a special

type of PBL, especially within the 7P model, it incorporates steps that promote active learning, engagement, interaction, and the ability to produce the desired product (Birnberg, 1998; van Rooij, 2009; Ganefri, 2013). Students in the PBP group have many opportunities to coordinate the project process, identify real problems that need to be solved, and transform the product as the goal of decomposition, in order to create a prototype of ideas and achieve final product formation through iteration and adjustment, customized to meet the values of the product. By focusing on clear project goals and specific product outcomes, students achieve a common goal of product design in a collaborative learning environment, thus effectively developing project management skills and promoting leadership (Loo, 1996; Burke and Barron, 2014). When it comes to product shaping, the 7P model emphasizes the estimation of product value and pricing as a method to assist students in AI courses in planning and designing products from the perspective of managing budgets, resources, and performance (Shariff et al., 2011).

No significant difference was found in students' learning performance between product-based pedagogy and direct instruction

Contradicting our expectations, the second hypothesis was not supported, and results indicated no significant difference was found in students' learning performance between PBP and direct instruction. As claimed by previous studies, direct instruction could be very efficient in knowledge delivery (Hattie, 2008; Stockard, 2010; Flynn et al., 2012), because the one-way knowledge delivery process made by lectures and imitations is logical and systematical, which benefits students' knowledge mastery (Heward and Twyman, 2021). Comparatively, PBP may

be time-consuming for knowledge delivery, because students needed to learn by inquiry during the project; thus, the knowledge absorption could be fragmented. However, PBP has the advantage of enhancing the depth of the learning process and developing students' emotional, cognitive, and psychomotor abilities (Despoina and Aikaterini, 2015). The tangible product also made the knowledge learned more embodied, comprehensible, and applicable. In PBP, knowledge is absorbed subliminally into all aspects of product design. The high-school AI course emphasizes a hierarchical decomposition of the working processes of complex intelligence with the aid of real-life examples (Lu et al., 2021). Because direct instruction can promote students' mastery and absorption of AI knowledge efficiently, PBP can allow students to integrate their knowledge into the process of product design and enhance deeper learning. Both pedagogies have their benefit, which might be the reason for no obvious difference between them in terms of learning performance.

Product-based pedagogy helps to improve students' creativity

The third hypothesis that PBP promotes valid improvement in creativity was partially supported. Cross-sectional analysis of scores for each dimension (i.e., curiosity, risk-taking, challenge, and imagination) and the total scores of creativity revealed that students' total level of creativity in the treatment group is significantly superior to those in the control group. Especially, the dimensions of curiosity, risk-taking, and imagination have been significantly improved, whereas no significant difference was found in the challenge dimension.

Risk-taking stresses the ability to confront mistakes or criticism and maintain one's opinions while being able to anticipate versatility of thinking (Jia, 2008). Through the product iteration scaffold, students under PBP can make adjustments to the program by communicating content that is doubtful but form their understanding and then dare to try with trial and error. The perspective of curiosity consists of seeking out new things and situations, gaining insights from observations of particular phenomena, and investigating various explanations for why certain things happen (Zhang et al., 2012). As shown by treatment groups that examined artificial intelligence technology, this well describes the process of solving problems using curiosity. Conversely, the lack of curious exploration by the control group tends to cause a disconnection between learning outcomes and real-life problem-solving. Students in the PBP programs have the highest scores on imagination, and the process of creation is inherently the birth of new ideas, the ability of individuals to generate results from any kind of thinking (Zhou, 2015). In PBP, product-oriented learning enables students to pose questions and solve problems in imaginative ways, generate ideas from existing

experiences, and develop their ideas (Pritzker and Runco, 2011). The lack of product guidance in the control group prevented the participants from conceptualizing how specific thinking would result, so they were more limited to simple tasks, and their imagination was insufficient to unleash creativity.

Despite the third hypothesis, which predicted that PBP would boost creativity in every dimension, we found no significant differences between the pretest and posttest of the challenging dimension in the treatment group. According to Young (2003), challenging learning is a process of constant challenge and transcendence in which students move through a cycle of challenge, action, feedback, and reflection. In parallel, the process is an upward spiral, where an additional challenge is introduced after completing a cycle, and students become capable of moving beyond their current skill levels; therefore, challenge development cannot be achieved overnight but requires a longer period.

Product-based pedagogy helps to improve students' innovative thinking

The fourth hypothesis, that PBP can promote all dimensions of innovative thinking, was well supported. Innovation involves transforming an idea into a useful product or system (Pavitt, 2003), that is, the process of putting creative ideas into practice (Rickards, 1985; Fjortoft et al., 2018). Students under PBP are product-oriented, and after generating product prototypes through creative stimulation, they can realize new, unique, and meaningful ideas, consider their feasibility and value through product iterative design, and conduct value assessment and opportunity identification, in which innovative thinking is well trained. Cross-sectional analyses of the two groups and vertical analyses of the pre- and post-test scores of the treatment group showed that PBP significantly boosted all dimensions of innovative thinking.

Among the four dimensions, decision-making has the most prominence, focusing on the organization of knowledge in the group from a relationship-building perspective, along with an emphasis on the importance of individual effort in the formation of group decisions (Amabile and Pratt, 2016). The main component of innovative thinking training is decision-making, and the students under PBP divide labor within the group and examine all possible scenarios before deciding. Therefore, students had training in decision-making by discussing and choosing the best way to resolve the key issues that arose and contributing a convincing solution to promote the product design (Shi et al., 2018). There was also an improvement in the feasibility dimension, with students able to analyze AI technology and information processing from the standpoint of practicality and market acceptance of the technology and promote the product in terms of solving practical problems and offering commercial value. The

feasibility component of technological innovation emphasizes the relevance of products and ideas, and it seeks results that are recognized and beneficial (Pan, 2019), which is encouraged as part of the PBP. In contrast, control group students had a weaker understanding of feasibility because they did not have product-oriented market value guidance, and the final learning outcomes were not always expressed in the form of a product. Students in the treatment group were proficient at weighing the originality, practicality, and social value of their outcomes through the presentation of the 7P model, which emphasized social satisfaction and recognition that contributed to the commercial value of the product. Innovation and creativity are characterized by the balance between novelty and efficacy (Runco, 2014), which is a remarkable reflection of the transformation of the two types of thinking under PBP.

In terms of practicality, the focus is on the value added as the goal, emphasizing market demand and application orientation for practical value (Fila et al., 2012). The primary focus of this project is to explore AI applications and information processing, given that students' understanding of the business value and marketing skills are still superficial. Hence, practical training should expose students to projects with real market value and social significance, and more attention should be given to the product design and creation process for potential market and opportunity identification.

Implication

AI has significant disruptive potential in the form of speed, breadth, and depth. New technology is the product of innovation, and it is also one of the greatest forces for creativity and innovative thinking education. Society attaches more importance to cultivating innovative talents as the driving force for economic growth in the twenty-first century. Students will gradually learn more about business and market knowledge as they age so that they can consider the market value and social significance of their product creation and put their ideas into practice. As part of this process, it enables students to gradually adapt to the needs of society and cultivate innovative talents for industry, academia, and research to meet the needs of future social-economic development and technological reforms. The high-school students' creativity and innovative thinking should be nurtured at this stage, and we should drive students to develop better from internal and external motivators. In terms of knowledge learning and thinking training, the integration of PBP into high-school AI education has practical and theoretical significance.

The 7P model provides a feasible example for integrating PBP into high-school AI education. Using the phenomena of AI development in life, the course guides students to discover the actual problems that need solving, decompose and transform

the problems, and then clarify learning objectives during follow-up learning. Project plans are continuously adjusted based on the problem and product orientation, generating prototypes of AI-related products. In AI education, the aim should not just be mastery of knowledge and skills, but also to incorporate creativity, innovative thinking, and product-oriented thinking, which are important in pedagogy.

This article proposes a pedagogy for high-school AI courses that make product creation a priority to cultivate knowledge and train thinking. Based on the experimental school's situation, we propose a high-school AI curriculum that is based on PBP, for students to participate easily in the process of product creation, and learn effectively to develop creativity and innovative thinking. Having said that, not all projects end up as products, so this pedagogy may not be appropriate for projects that address political or ethical issues or where student activities tend to be learning-oriented rather than construct-oriented. Though there is some controversy over the application scope and the role of products in the learning process, we believe that the emphasis on product orientation in PBP can help cultivate students' creativity and innovative thinking, which could also serve as a model for the pedagogy of product-oriented entrepreneurship and maker education.

Limitations and future study

The purpose of this research is to demonstrate the effect of PBP on high-school AI courses and also to provide materials for future study. Certain difficulties arose in the design of this study, and there were some limitations. First, because the experiment was conducted by the same teacher using different pedagogies for the treatment group and the control group, it might cause individual preferences on the instructional guidance and affect the experimental outcome. In addition, change during thinking training was not measured. Creativity and innovative thinking can be improved through specific teaching methods and activity design, but it is hard to identify the point at which the links begin to make an effect. Therefore, in response to these limitations, some potential future directions were suggested for follow-up research.

First, it might be interesting to get more insights into the collaboration process of PBP. Attention must be paid to the individual creative concept formed by the divergence of thinking, and the learning task can be set up in layers so that students can gradually transform from individual activities to collaborative learning. Full play must be given to the effectiveness of prior knowledge and creativity in individual behaviors, and promote subsequent decision-making aggregation. Alternatively, it could be referred to as participatory creativity, which introduces opportunity, equity, and a dynamic reconfiguration of innovation and invention from individual or group presentations (Clapp, 2016; Clapp and Jimenez, 2017).

Second, it is important to investigate the mechanism of supporting the transformation from creativity to innovation and further develop the pedagogy for facilitating learning. In the process of cultivating innovative talents, we need to guide students to design creative products and fit the product into the actual market. It is essential for a product with a creative imagination and convergent innovation that could accelerate the market, and also through market feedback to amend creativity. Therefore, the realistic pursuit of student work should be emphasized in the innovation process.

Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving human participants were reviewed and approved by the South China Normal University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

ZZ identified research ideas, designed and facilitated this research, wrote the draft, and made substantial revisions to this work. WS conducted the experiments, analyzed the data, wrote the draft, and revised the manuscript. WL assisted with data collection and provided advice on revisions. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Effect of Game Playing and Goal Orientation on Creativity

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In an effort to bolster employee creativity, companies like Google and Groupon have adopted indoor work spaces that incorporate slides, swings, and unconventional design. While it may be costly and time-consuming to change certain aspects of a firm's work environment (e.g., the room design) to aid creativity and brainstorming, it is relatively easy for managers to encourage employees to engage in certain forms of unstructured recreation immediately prior to creative-based tasks for a new product development. This research addresses an important oversight in the literature by exploring the effect of cognitive game playing and goal orientation on subsequent new product development creativity. It was found that a cognitive game that engenders a greater degree of fun results in greater creativity on a subsequent new product development task, compared with both a cognitive-based game that engenders less fun and a control group. Furthermore, it was found that, for a cognitive-based game that engenders a high degree of fun, individuals who are primed with a process goal orientation are more likely to be creative on a subsequent new product development task than those who are primed with an outcome goal orientation.

Keywords: creativity, new product development, cognitive game, fun, goal orientation

INTRODUCTION

A plethora of academic studies have discussed the important downstream outcomes of creativity. Specifically, products that are original and useful are more likely to appeal to consumers (Cooper and Kleinschmidt, 1987). Dahl et al. (1999) supported this claim by demonstrating the mediating role of originality and usefulness of product design on customer appeal. A creative firm that provides original and useful products meets the needs of consumers by developing innovative and superior products in the market (Cooper, 1979; Deshpande et al., 1993). Griffin and Page (1996) showed that creativity for new products and marketing programs are strong determinants of new product success. Thus, creativity entails differentiation from one's competitors in the marketplace (Andrews and Smith, 1996). Furthermore, the accumulation of organizational intelligence regarding original and useful ideas gives a firm a competitive advantage, which in turn results in a greater likelihood of new product success (Barney, 1991; Hunt and Morgan, 1995). Similarly, Dahl and Moreau (2002) suggested that consumers are willing to pay a higher price for more original product concepts. Hence, firms can benefit financially from increases in the originality of their new product.

The potential of game playing to facilitate creativity has recently begun to receive attention from creativity researchers. Prior research has examined the positive effect of motor skill games, role playing games, and videogames on creativity (Squire, 2006; Williams et al., 2006; Hamlen, 2009; Hutton and Sundar, 2010; Cavallera et al., 2011; Jackson et al., 2011; Lupu, 2012; Chung, 2013; Balance-Herrera et al., 2019). Cognitive stimulation and physiological arousal have accounted for

the positive link between game playing and creativity. However, to the best of my knowledge, prior research has neither considered the potential underlying link between the level of *fun* experienced while playing a game and the subsequent creative outcomes nor examined the link between traditional cognitive-based games (e.g., math and pattern recognition games, brain teaser games, and card games) and creativity.

Hence, the first research question that I aim to answer is whether playing a cognitive-based game will enhance creativity and, if so, what is the key mechanism involved? To this end, I look at the centrality of fun as a process account in this highly “cognitive” domain. The second research question I attempt to answer is whether the effect of cognitive-based games on creativity, if any, depends on the goal orientation associated with the game itself (outcome-focused vs. process-focused). In **Figure 1**, an overview of the theoretical model underlying this research is shown.

THEORETICAL FRAMEWORK AND HYPOTHESES

Cognitive Games and Creativity: The Centrality of Fun in an Exclusively “Cognitive” Arena

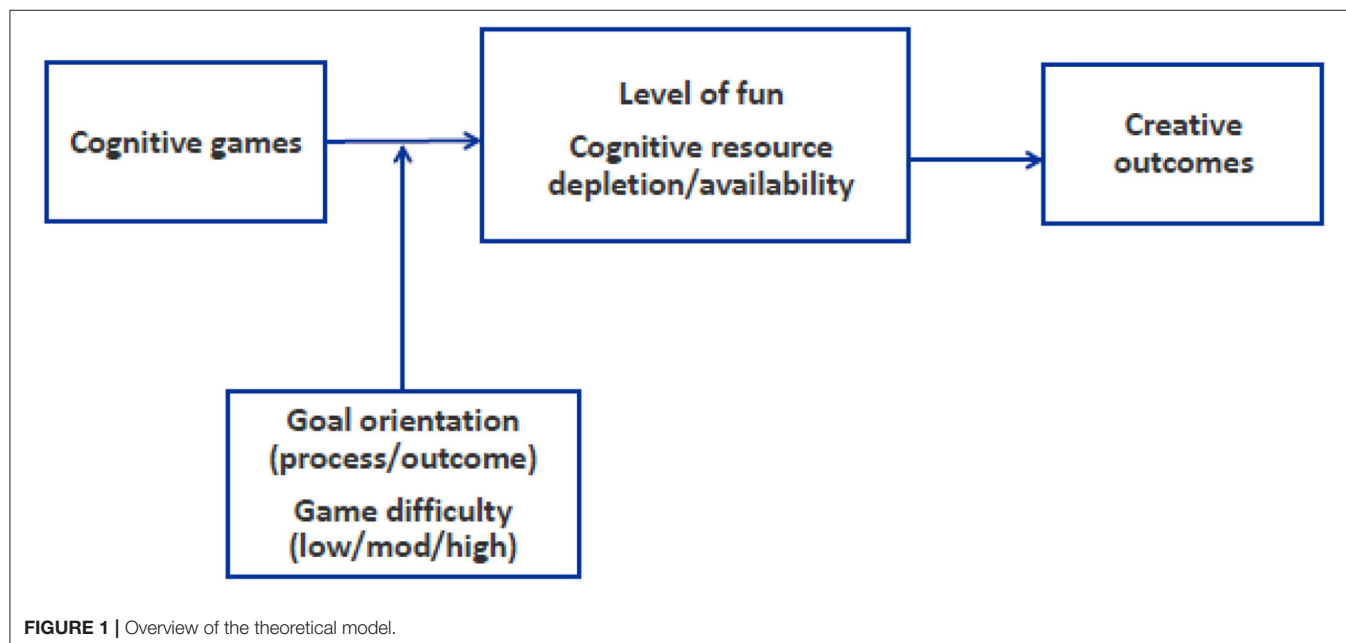
Prior research has shown that game playing can positively influence subsequent creative outcomes (Squire, 2006; Williams et al., 2006; Hamlen, 2009; Hutton and Sundar, 2010; Cavallera et al., 2011; Jackson et al., 2011; Lupu, 2012; Chung, 2013). As previously mentioned, video games (Hamlen, 2009; Hutton and Sundar, 2010; Jackson et al., 2011; Balance-Herrera et al., 2019) have been shown to increase creativity. In the domain of children’s education, it has been suggested that video games

embody good learning principles and enable the development of both creativity and critical thinking skills (Squire, 2006).

According to Kinrade et al. (2010), games can be classified as either “primarily” cognitive (e.g., math and pattern recognition games, brain teaser games, and card games) or “primarily” motor skill—gross and/or fine—(e.g., golf-putting and ping-pong) in origin. Furthermore, according to Baumeister et al. (1990), some games are combination-based in that they are neither “primarily” cognitive nor motor skill in origin but rather require a mix of both cognitive decision-making and physical reactions. For example, with respect to the latter category, a video game (e.g., a joystick controlling a car) typically tests both cognitive and motor skills as it involves choice, reactions, hand control, and visual tracking.

Underlying process accounts of the above-referenced relationship between game playing and creativity have been couched in terms of physiological arousal (e.g., *Dance* and *Dance* video game) (Hutton and Sundar, 2010). Recently, Frith et al. (2020) also found that embodied movement robustly enhances creativity. In addition, although not a game *per se*, Benedek et al. (2012) showed that cognitive stimulation, due to engagement in a task that required individuals to generate random sequences of key responses, resulted in a greater number of ideas being generated on a subsequent task. However, I posit that the level of fun experienced in the course of a game playing experience should also play a central role in the relationship between game playing (even a cognitive one) and subsequent creativity.

Positive affect has been shown to enhance creative cognition (Isen et al., 1985, 1987; Fredrickson, 2001; Isen, 2001; Benedek et al., 2020). Similarly, Pillay et al. (2020) found that positive emotion elicited greater enthusiasm and confidence, which led to an increase in the quantity of new ideas. Moreover, Benedek et al. (2020) found that enjoyment compared with other motives



such as social recognition and duty motives was the strongest motivation to driving everyday creativity. Fun is an experiential stimulation (Friedman et al., 2007) that engenders enjoyment and pleasure that people experience while they are engaged in particular actions. Importantly, fun is related to a specific type of positive affect resulting from engagement in certain experiences (Truhon, 1983; Mainemelis and Ronson, 2006; Pryor et al., 2010; Vijay and Vazirani, 2011).

Therefore, I predict that a cognitive game that engenders the greatest degree of fun will likewise lead to the greatest creative outcomes. Formally stated:

H1: A cognitive-based game that engenders a greater degree of fun will result in greater creativity on a subsequent new product development task, compared with a cognitive-based game that engenders less fun.

H2: A cognitive-based game that engenders a high degree of fun will result in greater creativity on a subsequent new product development task, compared with a control group.

The Moderating Role of Goal Orientation

A considerable body of research has shown that the locus of motivation (i.e., intrinsic/extrinsic motivation) influences creative outcomes, and there is a consensus that intrinsic motivation enhances creativity relative to extrinsic motivation (Amabile, 1996; Deci et al., 1999). With respect to intrinsic motivation, individuals tend to focus on the process itself including personal feelings of interest, positive emotion, or competence. In contrast, with respect to extrinsic motivation, individuals tend to focus on the outcome including obtaining goals, rewards, or recognition (Fogear and Mecklenburg, 2013). Consistently, Bakker et al. (2020) found that learning goal (vs. performance goal) orientation increased creativity in the workplace. Because creativity is an intellectual thought process requiring a great deal of cognitive effort (Simonton, 1977), the degree to which individuals are inherently interested in the problem and motivated to find a solution is necessary to be creative (Shalley and Oldham, 1985).

Previous research has shown that individuals in a positive mood state are more creative when working toward process-focused goals (i.e., enjoyment) and less creative when focusing on outcome-focused goals (i.e., performance) (Hirt et al., 1996). Importantly, fun is a specific type of positive affect resulting from engagement in certain experiences (Truhon, 1983; Mainemelis and Ronson, 2006; Pryor et al., 2010; Vijay and Vazirani, 2011). Hence, I hypothesize that when engaged in a cognitive-based game that engenders a high degree of fun, individuals will generally be in happy/positive mood states, and thus, a process-focused goal orientation with respect to the game should lead to greater creativity on a subsequent new product development task (vs. an outcome-focused goal orientation with respect to the game). Formally stated:

H3: Individuals who are primed with a process goal orientation for a cognitive-based game that engenders a high degree of fun will be more creative on a subsequent new product development task than those who are primed with an outcome goal orientation.

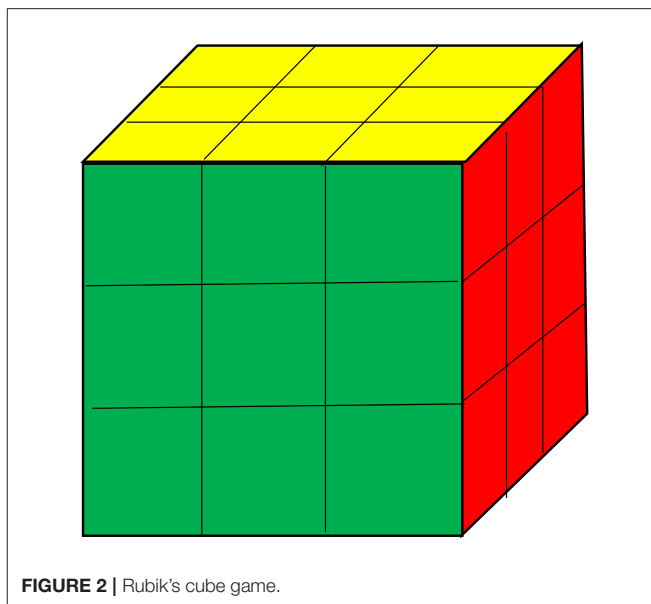


FIGURE 2 | Rubik's cube game.

EXPERIMENT 1

The purpose of experiment 1 is to test H1 and H2 to ascertain any cognitive game playing effects on subsequent creativity for a simple new product development task. A one-way ANOVA design was utilized.

Procedure

In total, 147 undergraduates in a large state university participated in the experiment. All students were majoring in business administration. The average age of subjects was about 20.8 years. The sample includes 86 male students (58.5%) and 61 female students (41.5%). The following three games were utilized: (1) a symbolic-pattern recognition game (shape Sudoku) called *Genie-ous*; (2) a Rubik's cube, which involved spatial reasoning; and (3) an unrelated experimental wild card in the form of a combination cognitive-motor skill free-form drawing game¹. Both *Genie-ous* and the Rubik's cube are employed in this study as treatment effects where participants use the cognitive domain but not motor skills or reaction. Since the Rubik's cube requires a certain level of spatial awareness and determination, it is considered to be less fun than *Genie-ous* for participants. Upon arrival, participants were randomly assigned to one of four conditions. Participants in the three game conditions were asked to engage in the given tasks first and then were asked to participate in a new product development task. The average time that participants engaged in the game tasks was 15–20 min (across three games)². Participants in the control

¹Not only is this a combination cognitive-motor skill game but its cognitive dimension is also different than what would be considered a traditional cognitive game (see Kinrade et al., 2010) in that it is “solution-less,” that is, it requires open-form versus closed-form cognition (such as a verbal, math, shape, or spatial puzzle/game).

²Subjects were given unlimited time to play each game in order to ensure that they had the choice to stop playing each game when they had completed it or else lost

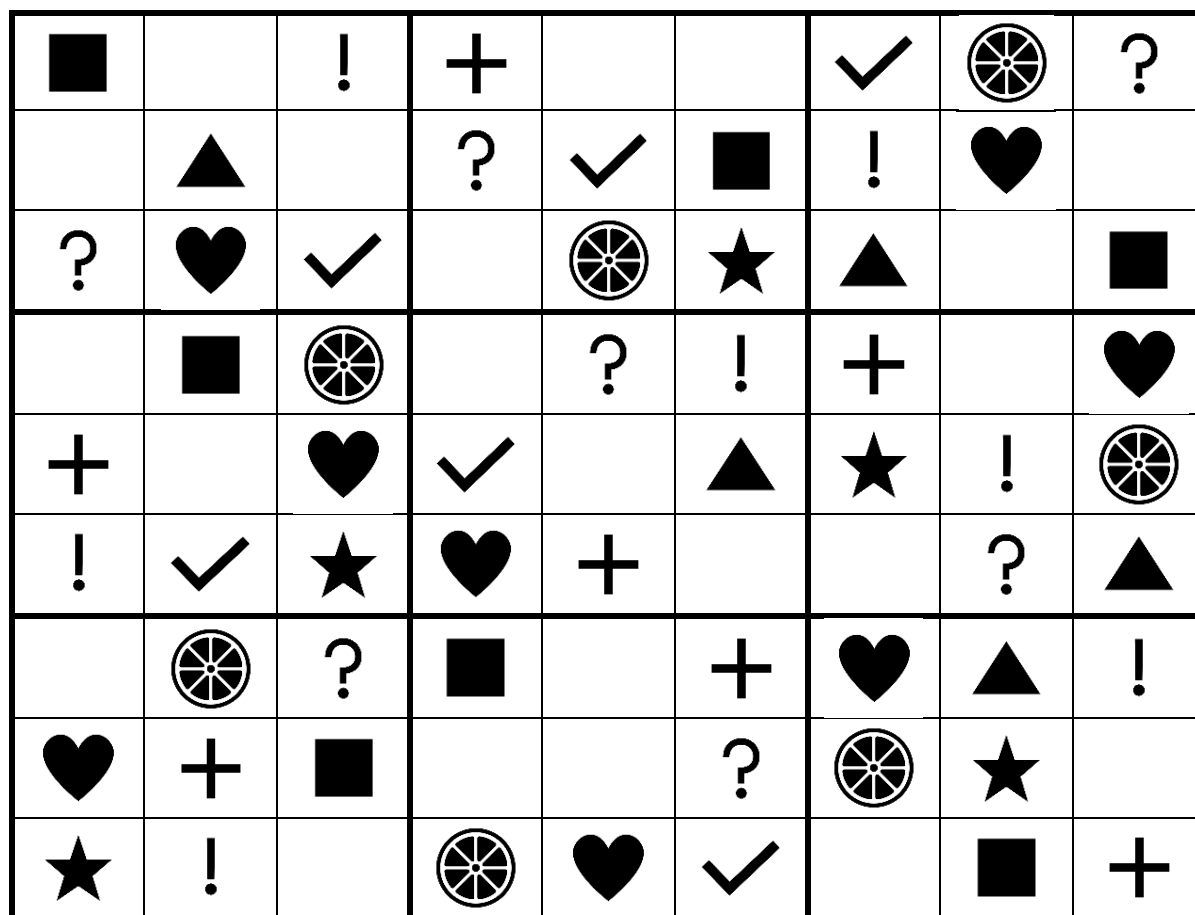


FIGURE 3 | *Genie-ous* (shape sudoku) game.

group did not engage in the game tasks. For the simple new product development task, all participants were asked to imagine themselves as a mattress manufacturer looking for creative ideas for a new kind of mattress (Mehta et al., 2012). Specifically, they were asked to read the following scenario:

“Please imagine yourself as a mattress manufacturer. Generate as many creative ideas for a new mattress. It may include a new feature or a new product as well.”

After reading the imaginary scenario, participants were asked to generate as many creative ideas as possible for a new feature or a new product and to type each idea into the computer. No time limit was imposed for the idea generation task. Finally, participants answered questions that assessed the level of fun related to playing the games. The experiment concluded with various demographic questions. The Rubik’s cube and *Genie-ous* (shape-sudoku) used in experiment 1 are shown in Figures 2, 3, respectively.

interest in it. The average time for *Genie-ous*, Rubik’s cube, and drawing were ~18, 20, and 15 min, respectively. Applying caution is advised to readers as different times across games may affect the results.

Results

Number of Ideas Generated

Table 1 presents the results of experiment 1. Note that five responses were excluded and will be excluded for further analysis because those participants did not generate any ideas. The results showed that the number of ideas generated in the *Genie-ous* group ($M = 4.03$, $p > 0.1$) was not significantly different from those in the control group ($M = 3.73$). However, pairwise comparisons showed that participants in the Rubik’s cube group ($M = 2.97$, $p < 0.05$) generated fewer ideas than those in the control group. Moreover, participants in the *Genie-ous* group generated significantly more ideas than those in the Rubik’s cube group ($p < 0.01$).

Creativity of the Ideas Generated

Two coders blind to the experimental conditions identified the most creative idea that each participant generated. The difference in selection was resolved through discussion between the coders. Each coder then rated the most creative idea generated by each participant. The correlation between the coders’ ratings was positive (0.43) and significant ($p < 0.01$). This measure

TABLE 1 | Summary of experiment 1.

	Number of shapes used	Novelty	Usefulness	Overall creativity	Level of fun for game
(1) Control ($n = 44$)	3.73	4.88	6.05	5.47	N/A
(2) <i>Genie-ous</i> ($n = 31$)	4.03	5.83	6.48	6.16	5.44
(3) Rubik's cube ($n = 34$)	2.97	4.73	5.61	5.17	4.49
(4) Drawing ($n = 33$)	3.45	5.30	6.06	5.68	4.41
Total ($n = 142$)	3.55	5.15	6.04	5.59	4.78
p-Value					
Diff: (1)-(2) [H2]	ns	**	ns	*	ns
Diff: (1)-(3)	**	ns	ns	ns	ns
Diff: (2)-(3) [H1]	***	**	*	**	***

***, **, and * denote significance at 1, 5, and 10% levels, respectively, from two-tailed. "ns" denotes a lack of statistical significance at the 10% level.

allowed us to assess creativity, independent of the number of ideas each participant generated (Yang et al., 2012). In other words, participants who generated one creative idea alongside many average ideas would not be penalized for their less creative ideas. Furthermore, those who generated one highly creative idea, but few additional ideas, would not be penalized either. Both creativity dimensions were measured (novelty and usefulness). Three items captured each of the two dimensions (Dahl et al., 1999; Moreau and Dahl, 2005; Burroughs et al., 2011).

For novelty, the three items were measured with a 7-point Likert scale ($\alpha = 0.98$): 1 = not at all original/7 = very original; 1 = not at all innovative/7 = very innovative; 1 = not at all novel/7 = very novel. Pairwise comparisons showed that the ideas generated by participants in *Genie-ous* group ($M = 5.83$) were significantly more original than the ideas generated by participants in the control group ($M = 4.88$, $p < 0.05$) or by those in the Rubik's cube group ($M = 4.73$, $p < 0.05$).

For usefulness, three items were measured as well ($\alpha = 0.98$): 1 = not at all useful/7 = very useful; 1 = not at all effective/7 = very effective; 1 = not at all worthwhile/7 = very worthwhile. Ideas generated by participants in the *Genie-ous* group ($M = 6.48$) were rated more useful than those in the Rubik's cube group ($M = 5.61$, $p = 0.07$).

In this research, I am more interested in overall creativity than in one of the two separate constructs, so I averaged the six items. Pairwise comparisons showed that the ideas generated by the *Genie-ous* group ($M = 6.16$) were more creative than those in the Rubik's cube group ($M = 5.17$, $p < 0.05$) and marginally more creative than the control group ($M = 5.47$, $p = 0.08$).

Fun

Participants were asked to rate the level of fun for the game in which they were engaged. Three items were measured with a 7-point Likert scale [modified from Carver and White (1994)]: 1 = not at all interesting/7 = very interesting; 1 = not at all exciting/7 = very exciting; 1 = not at all engrossing/7 = very engrossing ($\alpha = 0.87$). The level of fun experienced in the *Genie-ous* group ($M = 5.39$) was significantly higher than in the Rubik's cube group ($M = 4.49$, $p < 0.01$). Further results of t -tests for

the level of fun found that only the *Genie-ous* group ($t = 8.16$, $p < 0.01$) was significantly higher than the mid-point for the level of fun. The level of fun for the Rubik's cube group ($t = 1.95$, $p = 0.060$) was only marginally higher than the mid-point for the level of fun.

Mediation Analyses

Mediation analysis was conducted in order to test whether the level of fun is responsible for the effect of game playing on creative outcomes. Following the study by Preacher and Hayes (2004), a bootstrapping approach using 5,000 bootstrapping samples was used to assess the mediation effect. The result demonstrated that the 95% confidence interval for the Rubik's cube group and the *Genie-ous* group contrast, for the number of ideas (-0.73 – -0.06), usefulness (-0.96 – -0.02), and overall creativity (-0.73 – -0.03), did not include zero, which suggests that an indirect mediation effect for the level of fun was present. For idea originality (-0.67 – 0.06), it did include zero, which indicates a lack of a mediating role for fun in this regard.

Discussion

Experiment 1 showed that a cognitive game that engendered a greater level of fun resulted in more creative outcomes on a subsequent new product development task, compared with a cognitive game that did not engender as much fun. In addition, a cognitive game that engendered a high degree of fun resulted in greater creativity on a subsequent new product development task, compared with a control group.

These findings in experiment 1 have important implications. While prior research investigates the effect of playing games on subsequent creative outcomes, it mainly focuses on video games in which subjects are allowed to use both cognition and motor skills (Squire, 2006; Hamlen, 2009; Hutton and Sundar, 2010; Jackson et al., 2011; Balance-Herrera et al., 2019). Meanwhile, other studies focus on how sports or physical activity affect creativity (Cavallera et al., 2011; Lupu, 2012). In contrast, by using *Genie-ous* (a shape Sudoku) which is a cognitive-based game, I am able to isolate the effect of cognition-based fun on creativity from that of motor skills or physiological activity. Thus, this study adds to the literature by demonstrating the uniqueness of cognition-based fun as a process accounting for the link between game playing and subsequent creativity.

Post-test

The purpose of the post-test was to test the alternative explanation that differential levels of cognitive stimulation could possibly account for the pattern of results found in experiment 1. Hence, the post-test was designed to measure cognitive stimulation levels for the two cognitive-based games (*Genie-ous* and Rubik's cube) I adopted in experiment 1.

Procedure

As I attempted to test different levels of cognitive stimulation induced by cognitive-based games, a control group was not included in the post-test. Thus, the post-test consisted of a one-way ANOVA design. It included the Rubik's cube and the *Genie-ous* condition. Forty-two undergraduates (male = 26, average age

= 20.80) in a large state university participated in the post-test in exchange for class credit. Upon arrival, they were randomly assigned to one of two groups. After performing the given game, participants were asked to rate the cognitive stimulation level for the given task on a 9-point Likert scale (1 = highly disagree, 9 = highly agree). The scale consisted of the following questions: "When I was engaged in the task, I felt that my thinking process was actively stimulated; the task encouraged me to think intellectually; the task facilitated my intellectual functioning [$\alpha = 0.71$, modified from Bolkan and Goodboy (2010)]." Finally, participants answered demographic questions and debriefed.

Results

One-way ANOVA was conducted to test cognitive stimulation between the two games. It was found that cognitive stimulation was not significantly different across the two games [$F(1, 40) = 1.57, p > 0.1$]. Cognitive stimulation for the Rubik's cube was 6.79 ($n = 21$), and for the *Genie-ous*, it was 7.24 ($n = 21$). Thus, I could eliminate the possibility of the alternative explanation that differential levels of cognitive stimulation used between the two games accounted for the pattern of results found in experiment 1.

Discussion

Post-test showed that cognitive stimulation levels for the two cognitive-based games (*Genie-ous*, and the Rubik's cube) in experiment 1 were not significantly different. Hence, cognitive stimulation did not account for the pattern of results in experiment 1. By holding the level of cognition constant, the post-test results enhance our understanding of the central role of fun in creative outcomes for a new product development task, as discussed by Baumeister et al. (1990) and Kinrade et al. (2010).

EXPERIMENT 2

Experiment 2 was designed to test H_3 , which adopts one-way ANCOVA (goal orientation: process vs. outcome). The purpose was to examine the effect of a goal orientation context on the subsequent link between cognitive-based game playing and creativity. Goal orientation was manipulated by giving specific (process vs. outcome goal orientation) instructions for the given pattern recognition game (shape Sudoku). For the subsequent new product development task, designing a toy for a child was used (Moreau and Dahl, 2005). The dependent variables included two constructs of creativity (novelty and usefulness). Mood and self-efficacy were measured as covariates; 20 shapes for toy ideas used in experiment 2 are shown in **Figure 4**.

Procedure

A total of 81 undergraduate students (male = 40, average age = 21.1) from a large state university participated in this experiment in exchange for class credit. Upon arrival, participants were randomly assigned to one of two groups. Depending on the group to which they were assigned, participants read the goal orientation instructions related to the pattern recognition game (shape Sudoku) for the goal orientation manipulation. Participants in the process goal orientation condition read the instruction for the given task (focus on the process of playing

the game), whereas participants in the outcome goal orientation condition read another instruction (focus on the outcome of winning). The specific instructions for goal manipulation were as follows.

Process-focused goal orientation [modified from Escalas and Luce (2003)]: The following game is provided for you to play. Please focus on the process of playing the game. The primary goal is not speed and/or how many boxes you can fill in. Final scores will not be computed and distributed.

Outcome-focused goal orientation [modified from Burroughs et al. (2011)]: The following game is provided for you to play. Please focus on the outcome of winning. The primary goal is speed and/or how many boxes you can fill in. Final scores will be computed and distributed.

After completing the pattern recognition game, participants were asked to complete the subsequent new product development creativity task. The new product development task of designing a toy for children was used. Participants read the instruction "Please design a toy, anything a child of age 5–11 can use to play with. Twenty shapes can serve as components for your toy idea" (Moreau and Dahl, 2005; Yang et al., 2012; see **Figure 1**).

Fun was measured in order to test the expected process mechanism for goal orientation. In the same vein as in experiment 1, the three items used to measure fun included "I found the new product design task; interesting, exciting, and engrossing"; 1 = highly disagree, 7 = highly agree [modified from Carver and White (1994)].

Participants then rated covariates, mood, and self-efficacy. To measure mood, the PANAS scale of 20 items with a 5-point Likert scale was used (Watson et al., 1988). The 10 items indicating a positive mood were as follows: interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, and active. Meanwhile, the 10 items indicating a negative mood were as follows: distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid. The construct of perceived self-efficacy reflects an optimistic self-belief (Jerusalem and Schwarzer, 1992). This is the belief that one can perform novel or difficult tasks, or cope with adversity in various domains of human functioning. Perceived self-efficacy facilitates goal-setting, effort investment, persistence in the face of barriers, and recovery from setbacks. Therefore, it can be regarded as a positive resistance resource factor. Ten items with a 4-point Likert scale were used to measure perceived self-efficacy including "I can always manage to solve difficult problems if I try hard enough," "If someone opposes me, I can find the means and ways to get what I want," and "It is easy for me to stick to my aims and accomplish my goals" (1 = not at all true; 4 = exactly true).

Finally, manipulation check questions for goal orientation, a suspicion probe, and demographic questions were asked. The average time that participants engaged in the experiment was 15–20 min.

Results

Number of Components Used for Toy Design

Table 2 presents the results of experiment 2. The participants used 5.66 components out of 20 shapes when designing a toy ($SD = 5.21$). One-way ANCOVA found that goal orientation ($M_{process}$




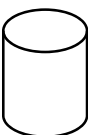

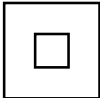
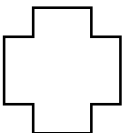
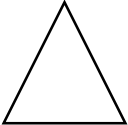
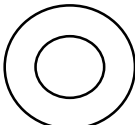
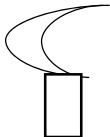
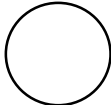

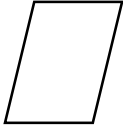
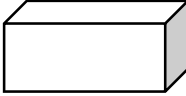

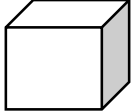

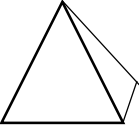
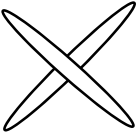

3-D Half Sphere	3-D Sphere	3-D Handle	3-D Cylinder	3-D Cone
				
Flat. Hollow Square	Flat Cross	Flat Triangle	Flat Ring	Solid Hook
				
Flat Circle (disk)	3-D Bracket	Flat Diamond	3-D Rectangular Block	3-D "U" Shape
				
3-D Cube	Flat Square	Pyramid	Flat Narrow Cross	Thin Pole
				

FIGURE 4 | Twenty shapes for toy idea in experiment 2. Twenty shapes shown in this figure can serve as components for your toy idea (Moreau and Dahl, 2005; Yang et al., 2012).

$= 5.51$, $M_{\text{outcome}} = 5.82$) did not have a significant effect on the number of components used for toy design [$F(1, 75) = 0.78$, $p > 0.1$]. Among the covariates of mood and self-efficacy, only positive affect had a significant effect on this measure [$F(1, 75) = 4.27$, $p < 0.05$]. It was further found that participants tended to use more components when they felt a more positive affect ($r = 0.24$, $p < 0.05$). Negative affect [$F(1, 75) < 0.1$, $p > 0.1$] and self-efficacy [$F(1, 75) = 0.78$, $p > 0.1$], by contrast, were not significant at all.

Creativity of the Ideas Generated

Examples of toys designed by participants are shown in **Figure 5**. Two independent coders blind to the experimental conditions rated the toy drawings of each participant according to six items of creativity, which consisted of two constructs, namely, novelty and usefulness. The correlation between the coders' ratings was positive ($r = 0.75$) and significant ($p < 0.01$). Just as in experiment 1, creativity was measured as two constructs, namely, novelty and usefulness. Three items captured each of the two

dimensions (Dahl et al., 1999; Moreau and Dahl, 2005; Burroughs et al., 2011).

For the novelty dimension, three items were measured with a 7-point Likert scale ($\alpha = 0.98$; original, innovative, novel). The novelty across two conditions was significant [$F(1, 75) = 4.64$, $p < 0.05$]. The toys designed by participants who were primed with a process goal orientation ($M_{\text{process}} = 4.00$) were significantly more original than the ideas generated by participants with an outcome goal orientation ($M_{\text{outcome}} = 3.23$). Among covariates, only positive affect had a marginal effect on this measure [$F_{\text{positiveaffect}}(1, 75) = 3.40$, $p < 0.1$], but negative affect [$F_{\text{negativeaffect}}(1, 75) = 2.71$, $p > 0.1$] and self-efficacy [$F_{\text{self-efficacy}}(1, 75) < 1$, $p > 0.1$] were not significant.

For the usefulness dimension, three items were measured as well ($\alpha = 0.99$; useful, effective, worthwhile). The usefulness across two conditions was significant [$F(1, 75) = 4.15$, $p < 0.05$]. Toys designed by participants in the process goal orientation group ($M_{\text{process}} = 4.00$) were rated more useful than those in the outcome goal orientation group ($M_{\text{outcome}} = 3.27$). Again, only positive affect was found to be significant [$F_{\text{positiveaffect}}(1, 75) =$

TABLE 2 | Summary of experiment 2.

	Number of shapes used	Novelty	Usefulness	Overall creativity	Level of fun for game
(1) Process ($n = 39$)	5.51	4.00	4.00	4.00	4.75
(2) Outcome ($n = 41$)	5.82	3.23	3.27	3.25	3.88
Total ($n = 80$)	5.66	3.62	3.64	3.63	4.33
p-Value					
Diff: (1)-(2) [H3]	ns	**	**	**	***
Covariate					
Positive effect	*	*	*	*	***
Negative effect	ns	ns	ns	ns	ns
Self-efficacy	ns	ns	ns	ns	ns

***, **, and * denote significance at 1, 5, and 10% levels, respectively, from two-tailed. "ns" denotes a lack of statistical significance at the 10% level.

4.05, $p < 0.05$] on this measure among covariates [$F_{\text{negative affect}}(1, 75) = 2.31$, $p > 0.1$; $F_{\text{self-efficacy}}(1, 75) < 1$, $p > 0.01$]. Participants tended to generate more useful ideas when they had a more positive affect ($r = 0.20$, $p < 0.1$).

Just as in experiment 1, I averaged the six items because the current research was more interested in overall creativity than in one of the two separate constructs. The results showed that overall creativity was significant [$F(1, 75) = 4.54$, $p < 0.05$]. The toy design generated by the process goal orientation group ($M_{\text{process}} = 4.00$) was more creative than the outcome goal orientation group ($M_{\text{outcome}} = 3.25$). Also, the level of fun for *Genie-ous* ($M = 4.33$) was higher than the mid-point of the scale ($t = 5.49$, $p < 0.01$). Thus, it can be asserted that H_3 was supported because individuals who were given a process goal orientation for a cognitive-based game that engendered a high degree of fun were more creative on a subsequent NPD task than those who were given an outcome goal orientation. In a similar vein to other measures, only positive affect was shown to be marginally significant [$F(1, 75) = 3.84$, $p < 0.1$] among covariates [$F_{\text{negative affect}}(1, 75) = 2.60$, $p > 0.1$; $F_{\text{self-efficacy}}(1, 75) < 1$, $p > 0.01$]. Moreover, toy designs were marginally more creative when participants felt a more positive affect ($r = 0.19$, $p < 0.1$).

Fun

Participants were asked to rate the level of fun for the given pattern recognition game (shape Sudoku) in which they were engaged. As was the case in experiment 1, three items were measured with a 7-point Likert scale ($\alpha = 0.93$; interesting, exciting, engrossing). The level of fun across two goal orientation conditions was significant [$F(1, 75) = 10.04$, $p < 0.01$]. The level of fun in the process goal orientation ($M_{\text{process}} = 4.75$) was significantly higher than the outcome goal orientation group ($M_{\text{outcome}} = 3.88$). Only positive affect was shown to be significant [$F_{\text{positive affect}}(1, 75) = 9.94$, $p < 0.05$] among covariates [$F_{\text{negative affect}}(1, 75) < 1$, $p > 0.1$; $F_{\text{self-efficacy}}(1, 75) < 1$, $p > 0.1$]. Furthermore, participants significantly rated the game as more fun when they felt more positive affect ($r = 0.32$, $p < 0.05$).

Mediation Analyses

Mediation analysis was conducted in order to test whether fun was playing a mediating role in the relationship between goal orientations (process vs. outcome) and creative outcomes. Preacher and Hayes' (2004) bootstrapping approach was adopted, in which 5,000 bootstrapping samples were used to assess the mediation effect. The results showed that the 95% confidence interval for novelty (0.11–0.83), usefulness (0.09–0.76), and overall creativity (0.11–0.80) did not include zero, which suggested that an indirect mediation effect for the level of fun was present.

Manipulation Check

A manipulation check was conducted to determine whether the manipulation for goal orientation (process vs. outcome) was successful. As intended, participants who were primed with a process goal orientation rated significantly higher for the questions "I was focused on playing for the sake of playing games [$M_{\text{process}} = 5.49$, $M_{\text{outcome}} = 4.45$, $F(1, 79) = 7.90$, $p < 0.01$]" and "I was focused on playing for the challenging of playing games [$M_{\text{process}} = 5.66$, $M_{\text{outcome}} = 4.93$, $F(1, 79) = 4.14$, $p < 0.05$]" compared to those with an outcome goal orientation. Also, participants who were manipulated with an outcome goal orientation rated significantly higher for the questions "I was focused on playing in order to score points [$M_{\text{outcome}} = 5.15$, $M_{\text{process}} = 3.24$, $F(1, 79) = 21.47$, $p < 0.01$]" and "I was focused on playing in order to win [$M_{\text{outcome}} = 5.40$, $M_{\text{process}} = 3.83$, $F(1, 79) = 12.13$, $p < 0.01$]" compared to those with a process goal orientation. Hence, the manipulation of goal orientation was entirely successful in the current experiment.

Discussion

The results from experiment 2 showed the effects of goal orientation (process vs. outcome) on creative outcomes in terms of novelty, usefulness, and overall creativity. More specifically, the toys designed by participants who were primed with a process goal orientation were significantly more original, useful, and overall creative than the toys designed by participants with an outcome goal orientation. Furthermore, the level of fun in the process goal orientation was significantly higher than that in the outcome goal orientation group. Among the covariates of mood and self-efficacy, only positive affect was shown to have a significant influence on the novelty, usefulness, overall creativity, and level of fun. Positive affect was found to be positively related to the usefulness dimension, overall creativity, and the level of fun as well. The mediating role of the level of fun was detected for each dimension of novelty and usefulness, as well as overall creativity. Moreover, as in the previous experiment, the level of fun for the given shape Sudoku was rated significantly higher than the mid-point scale.

Therefore, I found support for H_3 , which stated that individuals who were given a process goal orientation for a cognitive-based game that engendered a high degree of fun were more creative on a subsequent new product development task than those who were given an outcome goal orientation. Prior studies are muted about how the association between fun, which is a specific type of positive effect (Truhon, 1983; Mainemelis and Ronson, 2006; Pryor et al., 2010; Vijay and Vazirani, 2011), and

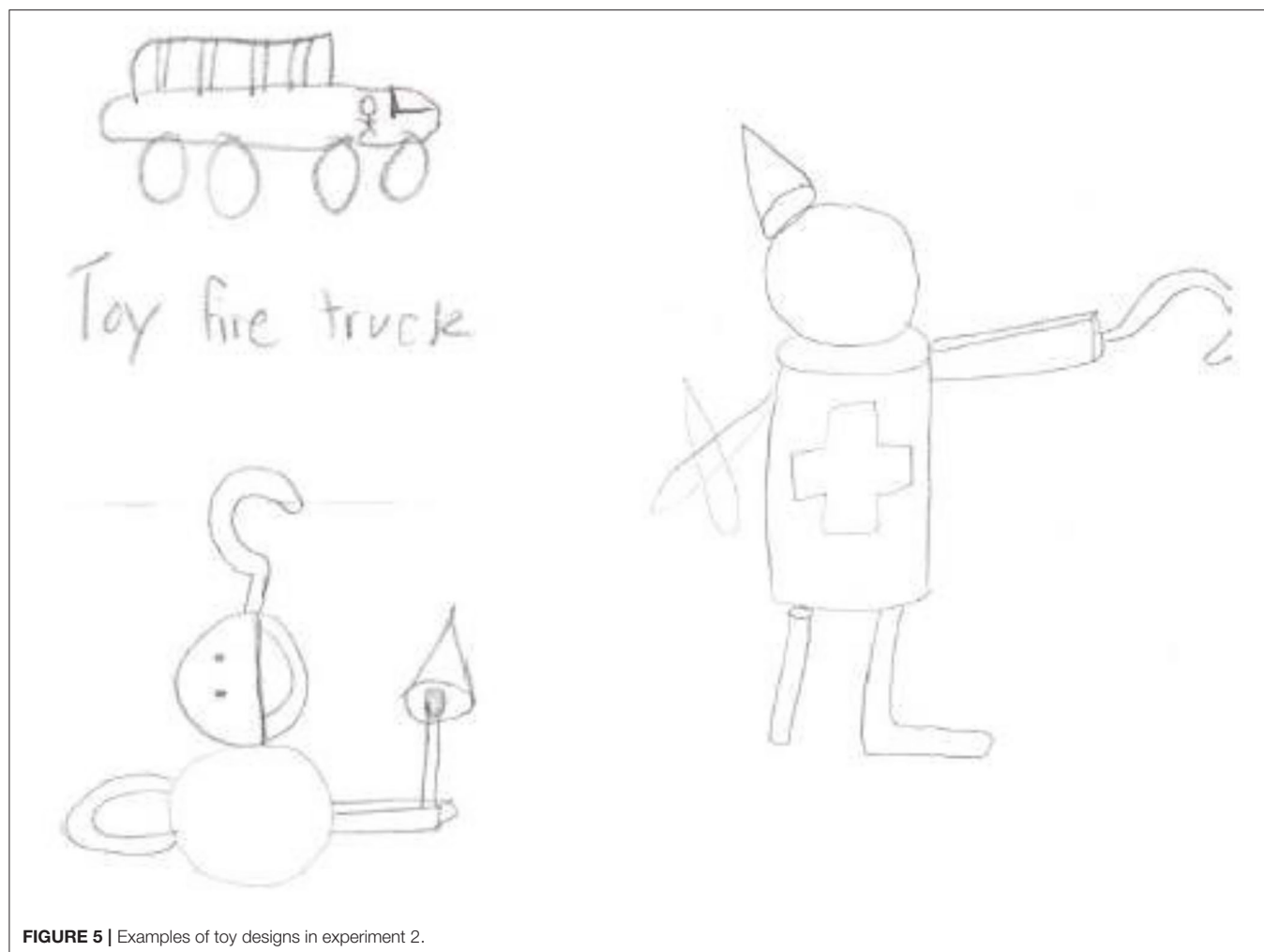


FIGURE 5 | Examples of toy designs in experiment 2.

creativity varies across the level of goal orientation. Therefore, the evidence documented in this section fills the gap in the literature on process goal orientation (Amabile, 1996; Deci et al., 1999) such as positive affect and creativity (Hirt et al., 1996).

CONTRIBUTION

This research addresses the effect of cognitive game playing on subsequent new product development creativity and the role of the degree of fun experienced as possible process accounts for the pattern of results derived.

Theoretically, this research seeks to expand the creativity literature by exploring the effect of cognitive game playing and goal orientation on creativity and by examining the centrality of fun in driving creative outcomes with respect to game playing, in general, and even in a “cognitive” domain.

The potentially substantive and managerial contributions of this research include the ability to provide managers with a timely and cost-effective lever for increasing creative outcomes. While it may be costly and time-consuming to change certain aspects of a firm’s work environment (e.g., the room design) to aid

creativity and brainstorming, it is relatively easy for managers to encourage employees to engage in certain forms of unstructured recreation such as games prior to brainstorming sessions for a new product development.

Similarly, organizations or educators may seek to develop in-house, unstructured employee recreation training programs that are focused in whole or part around the concept of utilizing game playing at work to enhance individual employee creativity on a day-to-day basis and with respect to a plethora of creativity-based work-place tasks.

This study is subjected to several caveats. I acknowledge that the participants were given unlimited time to play each game. Although this design was to ensure that they had the choice to stop playing each game when they had completed it or else lost interest in it, the average time engaged was not consistent across Genie-ous, Rubik’s cube, and drawing. This may affect inferences made from the experiments. I also note that the number of subjects used in experiments is somewhat small. Caution is required in making inferences from the documented evidence. Finally, this study does not fully exploit the differential effects of fun activity on creative outcomes. For example, by

playing video games, participants are able to use different levels of both cognition and motor skills. Future research that utilizes various video games to examine the effect of fun on creativity is warranted. Investigating not only the effect of cognitive stimulations but also the effect of emotional competencies on creativity seems promising.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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ETHICS STATEMENT

The studies involving human participants were reviewed and approved by State University of New York–Buffalo, Institutional Review Board (IRB). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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In search of mediators of leadership behavior to Team Creativity in Team Start-ups

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Creativity is believed as the first step to innovation, especially in a team or workgroup in an organization. Team Creativity will lead to several innovations in a team, such as product and process innovation. Team leaders play a significant role in embracing Team Creativity. Our study investigates the mediator variables to foster the impact of leadership behavior on Team Creativity in Team Start-up. Earlier research shows that two value-based leadership styles, Transformational and Servant Leadership, significantly affect a team's creativity. We proposed two mediators of leadership behavior to foster Team Creativity: Team Climate and Team Ambidexterity. The sample is early Team Start-ups in several cities in Indonesia, run and led by young people. It is empirical cross-sectional quantitative research with more than 434 participants aggregated into 145 teams. The result shows that Team Climate and Team Ambidexterity are good mediators of Servant and Transformational Leadership behavior to Team Creativity in Team Start-ups. The two variables maximize the impact of leadership behavior on Team Creativity.

KEYWORDS

Servant Leadership behavior, Transformational Leadership behavior, Team Ambidexterity, Team Climate, Team Creativity, Team Start-up

Introduction

Creativity as the generation of new and novel ideas is studied not only in the cognitive area of an individual or intrinsic personal motivation (Amabile, 1988; Woodman et al., 1993) but also as inter-personal collaboration/interaction within a team (Bullinger et al., 2004). Creativity is often emerging at the crossroads of divergent avenues of knowledge (Amabile and Conti, 1999) and inter-collaboration among individuals. In responding to the rapid change and the competitiveness in the business, a start-up relies on team creativity (Tjosvold et al., 2004), not individual creativity. More studies have been done to investigate the factors influencing Team Creativity (Shin and Zhou, 2007, p. 1,715; Shalley et al., 2009). Later studies have concluded that several aspects of the surrounding, such as leadership and organizational hierarchy, influence Team Creativity (Amabile et al., 2004; Artz et al., 2010).

Team Creativity has an essential effect on the success of an organization (Sun et al., 2016) and refers to the collective effort of every team member to create a new idea (Carmeli and Paulus, 2015). It evolves from a complex and contextual interaction among team members (Koh et al., 2019) and needs support and empowerment from the team leader (Zaccaro et al., 2001). Leadership behaviors are imperative for fostering Team Creativity in an organization or a team (Yang et al., 2017; Zhou et al., 2019). Investigating leadership behavior's role in Team Creativity and their mediators is vital for Team Start-ups since leadership behavior directs and influences creativity (Herrmann and Felfe, 2014) and develops competencies to encourage the process of creativity as well as opportunity recognition in the business (Swiercz and Lydon, 2002; Chen et al., 2009).

Earlier research shows that two value-based leadership styles, Transformational and Servant Leadership, significantly affect a team's creativity. Gumusluoglu and Ilsev (2009) study the influence of Transformational Leadership on creativity in an organization, followed by He et al. (2020), who investigate how Transformational Leadership facilitates individual creativity into team creativity. Yoshida et al. (2014) and Antonio et al. (2020) researched how Servant Leadership affects creativity in a team, while Chen et al. (2022) investigated the influence of Servant Leadership on creativity based on the Social Exchange Theory. The two-leadership style needs mediators to foster creativity in a team. The direct influence of leadership behaviors on Team Creativity needs to be empowered and maximized. We propose potential variables to mediate the influence.

Rosing et al. (2011) study the concept of Ambidexterity in team leadership and recommend that certain leadership behaviors are required to bring about the ambidexterity process of creativity and innovation. Jacob et al. (2015) studied the role of Ambidexterity at a team level and recommended investigating the potential antecedent to Team Ambidexterity that leads to creativity. Leadership behaviors are a good antecedent for Ambidexterity for creativity. We proposed two leadership behaviors—Servant Leadership and Transformational Leadership—to be investigated and Team Ambidexterity as the mediators for Team Creativity.

The basic understanding of climate in an organization was developed by Patterson et al. (2005) as an intervening variable between the organizational context and the member's behavior. Anderson et al. (2014) expand the idea of the climate in a work unit or team as a missing link between management and the team outcome. Team Climate is a means where team members could have information about the appropriate role behavior of the team members and the expected team outcomes. The expected outcome may vary depending on the characteristics of the team (Schneider et al., 2013). In a team context, a leader influences members through several paradoxical processes. Besides working on a dyadic basis to push the member to meet the performance demand, they also need to embrace a motivational climate and creative environment to bear team

creativity (Zhang et al., 2021). Xu et al. (2019) recommend Team Climate as an antecedent to Team Creativity, while Team Climate is also positively related to and associated with positive leadership behavior (Piccolo and Colquitt, 2006; Shin and Zhou, 2007).

Finally, this study proposes two mediators of leadership behavior—Transformational Leadership and Servant Leadership behavior—to foster Team Creativity, namely Team Climate and Team Ambidexterity.

Literature review and hypotheses development

Team Starts-up

Early Entrepreneurship activities are primarily done in a team rather than in a lone ranger mode. For example, Ruef (2010) reports that almost 95% of the individuals starting a business either involve others or intend to collaborate later.

Forsström-Tuominen et al. (2017) found that this team-based entrepreneurship or Team Start-up is characterized by (i) the definition, (ii) the link between Team Start-up characteristics and team performance, and (iii) the antecedents and effects of team cognition. We will start by discussing some definitions of Team Start-up to find the base of start-up understanding and then explore the other two characteristics to build the theoretical model of this study.

Lazar et al. (2020) define Team Start-up as an entrepreneurial team that consists of individuals who have new business ideas and share ownership of the team, while Forsström-Tuominen et al. (2017) defined it as a team that consists of individuals who develop and establish a business with equity ownership, and commitment to common goals/outcomes. Bolzani et al. (2019) mention it as a group of individuals pursuing business opportunities. Every individual has a significant role and ownership interest in team management and directly influences the team's strategic choices.

Knight et al. (2020) expanded the research by providing a multidimensional conceptualization of the start-up framework with three key dimensions: first is the Ownership of Equity, second is the Autonomy of Strategic Decision-Making, and third is Entitativity. Ownership of Equity is the core dimension of a Team Start-up that explains the need, the amount, and the distribution of equity among team members. Autonomy of Strategic Decision-Making describes the exercising agency and the scope and authority of decision-making. Entitativity reflects the closeness of a team where the team is a unified whole, coherent, and unified organization entity. All the dynamics of the team range between these three dimensions, including Team Creativity and other inter-team interaction.

The theoretical framework of a Team Start-up is surveyed by Antonio et al. (2021) as follows: (i) "Theory

of Entrepreneurship” of Cantillon (1775) and the “Creative Destruction” theory of Schumpeter (1942), which stated that a start-up is a combination of creativity, novelty, innovation, and development, (ii) the concept of Life Cycle Theory (Kaulio, 2003) which consider start-up as a linear and dynamic entity that address several challenges through several phases, and (iii) Complexity Theory (Tsai and Lan, 2006) which reveal that a start-up follows a stiff transition during the journey. This transition is called a threshold; in this case, using the threshold is the ultimate way to let a new order arise.

Considering the various definitions and the theoretical frameworks above, Team Start-up can be defined as an entrepreneurship entity consisting of two to three individuals committed to a common goal and identified by opportunity creation, creativity/innovation, and risk-taking.

Team Creativity

Creativity is defined as the act of producing novel and purposeful ideas (West and Farr, 1990, p. 9). It is always associated with valuable and novel idea generations (Amabile, 1988, p. 126; Zhou and Shalley, 2010) and happens in specific periods (Woodman et al., 1993). Creativity is seen as the antecedent to innovation (Amabile and Conti, 1999; West, 2002; Klijn and Tomic, 2010). It occurs over the whole innovation implementation process (Tang, 2019). As part of the integral process of innovation, Anderson’s integrative definition of creativity in the workplace is written as the integration of improved processes, outcomes, and products. The creative process has several stages, from idea generation to idea implementation. These stages aim for a better procedure, practice, or products (Anderson et al., 2014).

Creativity in a team is defined as a process of producing novel and purposeful ideas through several collaboration procedures among team members (Shin and Zhou, 2007, p. 1,715). Team Creativity is imperative to respond to the rapidly changing demand in the marketplace (Tjosvold et al., 2004).

Early theory to support Team Creativity is the Componential Theory (Amabile, 1997). The theory explains three major significant components of individual and Team Creativity. First, is the expertise of team leaders and team members, second is the thinking skill, and third is their intrinsic motivations. A later study by Amabile shows additional components to enhance employee creativity. They are motivated to innovate, providing resources and better managerial practices (Amabile and Conti, 1999).

Woodman et al. (1993) studied the Interactionist Theory of organizational creativity, which is considered one of the most developed theories on organizational creativity and innovation (Shalley et al., 2009; Yuan and Woodman, 2010; Zhou and Shalley, 2010). The theory explains the interaction process among individuals in a team and an organization which occurs in various stages of the institution, such as individual, team unit,

and organization. Creativity is a result of holistic conditions of genetics, cognition, knowledge, social status, and surrounding contextual influence.

On the other hand, Team Creativity is composed of team members’ creativity, team characteristics, team interaction, and the contextual impact on the team. Individual creativity and team creativity will initiate organizational creativity. From the Interactionist perspective, creativity is determined mainly by the interaction among aptitude, process, and environment to produce a novel and purposeful idea within a social context (Plucker et al., 2004).

Creativity depends on culture. Different cultures will determine various kinds of creativity (Anderson et al., 2014). At the individual level, culture will influence the process of how creativity emerges and the assessment method, while at the team level, culture will impose team creativity (Chiu and Kwan, 2010; Hempel and Sue-Chan, 2010).

Based on these theoretical frameworks, we define Team Creativity as the generation of new and purposeful ideas in a team through the interaction of working together among the team members.

The mediator role of Team Ambidexterity

Team Ambidexterity

Ambidexterity combines exploration and exploitation to enhance creativity and innovation in team and organization performance (Raisch et al., 2009; Papachroni et al., 2015; Lee et al., 2017; Walrave et al., 2017; Luger et al., 2018). Bledow et al. (2009) laid out the ambidexterity theory and suggested that the exploration and exploitation activities should be engaged together to pursue creativity in a team or organization. This idea differs from the ambidexterity understanding proposed by Gupta et al. (2004), which mentioned that the two activities must be separated into two different activities. Rosing et al. (2011) echoed the idea of Bledow by proposing the integration of exploration and exploitation within the same system. Later research supports Bledow’s ambidexterity theory (Zacher and Wilden, 2014; Zacher and Rosing, 2015; Zacher et al., 2016; Rosing and Zacher, 2017; Alghamdi, 2018; Klonek et al., 2020). The integration process of exploration and exploitation pursues the paradoxical demand to achieve creativity (Klonek et al., 2020). The mechanical process can be seen from the paradox perspective (Papachroni et al., 2015; Cunha et al., 2019). The integration of the paradox perspective and the ambidexterity theory lay an excellent framework to deal with the inherent complexity of an organization or team.

Team Ambidexterity consists of two key activities: team exploratory and team exploitation activities. Hammond and Farr (2011) and Rosing et al. (2011) used a dynamic model of workgroup theory for the operationalization of Team Ambidexterity which was proposed earlier by Farr et al. (2003).

Team exploratory is a set of supporting activities to reach creative outcomes during creativity (Rosing et al., 2011). This set of activities includes problem identification, potential solutions, and idea generation to optimize the opportunity. In addition, the team contributes multiple ideas on how to face the problem or opportunity (Girotra et al., 2010) and conceptual combination (Ward, 2004) and transformed into great creativity (Simonton, 2003). Through exploratory activities, teams will improve the success of the creative process during the creativity phase. Team exploitative activities refer to a series of activities facilitating the implementation of ideas during the creative process, which is based on the same dynamic model (Rosing et al., 2011). Therefore, it includes evaluating identified ideas in the creative phase and selecting ideas to be implemented. Evaluating the various ideas may lead to choosing the best idea based on the problem context, the creativity needs, and resource constraints (Hammond and Farr, 2011).

The performance of exploratory and exploitative activities in teams can be accomplished in several ways, namely engaging in paradoxical thinking (Gibson and Birkinshaw, 2004) and switching between exploratory and exploitative activities (Rosing et al., 2011). Previous research has also demonstrated that exploratory and exploitative activities can coincide within a team (Gilson et al., 2005; Kostopoulos and Bozionelos, 2011).

Team Ambidexterity and Team Creativity

Radomska and Wołczek (2020) analyzed 62 previous studies on the relationship between ambidexterity and creativity in an organization. Their finding is as follows: (i) there are four research perspectives on ambidexterity and creativity issue, namely learning process and knowledge acquiring, organizational context, managerial practice, and company's characteristic; (ii) creativity belongs to the managerial practice, which is a dominant perspective compared to the other three perspectives; (iii) to enhance creativity in an organization, we need to facilitate Team Ambidexterity to embrace the right approach.

Enhancing creativity is perceived as a challenge in finding the balance between the two aspects of Ambidexterity (Jones and Casulli, 2014; Radomska and Wołczek, 2020). However, finding this balance requires an ambidexterity-based approach (Lubatkin et al., 2006). Sheremata (2000) mentions the two aspects of Ambidexterity as a centrifugal and centripetal force in an organization. The two forces will foster the organization to act creatively and collectively to develop a new creative product.

Hypothesis 1: Team Ambidexterity gives a positive impact on Team Creativity.

Servant Leadership

Servant Leadership is a specific leadership type with a unique approach initiated by Greenleaf (1970). It is based

upon characteristics such as Listening, Empathy, Persuasion, Conceptualization, Stewardship, Ethics, and an intention to serve others (Autry et al., 2001; Greenleaf, 2002; Blanchard and Hodges, 2003; Fisher, 2004). Larry Spears expands Greenleaf's initiation and highlights Servant Leadership as the new leadership model to serve and prioritize followers' needs (Spears, 1996). Spear's concept of Servant Leadership focuses on the holistic aspects of leadership in the workplace and community. It introduces the principle of power-sharing in decision-making.

Recent research mentions Servant Leadership as holistic and multi-dimensional leadership that covers the leaders' and followers' rational, relational, ethical, emotional, and spiritual aspects (Sendjaya and Cooper, 2011). The comprehensive approach enables leaders to completely address those dimensions that cannot be found in other leadership approaches (Barbuto and Wheeler, 2006; Liden et al., 2008). Sendjaya has three points to explain. First, servant leadership reflects a hearty internal orientation to serve others. Second, it is a follower-centered approach to leadership. Third, it is a holistic approach where leaders emphasize seeking the positive difference of the followers (Sendjaya et al., 2008). Finally, it will create a multi-aspect engagement between leaders and followers, which empowers the followers to grow to their best performance (Eva et al., 2019).

As stated in Eva et al. (2019), Servant Leadership is built on several conceptual frameworks, such as the Power theory (French et al., 1959), Social Exchange Theory (Blau, 1964), Social Learning Theory (Bandura and Walters, 1977), Social Identity Theory (Tajfel, 1978), and Conservation of Resource (Hobfoll, 1989).

Power Theory is a useful theoretical framework to explain the influence of a servant leader (Sikorski, 2016) and describes how leaders exercise their impact on their followers. The theory was established by French et al. (1959) and expanded by Baron-Cohen (1999). Some of the powers are reward, coercive, and legitimate. Reward power is the ability of a leader to give a reward, coercive power is the ability of a leader to punish (Sikorski, 2016), and legitimate power is the ability of a leader to influence subordinates. The Social Exchange Theory (SET; Blau, 1964) explains the relationship between servant leaders and their followers since SET is based on the norm of reciprocity. Social Learning Theory (Bandura and Walters, 1977) explains that leaders are role models in attitude, value, and behavior. Servant leaders are viewed as role models as they act altruistically to serve others (Schwarz et al., 2016). Social Learning Theory describes how the leaders influence the performance of the followers through modeling (Liden et al., 2014) and encourages creativity and innovation for the followers (Newman et al., 2017). Social Identity Theory (Tajfel, 1978) explains why and how servant leaders consider the followers as partners in the organization/team through empowering followers' identification (Chunghtai, 2016), prototyping leader identification (Yoshida et al., 2014), and Team Climate (Chen et al., 2015). These social theories help us understand servant

leaders' behavior that makes them different from other types of leaders.

Servant Leadership can be defined as a holistic leadership approach that influences the follower by focusing more to serve the followers not only for the organization's objective but also on developing the full potential of the followers. Servant leaders do understand that by focusing on the followers there will be an increase in several critical issues such as productivity, teamwork, and customer service.

Servant Leadership and Team Ambidexterity

When leaders stimulate the mind of their followers, this will encourage them to not stay with how things are and think beyond what is comfortable. However, it might also positively change their qualitative creativity and cognitive conflict (De Dreu, 2006).

Ambidexterity follows a non-linear, complex, and complicated process. In balancing this complex interaction, particular leadership behavior is needed. Rosing expanded the concept of ambidexterity of leadership to team creativity (Rosing et al., 2011). Thus, specific leadership behavior is required to manage the ambidexterity process. Bledow et al. (2009) argue that the current leadership style cannot integrate the leadership behavior needed to accommodate the exploitation and exploration process, while Gupta et al. (2004) believe that the most critical leadership feature for creativity is the development of exploration by increasing the variant of each follower's behavior. Moreover, Chang and Hughes (2012) reported that leadership behavior for ambidexterity is marked by the ability to adapt and the courage to take a risk.

Servant leaders are genuinely focused on the development of their followers (Hu and Liden, 2011; Van Dierendonck, 2011), and it displays an altruistic commitment to helping followers to grow. Following the work of Yoshida et al. (2014), where Servant leadership directly influences affect-based trust rather than cognitive-based within the team, and the study of Antonio et al. (2021) on the impact of Servant Leadership on Team Ambidexterity, we hypothesize that:

Hypothesis 2: Servant Leadership behavior gives a positive impact on Team Ambidexterity.

Transformational Leadership

James MacGregor Burns gives a basic understanding of Transformational Leadership as a mutual collaboration between leaders and followers in helping each other to advance to a higher level of morale and motivation for the benefit of the team, organization, or community (Burns, 1978). Bernard M. Bass developed a more comprehensive definition from the psychological mechanism perspective and explained how the transformation process of a follower happens through four

dimensions: individual consideration, intellectual stimulation, inspirational motivation, and idealized influence (Bass and Bass, 2009).

Individualized consideration is the condition where the leader listens to each follower's needs and gives mentoring and coaching. They treat followers as individuals by identifying their different needs, knowing each follower's ability, and respecting their aspirations (Braun et al., 2013). With intellectual stimulation, leaders encourage and motivate their followers through cognitive stimulation. They nurture and develop people to think independently, challenge assumptions, take risks, and solicit followers' ideas. These two dimensions of Transformational Leadership—individual consideration and Intellectual stimulation—stimulate the exploration by enhancing team members' self-esteem, supporting their individual needs, and encouraging them to convey their opinions (Nemanich and Vera, 2009).

Inspirational Motivation is where leaders challenge a higher standard of achievement, share the goals, and pass the optimism to the followers. Dimas et al. (2018) studied how Social Cognitive Theory supports the self-efficacy of the follower led by a transformational leader. The last dimension, Idealized Influence, is where leader exercise their influence as role models to provide for high ethical behavior and gain respect and trust from the followers (Bass and Bass, 2009). They share their knowledge and ideas to facilitate cooperative and efficient working among their followers (Aryee et al., 2012). Inspirational motivation and idealized influence are associated with inclusive and supportive behavior, which makes Transformational Leadership can exploit collective self-construal and self-efficacy (Elenkov and Manev, 2005). Transformational leadership correlates to the critical processes of Ambidexterity in the exploitation and dissemination of the team knowledge and information reservation (Amitay et al., 2006). The exploration and exploitation effects of the four dimensions of Transformational Leadership become the important driver for the exploration and exploitation of a team (Jansen et al., 2006). It will lead to:

Hypothesis 3: Transformational Leadership gives a positive impact on Team Ambidexterity.

With hypotheses 1, 2, and 3, we propose Team Ambidexterity as the mediator between leadership behaviors and Team Creativity.

The mediator role of Team Climate

Team Climate

The climate in a team may be defined as a means where team members derive information about their expected and appropriate role behavior to attain the team

outcomes (Schneider et al., 2013). It examines the team members' perceptions and experiences of embracing the work group's creative endeavors (Hunter et al., 2007). Team Climate will create shared perceptions of team members regarding the team policies, team procedures, and functional interaction in the team (Zohar and Tenne-Gazit, 2008) and construct a creative process where creative behavior leads to creative solutions (Anderson et al., 2014) concerning developing creative sourcing strategy of the team (Kiratli et al., 2015). Liang et al. (2010) studied the significant impact of Team Climate on the team members' perceptions and beliefs.

Further research shows that Team Climate differs between teams because of team-specific differences rather than organization-wide differences (Ashkanasy and Nicholson, 2003; Herman et al., 2008). Furthermore, it shows that the share of perception of effect at the team level is more significant than at the organizational level.

Based on different theoretical frameworks, several Team Climates models have been developed based on several concepts; such as (i) the West model, which is based on the theory of motivation (West, 1990); (ii) the Amabile model, which is rooted in intrinsic motivation theory and focused on the more considerable organizational climate (Amabile and Conti, 1999); (iii) the Ekvall model, which focused on integrating several dimensions of psychological processes theory (Ekvall, 1996) and (iv) the three-dimension model of affiliation, trust, and innovation, which is based on social influence and social behavior stated by Bock et al. (2005).

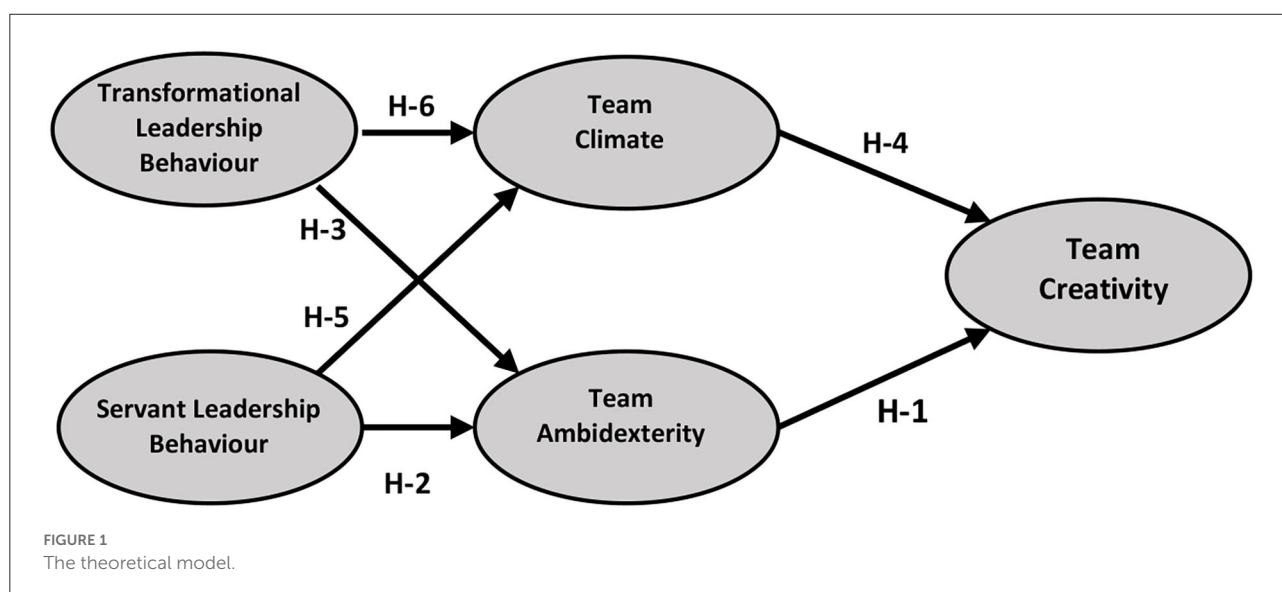
The first four-factor model of Team Climate is proposed by West and Farr (1990) and then expanded by West and Anderson (1996) and improved by Anderson et al. (2014). The four aspects of the four-factor model are vision, participative

safety, task orientation, and support for innovation. Vision is defined as a valued outcome that represents a higher-order goal and a motivation vigor at work. It embodies clarity, visionary nature, attainability, and sharedness. Safety participation reveals the safety of the team member when they are implicated in the decision-making process. It relates to the active involvement of the team member, trustworthiness among members, leader support, and mostly not feeling threatened. The task orientation describes a general commitment to excellence in task performance in connection with the shared vision. Creativity support is the expectation, approval, and support to improve the fresh ideas of doing things at work. The support level may differ among teams (Anderson et al., 2014).

Team Climate and Team Creativity

A Team Climate for creativity accommodates a team's values and norms to emphasize creativity and innovation (West and Anderson, 1996). Creativity climate is considered a method in which the negative effect of work demands on organizational performance may be improved (King et al., 2007). In a supportive situation, team members will be triggered to develop new approaches, explore potential solutions, and attempt to practice new problem-solving activities (Baer and Oldham, 2006). The challenge to the supporting climate will come when the team puts more on efficiency and reliability than the performance outcomes (Hirst et al., 2009). Team Climate is needed to accommodate and influence the relationship between the creative process and company performance (Baer and Frese, 2003).

Hypothesis 4: Team Climate gives a positive impact on Team Creativity.



Team Climate and leadership behavior

The climate in an organization also plays an intervening variable in employee behavior (Patterson et al., 2005). A work unit or team mediates the gap between management and expected outcomes (Anderson et al., 2014). The expected outcome may vary depending on the context and the level difference of the organization (Schneider et al., 2013). Some examples of the outcome are creative performance (Si and Wei, 2012), firm performance (Baer and Frese, 2003), safety (Zohar and Tenne-Gazit, 2008), and innovation (Antonio et al., 2021).

Kinnunen et al. (2016) report a study on the relationship between Leadership and Team Climate. While, Liu et al. (2012) conclude their research that team leaders empowering behavior will increase the Team Climate, Xue et al. (2011) reported that the influence of empowering leadership behavior on extrinsic and extrinsic motivation is not the same. A leader with extrinsic motivation will provide guidance and fair treatment to team members and respect their input for the team's sake. Recent research by Coffeng et al. (2021) mentions that Empowering leadership influences the Team Climate for joint decision-making.

We propose two types of leadership to investigate the impact of leadership behavior on Team Climate, i.e., Servant leadership as a horizontal leadership and transformational leadership as a vertical type of leadership.

Hypothesis 5: Servant Leadership gives a positive impact on Team Climate.

Hypothesis 6: Transformation Leadership gives a positive impact on Team Climate.

With hypotheses 4, 5, and 6, we propose Team Climate as the mediator between leadership behaviors and Team Creativity.

Materials and methods

Research model

We design a theoretical model from the proposed hypotheses as illustrated in Figure 1. It has five variables that make Team Creativity the dependent variable with two mediator variables i.e., Team Ambidexterity and Team Climate, and two of the independent variables are Servant Leadership behavior and Transformational Leadership behavior.

Research method

This study used early start-up teams in Indonesia as the population. The early start-ups in several cities in Indonesia, such as Jakarta, Bandung, and Surabaya, are chosen as the unit of analysis. Thus, different types of start-ups will also be

TABLE 1 Sample profile.

Item	Segment	Frequency	Percentage
Gender	Male	265	61.0
	Female	169	39.0
Age	Student	92	21.2
	Vocational	35	8.1
	Uni grad	289	66.6
	Master's degree	17	3.9
	Doctoral degree	1	0.2
Business	Tourism/culinary	43	29.7
	Personal dev	22	15.2
	Design	16	11.0
	Trading	16	11.0
	Technology	8	5.5

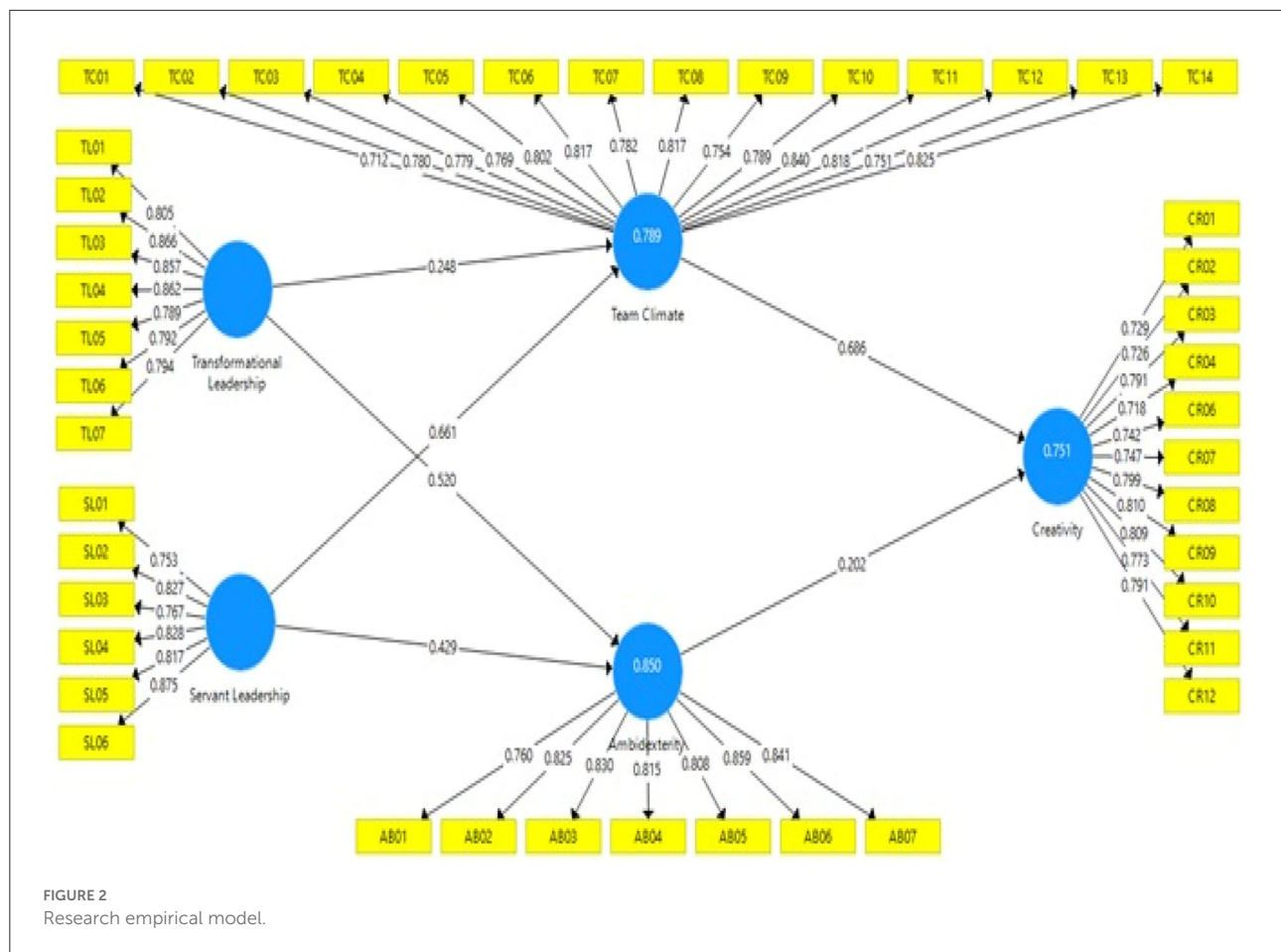
examined, such as government-sponsored, private initiatives, and university-based start-ups. The elected start-ups should have a minimum of 1 year of operation to ensure the team has experienced some innovation journeys during the business activities.

A total of 434 purposive non-probability samples were involved in this research. The samples were then grouped into 145 teams. The member perceptions of the leader are the focus of this study. The measurement instrument is being circulated to the member of the start-up in digital form (Google Forms and email) as a survey questionnaire. The survey questions are translated into Bahasa Indonesia (Indonesian) to make it easier for the respondents. The questionnaire questions are grouped into five categories of variables to avoid common method variance. This empirical study uses quantitative data analysis using version 3.2.9 of the Smart Partial Least Square (PLS) procedure (Hair et al., 2019). The reliability and validity of the outer model are analyzed, while the structural model assessment encompasses the coefficient of determination and the study's hypothesis.

Measurement instrument

Measures of the variables are outlined below. Detailed items of the measurement are given in the Appendix. The measurement uses the scale with five options ranging from 1, "not at all characteristics," to 5, "very characteristic."

Team Creativity is measured using a scale developed by Zhou and George (2001), an updated version of the Scott and Bruce (1994) measurement scale. There are 12 questions in the Zhou measurement scale to accommodate the creativity dimensions. The Servant Leadership scale is the Servant Leadership Behavior Scale (SLBS) which is developed by Sendjaya et al. (2019). There are six questions included in



SLBS. The scale has been used in both Western (Australia) and Eastern (Indonesia) contexts (Sendjaya and Pekerti, 2010; Sendjaya and Cooper, 2011), specifically in business entities. Transformational Leadership behavior is measured using the Multifactor Leadership Questionnaire (MLQ) developed by Avolio and Bass (1995). It has seven questions about the four dimensions of Transformational leadership. Accessing open and closed leadership behavior is the way to measure ambidexterity. The tool to measure was developed by Rosing et al. (2011) and expanded by Zacher and Rosing (2015). The elements include monitoring and controlling goal attainment, controlling adherence to rules, taking corrective action, and paying attention to uniform task accomplishment. They also include diverse ways of finishing a task, encouraging experimentation within, giving room for ideas, and encouraging error in learning. Anderson and West (1996) developed Team Climate Inventory (TCI) based on West's work in 1996. Thus, a shorter version of TCI was developed by Kivimäki and Elovainio with only 14 questions to answer (Kivimäki and Elovainio, 1999). The indicators used are the attitude toward team objectives, which make the member feel understood and accepted. Information is shared within the team,

allowing the team to be open, and they appraise weaknesses to achieve an outcome and give time to develop creative ideas.

Results and data analyses

Table 1 reveals the size and profile of each start-up used as a sample. The demography of the samples is as follows: (i) The members of each start-up range from 1 to 5 people. (ii) The members are below 30 years old and hold an academic degree from graduate diplomas up to doctoral qualifications, which consists of various academic disciplines. (iii) All Start-up has been at least 1 year of operation; only a few have lasted more than 2 years. (iv) Team Start-ups come from several types of business areas, as shown in Table 1.

The result analysis refers to the PLS method by Hair et al. (2019). The reflective measurement model assessment covers the outer and inner evaluation. The evaluation includes convergent validity, discriminant validity, and composite reliability, then discuss the *R*-square, internal consistency reliability assessment, and path analysis.

TABLE 2 Outer loading, AVE, and *t*-statistic.

Variable	Indicator	Outer model	AVE	<i>T</i> -statistics
Ambidexterity	AB01	0.760	0.673	17.008
	AB02	0.825		25.675
	AB03	0.830		26.283
	AB04	0.815		23.560
	AB05	0.808		21.539
	AB06	0.859		33.976
	AB07	0.841		28.031
Creativity	CR01	0.729	0.589	14.583
	CR02	0.726		12.443
	CR03	0.791		20.664
	CR04	0.718		13.863
	CR06	0.742		14.205
	CR07	0.747		16.907
	CR08	0.799		24.573
	CR09	0.810		27.284
	CR10	0.809		20.909
	CR11	0.773		18.807
	CR12	0.791		20.398
Servant Leadership	SL01	0.753	0.660	15.126
	SL02	0.827		24.576
	SL03	0.767		11.286
	SL04	0.828		24.344
	SL05	0.817		23.887
	SL06	0.875		41.531
Team Climate	TC01	0.712	0.622	13.777
	TC02	0.780		18.947
	TC03	0.779		19.025
	TC04	0.769		19.079
	TC05	0.802		20.983
	TC06	0.817		24.737
	TC07	0.782		19.715
	TC08	0.817		24.145
	TC09	0.754		18.265
	TC10	0.789		21.884
	TC11	0.840		28.812
	TC12	0.818		26.556
	TC13	0.751		17.928
	TC14	0.825		28.786
Transformational Leadership	TL01	0.805	0.680	18.222
	TL02	0.866		31.029
	TL03	0.857		26.739
	TL04	0.862		33.913
	TL05	0.789		17.523
	TL06	0.792		22.428
	TL07	0.794		19.627

Convergent validity

The result of the analyses is shown in Figure 2 and Table 2. Figure 2 shows that the value of the loading factor is >0.7 , which means the indicator is valid for measuring its construction. All the average variance extracted (AVE) values displayed in Table 2 are higher than 0.5, which satisfies the requirement of convergent validity.

Discriminant validity

Two kinds of tests are used for Discriminant validity. First is the Fornell-Larcker criteria, where the AVE value must be higher than the R^2 in all other latent variables. The second criteria are the cross-loading indicators which must be a higher correlation with other latent variables than their own. Based on the result in Table 3 (cross-loading) and Table 4 (correlation between variables), both the AVE and the cross-loading meet the criteria. Based on the two tables, it can be concluded that the Discriminant Validity assessment is valid.

Reliability assessment

To evaluate the reliability, we evaluate the value of Cronbach's alpha and the value of composite reliability. Table 5 shows that all Cronbach's alpha is ≥ 0.7 and all Composite Reliability is ≥ 0.7 as well. These results meet the criteria of the Internal Consistent reliability assessment. The constructs are reliable.

Influence of exogenous latent variable assessment

The R^2 is defined as the magnitude of the variability of endogenous variables that able to be explained by exogenous variables. Chin (1998) recommended three classifications of R^2 : the first classification is substantial for $R^2 \geq 0.67$, the second classification is moderate for $R^2 \geq 0.33$ and the last is a weak classification for $R^2 \geq 0.19$. Table 6 shows all variables have >0.67 in R^2 , which belong to the substantial category.

Predictive relevance assessment

The Predictive Relevance assessment is executed by calculating the (Q2) value. The research model considers a relevance prediction for the Q2-value close to 1 (Hair et al., 2019). Using the formulation of Q2 as follows: $Q2 = 1 - (1 - R12) (1 - R22)$, where R12 and R22 are the R-square of the endogen variable (Team Ambidexterity and Team Climate). Substituting the value gives a Q2-value of 88%. The value is more than 0, indicating an excellent exogenous latent variable (corresponding) as an explanatory variable and foreseeing its endogenic variables.

TABLE 3 Cross loading.

Indicator	Ambidexterity	Creativity	Servant Leadership	Team Climate	Transformational Leadership
AB01	0.760	0.598	0.683	0.657	0.641
AB02	0.825	0.646	0.734	0.708	0.718
AB03	0.830	0.641	0.772	0.722	0.790
AB04	0.815	0.670	0.728	0.715	0.791
AB05	0.808	0.655	0.689	0.709	0.683
AB06	0.859	0.700	0.734	0.723	0.758
AB07	0.841	0.665	0.768	0.752	0.776
CR01	0.559	0.729	0.601	0.623	0.577
CR02	0.584	0.726	0.568	0.590	0.573
CR03	0.624	0.791	0.584	0.673	0.570
CR04	0.489	0.718	0.534	0.606	0.565
CR06	0.549	0.742	0.561	0.634	0.579
CR07	0.596	0.747	0.573	0.588	0.570
CR08	0.604	0.799	0.634	0.704	0.598
CR09	0.678	0.810	0.672	0.730	0.678
CR10	0.656	0.809	0.638	0.717	0.662
CR11	0.654	0.773	0.604	0.696	0.648
CR12	0.710	0.791	0.646	0.681	0.644
SL01	0.647	0.547	0.753	0.632	0.616
SL02	0.743	0.712	0.827	0.783	0.748
SL03	0.669	0.571	0.767	0.707	0.692
SL04	0.755	0.625	0.828	0.700	0.722
SL05	0.735	0.664	0.817	0.707	0.739
SL06	0.782	0.694	0.875	0.755	0.802
TC01	0.616	0.623	0.681	0.712	0.603
TC02	0.638	0.672	0.606	0.780	0.599
TC03	0.735	0.624	0.738	0.779	0.672
TC04	0.701	0.714	0.724	0.769	0.699
TC05	0.665	0.672	0.649	0.802	0.613
TC06	0.650	0.661	0.653	0.817	0.623
TC07	0.601	0.693	0.620	0.782	0.589
TC08	0.649	0.663	0.660	0.817	0.635
TC09	0.718	0.595	0.686	0.754	0.662
TC10	0.704	0.695	0.689	0.789	0.677
TC11	0.721	0.722	0.760	0.840	0.718
TC12	0.803	0.741	0.765	0.818	0.750
TC13	0.661	0.694	0.724	0.751	0.649
TC14	0.709	0.715	0.745	0.825	0.704
TL01	0.689	0.613	0.687	0.634	0.805
TL02	0.758	0.692	0.743	0.714	0.866
TL03	0.750	0.650	0.744	0.701	0.857
TL04	0.803	0.696	0.770	0.724	0.862
TL05	0.704	0.619	0.752	0.654	0.789
TL06	0.749	0.599	0.735	0.684	0.792
TL07	0.736	0.691	0.697	0.701	0.794

TABLE 4 The root of AVE and correlation between variables.

Variable	AVE	Root AVE	Correlation between variables				
			Ambidexterity	Creativity	Servant Leadership	Team Climate	Transformational Leadership
Ambidexterity	0.673	0.820	1				
Creativity	0.589	0.767	0.797	1			
Servant Leadership	0.660	0.812	0.890	0.785	1		
Team Climate	0.622	0.788	0.869	0.861	0.881	1	
Transformational Leadership	0.680	0.824	0.901	0.791	0.889	0.835	1

TABLE 5 Cronbach's alpha and composite reliability.

Variable	Cronbach's alpha	Composite reliability
Ambidexterity	0.919	0.935
Creativity	0.930	0.940
Servant Leadership	0.896	0.912
Team Climate	0.953	0.958
Transformational Leadership	0.921	0.937

TABLE 6 The *R*-square.

	<i>R</i> -square
Ambidexterity	0.850
Creativity	0.751
Servant Leadership	0.789

Hypothesis evaluation

The performance of the inner model is assessed using bootstrap resampling procedures. A bootstrap resampling procedure can evaluate it. The result is tabulated in [Tables 7, 8](#). As shown in the table, the *T*-statistics value (higher than 1.96) and the *p*-value (<0.05) mean that all the indicator variables used are significant and all hypotheses are supported.

To summarize the structural model assessment, it shows that the value of R^2 , predictive relevance, and the relationship between variables are satisfactory since both the outer and inner model meets the standard. The assessment also shows that all hypothesis is supported.

Mediation analysis

[Zhao et al. \(2010\)](#) presented a conceptual method of mediation analysis that is echoed by other researchers ([Nitzl et al., 2016](#); [Hair et al., 2017](#); [Memon et al., 2018](#)). Zhao et al. proposed five mediation kinds: (i) Direct-only mediation, (ii) No-effect mediation, (iii) Indirect-only mediation, (iv)

Competitive mediation, and (v) Complementary mediation. The concept is plotted into a flowchart in [Figure 3](#). The *p*-value among the mediator variable in [Figure 2](#) can be summarized in [Table 9](#). Substituting these significant *p*-values to the flowchart will give us the result that both mediator variables are partial complementary mediation.

Discussion

This study aims to give a systematic, evidence-based mediation effect between leadership behaviors and Team Creativity in Team Start-ups. The mediation analyses support the fact that the mediation effect of the two mediators is partial complementary mediation which means that the mediation effect exists with the direct effect pointing in the same direction ([Zhou and Shalley, 2010](#)).

The mediating role of Team Climate and Team Ambidexterity

Both mediators have a direct effect on Team creativity and mediate leadership behaviors. The mediator role of Team Climate is significant while the impact of Team Ambidexterity is considered weak. Early research reports that Climate only moderates creativity ([Eisenbeiss et al., 2008](#)) and impacts creativity on the personal level ([Xue et al., 2011](#); [Xu et al., 2019](#)). Our finding confirms that Team Climate is a good mediator and impacts the creativity of the team. The correlation value between Team Climate and Team Creativity indicates that Team Climate influences Team Creativity more than Team Ambidexterity. Servant Leadership is also an excellent antecedent to Team Climate compared to Transformational Leadership, with a correlation value of 0.661. The result leads to the point that Team Climate is a good mediator between Servant Leadership and Team Creativity.

Our study reveals that the impact of Team Climate is three times higher compared to Team Ambidexterity. While earlier

TABLE 7 Outer loading and *t*-statistic.

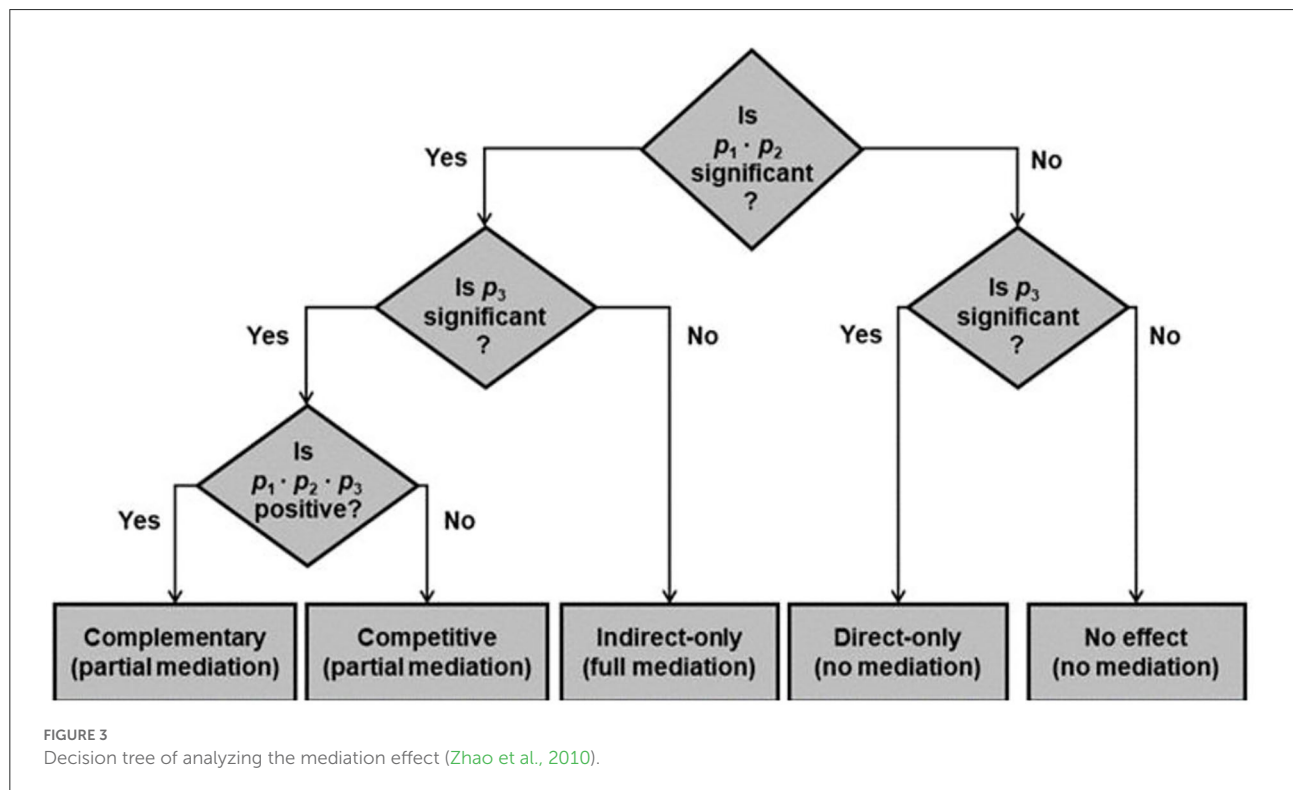
	Original sample (O)	Sample mean (M)	Standard dev (STDEV)	T-statistics (O/STDEV)	P-values
AB01 <- Ambidexterity	0.760	0.756	0.046	16.375	0.000
AB02 <- Ambidexterity	0.825	0.820	0.033	24.650	0.000
AB03 <- Ambidexterity	0.830	0.828	0.032	26.184	0.000
AB04 <- Ambidexterity	0.815	0.812	0.035	23.159	0.000
AB05 <- Ambidexterity	0.808	0.806	0.040	20.450	0.000
AB06 <- Ambidexterity	0.859	0.856	0.027	31.391	0.000
AB07 <- Ambidexterity	0.841	0.841	0.032	26.453	0.000
CR01 <- Creativity	0.729	0.724	0.048	15.277	0.000
CR02 <- Creativity	0.726	0.718	0.056	12.889	0.000
CR03 <- Creativity	0.791	0.787	0.039	20.251	0.000
CR04 <- Creativity	0.718	0.716	0.049	14.605	0.000
CR06 <- Creativity	0.742	0.736	0.054	13.660	0.000
CR07 <- Creativity	0.747	0.746	0.043	17.329	0.000
CR08 <- Creativity	0.799	0.800	0.034	23.707	0.000
CR09 <- Creativity	0.810	0.812	0.029	28.324	0.000
CR10 <- Creativity	0.809	0.808	0.038	21.380	0.000
CR11 <- Creativity	0.773	0.770	0.044	17.569	0.000
CR12 <- Creativity	0.791	0.790	0.040	19.955	0.000
SL01 <- Servant Leadership	0.753	0.746	0.054	13.940	0.000
SL02 <- Servant Leadership	0.827	0.825	0.039	21.147	0.000
SL03 <- Servant Leadership	0.767	0.764	0.072	10.700	0.000
SL04 <- Servant Leadership	0.828	0.832	0.033	25.112	0.000
SL05 <- Servant Leadership	0.817	0.819	0.033	25.118	0.000
SL06 <- Servant Leadership	0.875	0.874	0.023	38.881	0.000
TC01 <- Team Climate	0.712	0.708	0.050	14.161	0.000
TC02 <- Team Climate	0.780	0.775	0.043	18.059	0.000
TC03 <- Team Climate	0.779	0.778	0.038	20.618	0.000
TC04 <- Team Climate	0.769	0.766	0.039	19.682	0.000
TC05 <- Team Climate	0.802	0.798	0.037	21.761	0.000
TC06 <- Team Climate	0.817	0.814	0.035	23.452	0.000
TC07 <- Team Climate	0.782	0.778	0.038	20.834	0.000
TC08 <- Team Climate	0.817	0.815	0.035	23.281	0.000
TC09 <- Team Climate	0.754	0.751	0.043	17.406	0.000
TC10 <- Team Climate	0.789	0.784	0.037	21.252	0.000
TC11 <- Team Climate	0.840	0.839	0.031	27.070	0.000
TC12 <- Team Climate	0.818	0.817	0.032	25.340	0.000
TC13 <- Team Climate	0.751	0.747	0.045	16.808	0.000
TC14 <- Team Climate	0.825	0.824	0.030	27.569	0.000
TL01 <- Transformational Leadership	0.805	0.799	0.049	16.501	0.000
TL02 <- Transformational Leadership	0.866	0.864	0.029	29.830	0.000
TL03 <- Transformational Leadership	0.857	0.856	0.030	28.190	0.000
TL04 <- Transformational Leadership	0.862	0.860	0.026	33.702	0.000
TL05 <- Transformational Leadership	0.789	0.786	0.048	16.291	0.000
TL06 <- Transformational Leadership	0.792	0.792	0.038	21.079	0.000
TL07 <- Transformational Leadership	0.794	0.790	0.039	20.250	0.000

TABLE 8 Path coefficient and *t*-statistic.

	Original sample (O)	Sample mean (M)	Standard dev (STDEV)	<i>T</i> -statistics (O/STDEV)	<i>P</i> -values
Team Ambidexterity—Team Creativity	0.202	0.212	0.106	1.896	0.059*
Servant Leadership—Team Ambidexterity	0.429	0.429	0.095	4.527	0.000**
Servant Leadership—Team Climate	0.661	0.679	0.107	6.204	0.000**
Team Climate—Team Creativity	0.686	0.676	0.102	6.722	0.000**
Transformational Leadership -> Team Ambidexterity	0.520	0.518	0.093	5.607	0.000**
Transformational Leadership -> Team Climate	0.248	0.230	0.114	2.164	0.031**

(*) indicates the *p* value of 0.059 which is higher than 0.05 (accuracy 94.1%, lower than 95%).

(**) indicates the *p* value 0.000 (accuracy higher than 95 %).

TABLE 9 *p*-value among variables.

	Code	Value	Significant
Team Ambidexterity—Team Creativity	p_1	0.202	Significant
Servant Leadership behavior—Team Ambidexterity	p_2	0.429	Significant
Transformational Leadership—Team Ambidexterity	p_3	0.520	Significant
Team Climate—Team Creativity	p_4	0.686	Significant
Servant Leadership behavior—Team Climate	p_5	0.661	Significant
Transformational Leadership—Team Climate	p_6	0.248	Significant

studies by Jacob et al. (2015) and Antonio et al. (2020) show that Ambidexterity is a good antecedent to creativity in a team, our finding expands the idea that as the mediator, Team Ambidexterity gives a weak impact.

Leadership behavior and Team Creativity

Leaders should stimulate their follower's creativity (Bledow et al., 2009), but the mechanism of the simulation process still

needs more exploration. Our study tries to answer the question that [Burke et al. \(2006\)](#) asked on the leadership behavior that can function well in a team. The study shows that both Transformational Leadership behavior and Servant Leadership behavior can function well in teams with proper mediators. Our finding echoes the work of [Cengiz Ucar et al. \(2021\)](#), who report that Servant Leadership and Transformational Leadership directly affect team member creativity. The correlation between the research variables shows that Servant Leadership is a better antecedent to Team Climate and Team Creativity. At the same time, Transformational Leadership is better for Team Ambidexterity which opens a question on the different leadership behavior between vertical and horizontal leadership styles.

Theoretical contribution

This study extends the leadership theory and the ambidexterity theory in the context of a start-up team. The two leadership styles, Transformational Leadership and Servant Leadership which are mostly applied in the organizational or company context can be implemented in the Team Start-up context. This extension is important for the leadership theory because it underlies the role of leadership in a start-up team. Servant Leadership which has more shared authority among the member give more impact on Team Creativity compared to the vertical approach of Transformational Leadership. Both leadership approaches work well in Indonesian culture.

The other theory contribution is the role of Servant Leadership as the antecedent to Ambidexterity. This combination of motivational-based and process-based leadership give a higher impact on team creativity or team performance at large. Servant Leadership is also a good antecedent to Team Climate (behavioral-based theory of West) which in turn influences creativity.

The extent of ambidexterity theory shows that the exploration and exploitation processes give less impact on the team creativity compared to the two leadership approaches. It indicates that early Team Start-ups need a more guided or motivational leadership style rather than process based. Combining different streams of research advances our understanding of the relationship between leadership, processes, and creativity.

Practical implications

Since the research shows that Team Climate is a good mediator of leadership behavior on Team Creativity. Intentionally, all start-ups need to build a conducive atmosphere in their working space. A right climate is unavoidable if we want to keep the team's performance high.

A warm and pleasant ambiance in the workplace is not enough without an intentional plan to provide psychologically

friendly interaction and a good atmosphere to practice exploration and exploitation of ambidextrous leadership. It is our homework as leaders to create a good climate and provide ambidextrous friendly circumstances for every start-up team.

The result of the study leads to an understanding of important aspects of keeping good team performance in a start-up team. A comprehensive approach is needed to equip team leaders with suitable behavior for Team Start-ups. A research-based leadership training module can be developed not only for capacity building but for fostering creativity among business people and professionals since most training modules do not have deep theoretical and empirical roots.

Research limitation

In terms of area of study, this research has limitations. First, it focuses on the start-up teams in several big cities in Indonesia, such as Surabaya, Jakarta, and Bandung. Various cities in Indonesia or other countries may give different results due to the cultural context. The other limitation is the type of start-up business. This study only covers seven types of business such as tourism (including culinary business), personal development, fashion, design and marketing, trading, technology-based, and social entrepreneurship with the same treatment. We believe that Team Start-ups with other business types will differ in response to leadership behavior. This study exercises how Team Creativity emerges in the team context without external interruption such as investor intervention, although we believe that investors can be the final decision maker in creativity.

Recommendation for further research

This study leaves a lot of room for further research in the field of the team aspect and its derivatives such as team anxiety, team culture, and team resilience. In the era of millennial workers, the issue of the team is important. While millennials are often considered individualistic, they can become good team players eventually. Furthermore, this study opens the door for Indonesian and other countries' ethnic and cultural leadership studies. A study of team leadership aspects in multigroup, longitudinal, and experimental research based on geographical, gender, technology, and team composition is recommended. The research methodology may be extended to longitudinal and experimental both randomized and non-randomized subject research is needed as further research on leadership behavior and its influence on innovation and creativity ([Uy et al., 2021](#)).

Conclusions

This study begins with a single question what are the mediators for a team leader to foster Team Creativity

in Team Start-up? Starting with a theoretical study of previous research in leadership behaviors and start-ups, we propose two types of leadership, Transformational Leadership and Servant Leadership, and two potential mediators, Team Ambidexterity and Team Climate. The sum of evidence presented in the data analyses confirms that Team Ambidexterity and Team Climate are good moderators for Team Creativity.

This simple question has far-reaching implications for articulating leadership theory and its application in Team Start-ups. Good team leaders are imperative for Team Start-ups to maintain their performance through creativity. Both vertical leadership and horizontal leadership types play a significant role in embracing the creativity and innovation process in start-ups. Team leaders should equip themselves to keep the performance of the team. A start-up's success depends not only on the team but also on the team leader.

We believe that the mediator's role is significant to keep the start-up's performance well. Our mediation analysis shows that building a better Team Climate will enhance the team member to be more creative. Work climate in the young generation is more important than other aspects in the co-working space. Creating a warm and conducive environment in a start-up team is unavoidable to keep the business running. Second, to Team Climate, Team Ambidexterity is good to empower the team member with creativity. Therefore, the combination of the exploration and exploitation process is necessary to optimize all team members' competence and talent.

The growing start-up business shifts the leadership struggle from a big organization to a smaller team context. A deeper understanding of team leadership and its mediator and the moderator is essential for theoretical and practical start-up development.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

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Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

TA initiates the research model before it is discussed and improved by all authors and provides the initial study of the theoretical background. AI and LP responsible for the sample collection. All authors did the data analysis and the discussion and conclusion of the research. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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