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Digital intelligence technology and curriculum ideology in sports colleges: the mediating roles of teaching effectiveness and student engagement

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Introduction: This study explores the role of digital intelligence technology (DIT) in indirectly enhancing curriculum ideological effectiveness in sports colleges through improvements in teaching effectiveness and student engagement. The research provides insights into how technology integration can influence ideological and political education outcomes.

Methods: A nationwide sample of 804 faculty and student respondents was analyzed using a chain mediation model grounded in the Technology Acceptance Model, Self-Determination Theory, and Educational Ecosystem Theory. Structural Equation Modeling (SEM) was applied to examine the relationships between DIT, teaching effectiveness, student engagement, and curriculum ideology outcomes.

Results: The findings reveal that DIT significantly enhances teaching effectiveness and student engagement, which sequentially contribute to improved curriculum ideology outcomes. Student engagement accounted for a greater proportion of variance compared to teaching effectiveness, emphasizing the critical role of interactive learning in ideological and political education.

Discussion: This study introduces a novel chain mediation pathway—DIT → Teaching Effectiveness → Student Engagement → Curriculum Ideology—highlighting the synergistic relationship between teaching quality and learner participation. The findings provide theoretical contributions to understanding technology integration in sports education and practical recommendations for professional development and interactive classroom practices to optimize the impact of DIT.

KEYWORDS

chain mediation, curriculum ideology, digital intelligence, student engagement, teaching effectiveness

1 Introduction

1.1 Known content

The dual processes of globalization and digitalization have profoundly influenced contemporary education, prompting extensive efforts to integrate digital intelligence technology into teaching and learning. National policy directives emphasize that building a robust education system is essential for the rejuvenation of the Chinese nation, designating digital intelligence technology as a critical driver in modernizing higher education and achieving national educational goals (Gautam et al., 2024; Gauttam et al., 2021). In the domain of sports colleges and universities, digital intelligence technology not only transforms traditional classroom teaching models but also provides substantial technical support for embedding socialist core values into curricula. This is especially relevant for curriculum ideology and politics, where enhancing students' ideological and political awareness and literacy remains a central objective (Luo, 2024). Existing literature acknowledges the direct impact of digital intelligence technology on outcomes such as teaching quality and engagement, yet the interconnections among these factors are not fully understood (Chen et al., 2020; Kohnke et al., 2023).

1.2 Unknown content

Despite an emerging consensus on the importance of digital intelligence technology in educational reform, there is limited exploration of its multi-level mediating mechanisms, particularly within sports colleges. Most prior research investigates isolated effects—for example, focusing on teaching quality or student engagement—while overlooking how technology might simultaneously affect multiple dimensions of curricular effectiveness in complex educational environments (Burns et al., 2015; Deci and Ryan, 2012; Cropanzano and Mitchell, 2005; Davis et al., 1989). This gap underscores the need for a more holistic investigation that explores how digital intelligence technology indirectly shapes curriculum ideology through potential intermediaries.

1.3 Latest technology

With ongoing educational digitalization, digital intelligence technology—encompassing real-time data analytics, adaptive learning systems, and intelligent tutoring—holds considerable promise for driving educational equity and quality (Ng et al., 2023). According to the Technology Acceptance Model (TAM), users' perceptions of usefulness and ease of use significantly influence technology adoption (Abulibdeh et al., 2024). Concurrently, Self-Determination Theory (SDT) posits that technologies fostering autonomy, competence, and relatedness can bolster intrinsic motivation and engagement (Chiu et al., 2023; Cropanzano et al., 2017). Furthermore, within an Educational Ecosystem Theory framework, digital intelligence technology reallocates resources and reshapes learning conditions, potentially optimizing the broader educational environment (Liu et al., 2021). Nonetheless, how such technologies can be harnessed to enhance curriculum ideology in sports colleges remains underexamined.

1.4 Novelty

To address this gap, the present study constructs a chain mediation model—"Digital Intelligence Technology → Teaching Effectiveness → Student Engagement → Curriculum Civics Effectiveness." Grounded in TAM, SDT, and Educational Ecosystem Theory, this model aims to illuminate the pathways through which digital intelligence technology indirectly influences curriculum ideology. By integrating these theoretical perspectives, we provide a comprehensive examination of technology's effect on teaching effectiveness and student engagement, both of which are crucial for fulfilling curriculum ideology goals.

Although this study focuses on sports colleges, the chain mediation model of "Digital Intelligence Technology—Teaching Efficacy—Student Engagement—Ideological and Political Education Effectiveness" provides valuable reference points for other types of higher education institutions and broader sociocultural contexts. Educational policies, student characteristics, and teacher-student interaction patterns across different disciplines, regions, or countries may influence the implementation and effectiveness of digital intelligence technology in ideological and political education (IPE). Future research could extend this study by conducting validation tests in comprehensive universities, vocational colleges, or international institutions, further examining the applicability of these findings in interdisciplinary and cross-cultural contexts.

1.5 Research contribution

From a theoretical standpoint, this study enriches the existing literature by proposing and empirically validating a multi-level mediation model. Specifically, it extends the discussion on how perceived usefulness, teaching efficacy, and student motivation interact within the broader context of ideological and political education. Practically, the findings are especially relevant for sports colleges and universities committed to cultivating holistic student development under the strategic imperatives of "Sports Power" and "Healthy China" (Dong et al., 2020). The research offers evidence-based insights into the differentiated perceptions and strategies of teachers and students when employing digital intelligence technology, thereby informing targeted policy recommendations and instructional practices.

Based on the above considerations, this study aims to answer the following question: How does digital intelligence technology, through the mediating roles of teaching effectiveness and student engagement, impact the overall effectiveness of curriculum ideology in sports colleges and universities?

2 Research hypotheses

To systematically explore the pathways and mechanisms through which digital intelligence technology impacts the effectiveness of curriculum civics in sports colleges, this study integrates the Technology Acceptance Model (TAM), Self-Determination Theory (SDT), Social Exchange Theory (SET), and Educational Ecosystem Theory (EET) to formulate the following hypotheses:

> *H1*: The use of digital intelligence technology has a significant and direct positive effect on the effectiveness of curriculum civics (Pedro et al., 2019).
>
> *H2*: Teaching effectiveness mediates the relationship between the use of digital intelligence technology and the effectiveness of curriculum civics (Rangel-de Lázaro and Duart, 2023). According to the theory of educational efficacy, teaching effectiveness is a key indicator of overall curriculum effectiveness and the quality of instruction. Digital intelligence technology enhances teaching effectiveness by supporting personalized learning, providing real-time feedback, and enabling data-driven instructional design. Enhanced teaching effectiveness not only improves students' comprehension and application of knowledge but also positively influences their engagement and satisfaction in curriculum civics. Consequently, the following sub-hypotheses are proposed:
>
> *H2a*: The use of digital intelligence technology significantly and positively predicts teaching effectiveness. *H2b*: Teaching

effectiveness significantly and positively predicts the effectiveness of curriculum civics. *H2c*: Teaching effectiveness mediates the relationship between the use of digital intelligence technology and the effectiveness of curriculum civics.

H3: Student engagement mediates the relationship between the use of digital intelligence technology and the effectiveness of curriculum civics (Tschannen-Moran et al., 1998). According to SDT, when learners experience a sense of autonomy, competence, and relatedness, their intrinsic motivation to learn is significantly enhanced. Digital intelligence technology enriches students' learning experiences and classroom engagement through diverse interactive tools and immersive teaching scenarios, thereby indirectly improving the effectiveness of curriculum civics. Thus, the following sub-hypotheses are proposed:

H3a: The use of digital intelligence technology significantly and positively predicts student engagement. *H3b*: Student engagement significantly and positively predicts the effectiveness of curriculum civics. *H3c*: Student engagement mediates the relationship between the use of digital intelligence technology and the effectiveness of curriculum civics.

H4: Teaching effectiveness and student engagement form a chain mediation effect between the use of digital intelligence technology and the effectiveness of curriculum civics (Ndukwe and Daniel, 2020). Grounded in the theories of educational ecosystems and social learning, teaching effectiveness and student engagement are interlinked, often exhibiting a synergistic effect in enhancing both educational quality and curriculum outcomes. Digital intelligence technology enhances students' motivation and classroom outcomes by increasing the interactivity and engagement of instructional practices, thereby influencing the effectiveness of curriculum civics. Therefore, the following sub-hypotheses are proposed:

H4a: Teaching effectiveness significantly and positively predicts student engagement. *H4b*: Teaching effectiveness and student engagement form a chain mediation pathway between the use of digital intelligence technology and the effectiveness of curriculum civics.

H5: There are significant differences in the use of digital intelligence technology and its impact on curriculum civics among teachers with different gender, age, and teaching experience (Pace and Hemmings, 2007). Demographic factors such as gender, age, and years of teaching experience are known to significantly influence educators' acceptance and application of technology in the classroom. Differences in these variables may affect teachers' perceptions of digital intelligence technology and their efficacy in implementing curriculum civics, thereby shaping the outcomes of curriculum civics. Consequently, the following sub-hypotheses are proposed:

H5a: There is a significant difference between male and female teachers in the impact pathway of digital intelligence technology on the effectiveness of curriculum civics. *H5b*: There is a significant difference between teachers of different age groups in the impact pathway of digital intelligence technology on the effectiveness of curriculum civics. *H5c*: There is a significant difference between teachers with varying years of teaching experience in the impact pathway of digital intelligence technology on the effectiveness of curriculum civics.

2.1 Theoretical support for the research hypothesis model

The theoretical foundation of the proposed research hypotheses is anchored in the following frameworks:

A Technology Acceptance Model (TAM): This model posits that the perceived usefulness and perceived ease of use of digital intelligence technology significantly enhance teaching effectiveness and student engagement, thereby directly or indirectly impacting the effectiveness of curriculum civics.
B Self-Determination Theory (SDT): SDT explains that digital technologies can boost learning motivation and curriculum engagement by satisfying learners' psychological needs for autonomy, competence, and relatedness, ultimately affecting the effectiveness of curriculum civics.
C Social Exchange Theory (SET): SET analyzes how the cost–benefit considerations of teachers and students in using digital intelligence technology influence their participation and engagement in curriculum civics.
D Educational Ecosystem Theory (EET): EET suggests that, as a critical component of the modern educational ecosystem, digital intelligence technology optimizes resource allocation and the classroom environment, thereby indirectly enhancing the effectiveness of curriculum civics.

Figure 1 presents a simplified schematic of the proposed research model, illustrating the graphical representation of the relationships among the variables. In the path model, each pathway will be evaluated using standardized coefficients (e.g., β values) and corresponding significance levels (e.g., p-values) to test the proposed hypotheses. The path relationships will be analyzed and validated using Structural Equation Modeling (SEM) alongside a mediation effect analysis framework (Hayes Model 6). Chained mediation effects will be further examined to comprehensively assess the interconnected pathways and their indirect effects.

2.2 Implementation and validation of research hypotheses

In the empirical analysis, the research hypotheses will first be validated by evaluating path coefficients and model fit using Structural

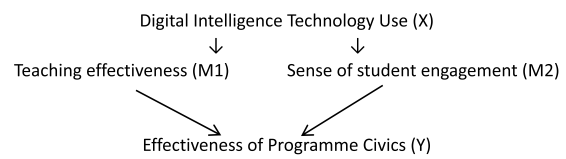

FIGURE 1
Schematic representation of the research model.

Equation Modeling (SEM). Next, the Bootstrap method, with 5,000 repeated samples, will be employed to assess the significance of the mediating and moderating effects along each hypothesized pathway. This approach ensures robust validation of the proposed relationships.

The hypothesis design and validation in this study aim to comprehensively elucidate the pathways through which digital intelligence technology influences the implementation of curriculum ideology in sports colleges and universities, providing a scientific foundation and practical guidance for its deeper integration into educational contexts.

3 Research methodology

3.1 Literature review

In the literature review phase, this study extensively collected and analyzed relevant research findings from both domestic and international sources to ensure a comprehensive academic perspective and robust theoretical foundation. Specifically, domestic databases such as China National Knowledge Infrastructure (CNKI), Wanfang Data, and VIP (Weipu) were utilized in conjunction with international academic databases like Web of Science and Scopus. Key terms such as "digital intelligence technology," "curriculum civics effectiveness," "teaching effectiveness," "teaching and learning effectiveness," and "student engagement" were systematically searched and screened. By synthesizing the latest research on educational technology and ideological and political education, the study clarified the conceptual definitions and measurement dimensions of core variables, ensuring the theoretical rigor and reliability of the subsequent data analyses. This research not only focuses on the specific educational practices of Chinese sports colleges and universities but also broadens the global perspective by integrating findings from international studies on the application of digital intelligence technology in curriculum civics, thus providing a solid theoretical foundation and a broad academic context for the study.

During the literature search, the keyword combinations used for domestic sources included ("Digital Intelligence Technology" AND "Curriculum Civics") AND ("Teaching Effectiveness" OR "Student Engagement"), while the combinations for international sources were ("Digital Intelligence Technology" AND "Ideological and Political Education") AND ("Teaching Effectiveness" OR "Student Engagement"). The search timeframe was limited to the last 5 years to ensure the inclusion of up-to-date and cutting-edge research.

3.2 Questionnaire method

Measurement tools widely used in international educational research were employed in this study, including the "Digital Intelligence Technology Acceptance Scale" (based on the TAM model), the "Teaching Effectiveness Scale," the "Student Engagement Scale," and the "Curriculum Civics Effectiveness Scale." Each of these scales was adapted to fit the context of Chinese educational practices while maintaining alignment with widely accepted international measurement standards to ensure their applicability and reliability across different cultural contexts. All scales were rated on a five-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The specific measurement tools include:

A Digital Intelligence Technology Acceptance Scale: This scale, grounded in the Technology Acceptance Model (TAM), measures teachers' and students' perceived usefulness (PU) and perceived ease of use (PEOU) of digital intelligence technology, assessing their attitudes and behavioral intentions toward integrating digital intelligence technology into teaching and learning practices (Ma and Liu, 2005).

B Teaching Effectiveness Scale: This instrument evaluates the effectiveness of teachers in the instructional process, covering dimensions such as classroom management, student feedback, and learning outcomes (Jani et al., 2018).

C Student Engagement Scale: This scale primarily measures students' classroom interaction and participation, encompassing dimensions such as learning motivation and collaborative learning (Zhoc et al., 2019).

D Curriculum Civics Effectiveness Scale: Based on an ideological and political literacy scale developed by Chinese scholars, this instrument assesses students' improvements in ideological and political literacy and changes in their values. Although not widely used in international contexts, the scale has been validated through numerous empirical studies, demonstrating strong reliability and validity in reflecting the impact of curriculum civics (Chen and Hu, 2024).

3.2.1 Questionnaire distribution and response rate

A convenience sampling method was employed to distribute questionnaires to teachers and students in several physical education colleges across the country. A total of 1,000 questionnaires were distributed, of which 804 valid responses were collected, yielding a response rate of 80.4%. This sampling approach not only targets faculty and students in Chinese sports colleges but also captures the diversity of educational backgrounds, ensuring broad applicability of the study's findings.

3.2.2 Reliability and validity testing

The reliability of the Digital Intelligence Technology Acceptance Scale, Teaching Effectiveness Scale, Student Engagement Scale, and Curriculum Civics Effectiveness Scale was assessed using SPSS 23.0. The internal consistency of each scale was measured using Cronbach's alpha coefficient. Generally, a Cronbach's alpha below 0.6 indicates low reliability, necessitating further adjustments; a value between 0.6 and 0.7 suggests acceptable reliability; a value between 0.7 and 0.8 indicates good reliability; and a value exceeding 0.8 signifies very high reliability. As shown in Tables 1–3, the Cronbach's alpha coefficients for the Digital Intelligence Technology Acceptance Scale, Teaching Effectiveness Scale, Student Engagement Scale, and Curriculum Civics Effectiveness Scale were all above 0.9, indicating excellent reliability for all instruments.

TABLE 1 Statistical Results of Reliability Analysis.

Scale	Cronbach's alpha	Number of items
Digital intelligence technology acceptance	0.640	6
Teachers' teaching effectiveness	0.870	8
Students' classroom engagement	0.890	7
Curriculum civics effectiveness	0.900	9

TABLE 2 Numeracy acceptance scale.

KMO sampling suitability measure		0.85
Bartlett's test of sphericity	Approximate chi-square	640.33
	Degrees of freedom	36
	Significance	0.000

TABLE 3 Teacher teaching effectiveness scale.

KMO sampling suitability measure		0.87
Bartlett's test of sphericity	Approximate chi-square	720.50
	Degrees of freedom	45
	Significance	0.000

TABLE 4 Student sense of classroom engagement scale.

KMO sampling suitability measure.		0.89
Bartlett's test of sphericity	Approximate chi-square	805.24
	Degrees of freedom	55
	Significance	0.000

TABLE 5 Curriculum civics effectiveness scale.

KMO sampling suitability measure.		0.90
Bartlett's test of sphericity	Approximate chi-square	900.60
	Degrees of freedom	60
	Significance	0.000

This study primarily collected data through self-reported questionnaires from teachers and students. While measures such as anonymous responses and ensuring independent completion were implemented during the questionnaire design and survey process to minimize common method bias and social desirability bias, it is difficult to entirely eliminate the influence of self-perception bias. Future research could address this limitation by incorporating more objective performance indicators or behavioral data (e.g., online learning platform logs, classroom interaction records, or student academic performance). Additionally, employing qualitative methods such as interviews and observations for triangulation could further enhance the robustness of the study's conclusions.

For validity testing, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used to evaluate the adequacy of the sample data. A KMO value greater than 0.6 indicates that the scale is suitable for factor analysis, while a significant Bartlett's test ($p < 0.05$) suggests sufficient correlation among the variables, confirming the appropriateness of the data for further analysis. The results of the reliability and validity tests are presented in Table 1.

Typically, a KMO value above 0.6 indicates that the scale is suitable for validity testing. The results of the validity analysis in Table 2 ("Digital Intelligence Technology Acceptance Scale"), Table 3 ("Teachers' Teaching Effectiveness Scale"), Table 4 ("Students' Classroom Engagement Scale"), and Table 5 ("Curriculum Civics Effectiveness Scale") show that the KMO values for all four scales are above 0.9, with a significance level of $p = 0.000$, indicating excellent validity and suitability for factor analysis. This suggests that the scales possess strong structural validity and are highly reliable for the intended measurement.

The results of the KMO and Bartlett's sphericity tests, as presented in Tables 2–5, demonstrate that all scales exhibit KMO values exceeding 0.9, with a significance level of 0.000. These results indicate excellent sampling adequacy and confirm that the scales possess strong construct validity, making them highly suitable for subsequent factor analysis.

3.3 Statistical methods

The statistical analyses were conducted using SPSS 23.0 for reliability testing, descriptive statistics, common method bias testing, analysis of variance (ANOVA), and correlation analysis. AMOS 24.0 was employed for confirmatory factor analysis, and the assessment of chain mediation effects was performed using PROCESS 4.1 for SPSS. All analytical procedures adhered to rigorous academic standards to ensure the robustness, validity, and reproducibility of the findings.

4 Findings and analyses

4.1 Descriptive statistical analysis

Based on the analysis of 804 valid responses, the demographic distribution of participants by gender, age, and status is presented in Table 6, providing a comprehensive overview of the sample characteristics.

4.2 Descriptive analysis

4.2.1 Gender distribution

As shown in Table 6, the sample comprised 466 males (57.96%) and 338 females (42.04%), indicating a slightly higher representation of males compared to females. This gender distribution aligns with the general characteristics of the gender ratio observed among teachers and students in domestic higher education institutions. Such a balanced gender ratio provides a solid foundation for subsequent research and analysis, ensuring the reliability of the findings.

4.2.2 Age distribution

The age distribution of the sample reveals that 352 respondents (43.78%) were aged 18–25 years, 279 respondents (34.7%) were in the 26–35 age group, 125 respondents (15.55%) were aged 36–45 years, and 48 respondents (5.97%) were over 45 years old. The majority of respondents fall within the 18–25 and 26–35 age groups, accounting for 43.78 and 34.7% of the total sample, respectively. This reflects the demographic characteristics of sports colleges, where the student and young faculty populations are predominant. In contrast, the proportion of respondents aged over 45 is relatively small (5.97%), consistent with the age profile of professionals in sports-related disciplines.

4.2.3 Status distribution

Regarding respondent status, the survey included 456 students (56.72%) and 348 teachers (43.28%). While the number of students slightly exceeds that of teachers, this distribution ensures a balanced

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TABLE 6 Demographic characteristics of respondents from sports institutions.

Category	Frequency	Percentage	Valid percentage	Cumulative percentage
Gender: Male	466	57.96%	57.96%	57.96%
Gender: Female	338	42.04%	42.04%	100.00%
Age: 18–25 years	352	43.78%	43.78%	43.78%
Age: 26–35 years	279	34.7%	34.7%	78.48%
Age: 36–45 years	125	15.55%	15.55%	94.03%
Over 45 years	48	5.97%	5.97%	100.00%
Status: Student	456	56.72%	56.72%	56.72%
Status: Teacher	348	43.28%	43.28%	100.00%

representation of perspectives from both groups. Such a composition is crucial for capturing the nuances of digital intelligence technology applications in curriculum ideological and political education (Civics), thereby enabling comprehensive insights into the differential impacts on students and faculty.

4.3 Common method bias test

Given that data were collected using a self-reported questionnaire, the study implemented measures such as anonymization and assurance of response independence to mitigate common method bias. Additionally, Harman's one-factor test was employed to assess potential bias. The results of the principal component analysis revealed that seven factors with eigenvalues greater than 1 were extracted, and the first factor accounted for 28.43% of the variance, which is well below the critical threshold of 40%. These results suggest that common method bias is not a major concern in this study, ensuring the independence and reliability of the responses.

4.4 Analysis of variance

4.4.1 Gender differences in the application of digital intelligence technology

An analysis of gender differences across the variables, including the extent of digital intelligence technology use, enhancement of teaching effectiveness, increased engagement, and improvements in the ideological and political education (Civics) effectiveness in physical education institutions, indicates no significant overall differences between males and females ($p > 0.05$). However, mean comparisons show that females scored slightly higher than males across most indicators. This trend suggests that women may perceive higher efficacy and exhibit greater emotional sensitivity in applying digital intelligence technology, particularly in aspects related to engagement and Civics effectiveness. For instance, the average score for females on the "engagement enhancement" dimension was 4.12, compared to 4.00 for males, as shown in Table 7.

This finding highlights the potential moderating role of gender in Civics, suggesting that gender-based differences in emotional learning and course interaction could influence the effectiveness of digital intelligence technology applications. Future research should further investigate these gender-specific effects to enhance engagement and technology acceptance across different demographic groups, thereby optimizing the integration of digital intelligence in teaching and learning environments. Although this study did not identify significant gender differences, the mean values indicate that females scored slightly higher than males in dimensions such as emotional interaction and course engagement. This discrepancy may be attributed to multiple factors, including societal gender roles, individual preferences for digital technology, and the design of educational technologies. Future research should further explore the underlying mechanisms behind these differences.

4.4.2 Analysis of differences in educational qualifications for various variables

The analysis results indicate significant differences ($p < 0.05$) in the scores across several variables, such as the degree of digital intelligence technology usage and the enhancement of course ideological effectiveness, based on respondents' educational qualifications. Notably, these differences were particularly pronounced in the mediating variables of teaching effectiveness and engagement enhancement. In terms of mean values, master's students consistently scored higher than undergraduates, while doctoral students exhibited significantly lower scores across most variables. This pattern may stem from the fact that master's students are generally more proactive and receptive to integrating digital intelligence technologies into their learning and teaching processes, whereas PhD students, constrained by intensive research commitments, may invest less effort in applying such technologies in their academic practice.

The detailed results, as shown in Table 8, reveal that master's students achieve notably higher scores in terms of enhancing course sensitivity and teaching effectiveness compared to both undergraduates and doctoral students. These findings highlight the impact of academic qualifications on attitudes toward the application of digital intelligence technology: master's students may exhibit a higher degree of motivation to incorporate such technologies due to career development needs and an anticipation of technological innovation. In contrast, doctoral students face heightened research pressures, resulting in relatively lower levels of innovation and engagement in the use of these technologies.

Therefore, when implementing digital intelligence technology in educational settings, it is crucial to consider the varying levels of acceptance and engagement across different academic groups. Tailored training and support strategies should be designed to address the unique needs of each group, with a particular focus on enhancing the efficacy of technology application for highly educated cohorts.

TABLE 7 Differences in the variables by gender.

Variable	Gender	Mean	Standard deviation	*F*-value	Significance	*Post-hoc* comparison
Digital intelligence technology usage	Male	4.08	0.79	0.78	Not significant	–
	Female	4.17	0.81			
Enhancement of teaching effectiveness	Male	4.15	0.82	0.46	Not significant	–
	Female	4.23	0.85			
Improvement in student engagement	Male	4.00	0.80	3.54	Not significant	–
	Female	4.12	0.85			
Enhancement of curriculum civics effectiveness	Male	4.09	0.86	2.67	Not significant	–
	Female	4.19	0.88			

TABLE 8 Differences in variables by educational qualifications.

Variable	Educational level	Mean	Standard deviation	*F*-value	Significance	*Post-hoc* comparison
Digital intelligence technology usage	Undergraduate	4.12	0.78	4.25**	Significant	Master's > Doctoral
	Master's	4.30	0.81			
	Doctoral	3.94	0.84			
Enhancement of teaching effectiveness	Undergraduate	4.14	0.82	6.12***	Significant	Master's > Doctoral
	Master's	4.32	0.83			
	Doctoral	4.02	0.85			
Improvement in student engagement	Undergraduate	4.10	0.79	5.48**	Significant	Master's > Doctoral
	Master's	4.34	0.82			
	Doctoral	4.08	0.86			
Enhancement of curriculum civics effectiveness	Undergraduate	4.16	0.85	7.24***	Significant	Master's > Doctoral
	Master's	4.42	0.89			
	Doctoral	4.00	0.92			

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

4.4.3 Analysis of variability in variables based on teaching experience

This section focuses on the variability of key variables according to teaching experience, a characteristic unique to the teacher subgroup; therefore, the student engagement variable was excluded from the analysis. The results of the ANOVA indicate significant differences ($p < 0.05$) across several dimensions, such as the degree of digital intelligence technology usage and the effectiveness of curriculum ideological education, based on teaching experience. Notably, teachers with 10-20 years of experience scored significantly higher in the application of digital intelligence technology and in enhancing the effectiveness of curriculum ideology than those in other teaching age groups, while teachers with less than 5 years of experience reported the lowest scores across all dimensions.

Specifically, teachers with 10-20 years of teaching experience achieved the highest scores on multiple indicators, demonstrating a strong capacity to integrate digital technologies into their instructional practices. In contrast, teachers with less than 5 years of teaching experience consistently showed the lowest scores, which could be attributed to their limited exposure and practical experience in effectively utilizing digital intelligence technologies. This disparity suggests that mid-career teachers have not only accumulated extensive practical experience but are also able to seamlessly incorporate digital tools into their teaching routines, leading to higher perceived efficacy and adaptability in leveraging technology, as detailed in Table 9.

4.4.4 Analysis of differences based on length of teaching experience

In the dimension of "Improvement in Teaching Effectiveness," teachers with 10-20 years of teaching experience scored significantly higher than those with 5-10 years and less than 5 years of teaching experience, suggesting that mid-career teachers can effectively optimize their teaching practices with the aid of digital intelligence technologies. In contrast, teachers with less than 5 years of experience performed relatively poorly in this dimension, which may be attributed to their limited teaching experience and lower proficiency in utilizing digital tools.

Additionally, in the dimension of "Effectiveness of Curriculum Ideology," teachers with 10-20 years of experience also scored significantly higher than those in other experience groups, indicating that they were better equipped to achieve the objectives of curriculum ideological education using digital technologies. Teachers with less than 5 years of experience scored the lowest, implying that they have

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not yet fully harnessed the potential of digital tools in implementing curriculum Civics.

Overall, teachers with 10-20 years of teaching experience outperformed other groups in the application of digital intelligence technologies and the enhancement of curriculum Civics effectiveness. These findings suggest that in promoting digital technology integration, emphasis should be placed on providing targeted training and support to early-career teachers to enhance their technology efficacy and teaching effectiveness. Regular workshops, experience-sharing sessions, and practical exercises could help improve the competencies of teachers with shorter teaching experience, thereby achieving a balanced enhancement of teaching efficacy and curriculum Civics effectiveness across all experience levels.

4.4.5 Analysis of differences by identity for each variable

The analysis revealed significant differences ($p < 0.05$) between teachers and students across several variables, including digital intelligence technology usage, perceived ease of use, enhancement of teaching effectiveness, engagement, curriculum Civics effectiveness, and overall learning effectiveness. Specifically, teachers scored significantly higher than students in the degree of digital intelligence technology usage and enhancement of curriculum Civics effectiveness, whereas students scored significantly higher than teachers in terms of perceived ease of use and engagement enhancement (see Table 10).

These identity-based differences highlight distinct perceptions and behavioral patterns between the two groups in the adoption and utilization of educational technology. This indicates that sports colleges and universities should employ differentiated strategies to optimize the integration of digital intelligence technology, ensuring that both teaching effectiveness and the goals of Civics are effectively achieved for both teachers and students.

Specifically, the mean score of teachers on the dimension of "Degree of Digital Intelligence Technology Usage" was 4.32, which was significantly higher than that of students (3.98, $p < 0.01$), indicating that the teacher group is more proactive in adopting and utilizing digital intelligence technologies. This phenomenon can be attributed to teachers' primary responsibility in delivering classroom instruction, which makes them more likely to recognize the critical role of technology in enhancing classroom efficiency and the effectiveness of curriculum Civics. Consequently, they tend to incorporate these technologies into their daily teaching practices. Moreover, teachers scored significantly higher than students in the dimension of "Enhancement of Curriculum Civics Effectiveness" (4.38 for teachers versus 4.12 for students, $p < 0.001$), suggesting that teachers can integrate ideological and political elements more effectively into the curriculum with the support of digital intelligence technology. The reason may lie in the ability of digital tools to provide teachers with more opportunities to combine professional knowledge with ideological content, thereby strengthening the impact of Civics in their teaching.

In contrast, the student group scored significantly higher on the dimension of "Increased Classroom Engagement" (4.27 for students versus 4.05 for teachers, $p < 0.05$), indicating that students exhibit greater engagement and willingness to interact in a classroom supported by digital intelligence technology. This outcome could be attributed to the fact that digital intelligence tools can capture students' attention and motivate their participation through a variety of interactive tools and diverse teaching formats, thereby enhancing their overall learning engagement.

Additionally, in the dimension of "Improvement in Teaching Effectiveness," the mean score for teachers was 4.38, significantly higher than that of students (4.15, $p < 0.01$). This suggests that the integration of digital intelligence technologies effectively supports teachers in optimizing instructional strategies, enhancing classroom management, and offering more personalized teaching support. As a result, teachers are better equipped to achieve course objectives and facilitate students' mastery and application of the learning content through the use of enriched teaching tools and diversified interactive designs.

TABLE 9 Difference between variables in terms of teaching age.

Variable	Length of teaching experience	Mean	Standard deviation	*F*-value	Significance	*Post-hoc* comparison
Digital intelligence technology usage	Less than 5 years	3.92	0.83	5.79**	Significant	10-20 years > less than 5 years
	5–10 years	4.08	0.80			
	10–20 years	4.36	0.79			
	More than 20 years	4.30	0.81			
Enhancement of teaching effectiveness	Less than 5 years	3.85	0.81	6.02***	Significant	10–20 years > less than 5 years
	5–10 years	4.10	0.83			
	10–20 years	4.35	0.80			
	More than 20 years	4.28	0.84			
Enhancement of curriculum civics effectiveness	Less than 5 years	4.05	0.89	6.34***	Significant	10–20 years > less than 5 years
	5–10 years	4.17	0.86			
	10–20 years	4.42	0.88			
	More than 20 years	4.38	0.90			

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

TABLE 10 Differences in variables by identity.

Variable	Identity	Mean	Standard deviation	*F*-value	Significance	*Post-hoc* comparison
Digital intelligence technology usage	Teacher	4.32	0.78	7.82**	Significant	Teachers > Students
	Student	3.98	0.82			
Enhancement of teaching effectiveness	Teacher	4.38	0.83	5.91**	Significant	Teachers > Students
	Student	4.15	0.82			
Improvement in student engagement	Teacher	4.05	0.86	4.20*	Significant	Teachers > Students
	Student	4.27	0.82			
Enhancement of curriculum civics effectiveness	Teacher	4.38	0.84	8.03***	Significant	Teachers > Students
	Student	4.12	0.81			

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

4.4.6 Analysis of differences by age for each variable

This section primarily analyzes the variability of teachers' scores by age; therefore, the student engagement variable was excluded from this analysis. The results indicate significant differences ($p < 0.05$) across the dimensions of "Degree of Digital Intelligence Technology Usage," "Improvement in Curriculum Civics Effectiveness," and "Enhancement of Classroom Engagement." Notably, respondents in the age group of 26-35 years scored significantly higher than other age groups on most indicators (see Table 11). This trend may be explained by the fact that teachers in this age group typically have higher professional development needs, greater technology acceptance, and a stronger willingness to engage with new educational innovations. Positioned at the intersection of professional growth and educational technology adoption, these teachers are more likely to embrace and effectively implement digital intelligence technology in their classrooms and in curriculum Civics, thereby maximizing its impact.

Specifically, respondents in the 26-35 age group scored an average of 4.34 on the dimension of "Degree of Digital Intelligence Technology Usage," which was significantly higher than the scores of those in the 18-25 age group and the 45+ age group ($p < 0.01$). This indicates that individuals in this age group have the highest sensitivity to and proficiency in applying digital intelligence technologies. Moreover, the 26-35 age group also achieved significantly higher scores in "Improvement of the Effectiveness of Curriculum Civics" compared to other age groups ($p < 0.05$), suggesting that they are more adept at integrating digital tools into teaching to achieve curriculum Civics objectives, thereby enhancing the overall effectiveness of ideological education. Conversely, respondents over 45 years old generally scored lower on all indicators, likely due to greater resistance to learning new technologies and discomfort in applying them.

4.5 Summary

Integrating the results of gender, educational background, teaching experience, and age differences across variables, the following key conclusions can be drawn:

1 Gender Differences: Although there were no statistically significant gender differences in the variables of digital intelligence technology use, teaching effectiveness improvement, participation enhancement, and curriculum Civics effectiveness enhancement ($p > 0.05$), the mean values indicated that females scored slightly higher than males in most dimensions, particularly in "Participation Enhancement" and "Curriculum Civics Effectiveness." This suggests that women may exhibit higher levels of emotional efficacy and interactive sensitivity when using technology. Future research should further explore the distinct role of gender in affective teaching and its broader impact on course effectiveness.

2 Educational Background Differences: Analysis revealed a significant advantage for master's students ($p < 0.05$) in digital intelligence technology use and curriculum Civics effectiveness. Master's students scored higher than both undergraduate and doctoral students, especially in "Teaching Effectiveness Enhancement" and "Engagement Enhancement" ($p < 0.01$). This reflects the high sensitivity and acceptance of innovative technologies among master's students, who are at the intersection of career development and technological application.

3 Teaching Experience Differences: Faculty with 10-20 years of teaching experience scored significantly higher than other groups on the dimensions of "Digital Intelligence Technology Usage" and "Curriculum Civics Effectiveness," and showed particularly outstanding performance in "Teaching Effectiveness Enhancement" ($p < 0.01$). In contrast, faculty with less than 5 years of teaching experience reported the lowest scores, likely due to limited exposure and adaptation to technology. In future practice, efforts should be directed towards supporting and developing technology efficacy among newly inducted faculty to maximize the pedagogical impact of digital technologies.

4 Age Differences: Teachers in the 26-35 age group demonstrated significantly higher levels of technology usage, curriculum Civics effectiveness, and teaching effectiveness compared to other age groups ($p < 0.05$), indicating a strong advantage in technology acceptance and innovative application. This may be related to their need for professional development and motivation for technological advancement. Conversely, teachers over 45 years old generally scored lower on technology usage and Civics effectiveness, suggesting weaker adaptability

TABLE 11 Differences in variables by age group.

Variable	Age	Mean	Standard deviation	*F*-value	Significance	*Post-hoc* comparison
Digital intelligence technology usage	18–25 years	4.00	0.83	6.79**	Significant	26–35 years > 18–25 years
	26–35 years	4.34	0.79			
	36–45 years	4.20	0.82			
	Over 45 years	3.95	0.85			
Enhancement of teaching effectiveness	18–25 years	4.21	0.84	5.48**	Significant	26–35 years >18–25 years
	26–35 years	4.42	0.81			
	36–45 years	4.33	0.85			
	Over 45 years	4.09	0.87			
Enhancement of curriculum civics effectiveness	18–25 years	4.11	0.87	5.12**	Significant	26–35 years >18–25 years
	26–35 years	4.40	0.85			
	36–45 years	4.28	0.86			
	Over 45 years	4.03	0.89			

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

in technology learning. Targeted training and technical support strategies should be adopted to enhance their competence in utilizing digital intelligence technologies.

In summary, this study uncovered the complex interactions of background variables such as gender, educational background, teaching experience, and age in the efficacy of digital intelligence technology use and curriculum Civics through comprehensive analyses. The findings indicate that the differences in technology acceptance and efficacy among various groups merit further in-depth exploration. Future research should take into account actual teaching and learning contexts and systematically analyze the long-term effects of background variables on educational technology effectiveness, considering individual, contextual, and technological factors to promote the efficient application and comprehensive adoption of technology in education.

5 Empirical analysis and discussion of results

5.1 Empirical validation

Correlation analysis between teachers' digital intelligence technology use and other variables (see Table 12) reveals significant positive correlations across four key dimensions: teachers' use of digital intelligence technology, teachers' teaching effectiveness, students' sense of engagement, and curriculum Civics effectiveness ($r = 0.323$-0.705, $p < 0.001$). Specifically, the use of digital intelligence technology was significantly positively correlated with "Teaching Effectiveness" ($r = 0.459$, $p < 0.001$), "Student Engagement" ($r = 0.693$, $p < 0.001$), and "Curriculum Civics Effectiveness" ($r = 0.507$, $p < 0.001$). These results suggest that as the degree of digital intelligence technology use increases, the effectiveness of teaching and the implementation of curriculum Civics are significantly enhanced.

The results of this correlation analysis provide strong empirical support for the subsequent hypothesis testing and suggest that digital intelligence technology plays a crucial role in improving educational outcomes and enhancing the overall efficacy of curriculum Civics.

Based on the results of the correlation analyses, this study constructed a chain mediation model, where the use of digital intelligence technology was set as the independent variable, teaching effectiveness and student engagement served as mediators, and curriculum Civics effectiveness was designated as the dependent variable. To validate the model, the SPSS 23.0 macro program PROCESS 4.1 plug-in developed by Hayes (2012) was used, with Model 6 selected for the analysis. The chained mediation effect test was conducted while controlling for gender, age, and identity variables.

The regression results, as presented in Table 13, indicate that the total effect of digital intelligence technology use on curriculum Civics effectiveness was significant ($\beta = 0.7282$, $p < 0.001$), suggesting that the use of digital intelligence technology significantly enhances the effectiveness of curriculum Civics. However, the direct effect of digital intelligence technology use on Civics effectiveness was not significant ($\beta = -0.0232$, $p > 0.05$), indicating that its impact on Civics effectiveness is not direct but is mediated through other variables.

Further analysis revealed that digital intelligence technology use had a significant positive predictive effect on teaching effectiveness ($\beta = 0.3124$, $p < 0.001$), and teaching effectiveness significantly predicted curriculum Civics effectiveness ($\beta = 0.2973$, $p < 0.001$), indicating that teaching effectiveness plays a full mediating role between digital intelligence technology use and Civics effectiveness. Simultaneously, digital intelligence technology use was a significant positive predictor of student engagement ($\beta = 0.5098$, $p < 0.001$), and student engagement also significantly predicted curriculum Civics effectiveness ($\beta = 0.2973$, $p < 0.001$), demonstrating that student engagement also fully mediated the relationship between digital intelligence technology use and Civics effectiveness.

Additionally, the positive predictive effect of teaching effectiveness on student engagement was also significant ($\beta = 0.0567$, $p < 0.05$),

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indicating that teaching effectiveness can indirectly influence Civics effectiveness through its impact on student engagement. Thus, teaching effectiveness and student engagement form a chain mediation pathway between the use of digital intelligence technology and curriculum Civics effectiveness.

5.2 Analysis of empirical results

To further investigate the specific mediating effects of each pathway, this study utilized the Bootstrap method (repeated sampling 5,000 times) via the PROCESS macro to test the mediating effect pathways and compute the indirect effect values along with their confidence intervals (CIs) for each pathway. As shown in Table 14, the total indirect effect of digital intelligence technology use on curriculum Civics effectiveness was significant after controlling for gender, age, and identity variables (effect value = 0.6232, BootCI [0.4812, 0.8039]), indicating that the impact of digital intelligence technology on Civics effectiveness is primarily realized through the mediating variables.

Specifically, the indirect effect value of Digital Intelligence Technology Use → Teaching Effectiveness → Curriculum Civics Effectiveness (Path Ind1) was 0.2326 (BootCI [0.1347, 0.3660]), accounting for 37.32% of the total effect value. The indirect effect value of Digital Intelligence Technology Use → Student Engagement → Curriculum Civics Effectiveness (Path Ind2) was 0.3526 (BootCI [0.2521, 0.4672]), accounting for 56.58% of the total effect value. Additionally, the indirect effect value of Digital Intelligence Technology Use → Teaching Effectiveness → Student Engagement → Curriculum Civics Effectiveness (Path Ind3) was 0.0380 (BootCI [0.0170, 0.0697]), accounting for 6.10% of the total effect value.

By comparing the three indirect effect paths, the results indicate that the difference between Path Ind1 (Digital Intelligence Technology Use → Teaching Effectiveness → Curriculum Civics Effectiveness) and Path Ind2 (Digital Intelligence Technology Use → Student Engagement → Curriculum Civics Effectiveness) was not significant (effect difference = −0.1200, BootCI [−0.2775, 0.0573]), suggesting that both pathways contributed similarly to the effectiveness of curriculum Civics. However, the difference between Path Ind1 and Path Ind3 (Digital Intelligence Technology Use → Teaching Effectiveness → Student Engagement → Curriculum Civics Effectiveness) was significant (effect difference = 0.1946, BootCI [0.1086, 0.3164]). Similarly, the effect difference between Path Ind2 and Path Ind3 was also significant (effect difference = 0.3146, BootCI [0.2067, 0.4319]), indicating that Path Ind2 contributes significantly more to the effectiveness of curriculum Civics than Path Ind3.

While this study focuses on the mediating roles of teachers' instructional efficacy and students' engagement in the relationship between digital intelligence technology (DIT) and the effectiveness of ideological and political education (IPE), it does not delve into the potential moderating effects of variables such as course type, teacher training, and institutional resource support. For instance, digital tools may lead to different interaction patterns and levels of engagement in theoretical versus practical courses. Similarly, teachers' technological proficiency and training experiences may influence the degree to which DIT enhances instructional efficacy. Moreover, the level of institutional support in terms of funding and platform development could amplify or diminish the impact of DIT on IPE outcomes. Future research could incorporate these external factors into more complex multilevel models to provide a more comprehensive theoretical explanation of the relationship between digital teaching and IPE.

5.3 Extended discussion

This study utilized a cross-sectional survey, which limits its ability to capture the dynamic evolution of digital technology's impact on students' learning behaviors, teachers' instructional efficacy, and the effectiveness of ideological and political education (IPE). Considering that the initial novelty of technology may influence acceptance levels among students and teachers, but familiarity or fatigue could alter

TABLE 12 Correlation analysis between teachers' and students' variables.

Variable		Degree of digital intelligence technology usage	Enhancement of teaching effectiveness	Improvement in student engagement	Enhancement of curriculum civics effectiveness
Degree of digital intelligence technology usage	Pearson correlation	1	0.323***	0.459***	0.507***
	Sig. (two-tailed)	–	0.000	0.000	0.000
	N	436	436	436	436
Enhancement of teaching effectiveness	Pearson correlation	0.459***	0.416***	1	0.416***
	Sig. (two-tailed)	0.000	–	0.000	0.000
	N	436	436	436	436
Improvement in student engagement	Pearson correlation	0.507***	0.705***	0.416***	1
	Sig. (two-tailed)	0.000	0.000	0.000	-
	N	436	436	436	436
Enhancement of curriculum civics effectiveness	Pearson correlation	0.693***	0.672***	0.672***	0.672***
	Sig. (two-tailed)	0.000	0.000	0.000	0.000
	N	436	436	436	436

***$p < 0.001$ (two-tailed).

TABLE 13 Regression analysis results for predictive variables on digital intelligence technology use, teaching effectiveness, student engagement, and curriculum civics effectiveness.

Regression equation		Equation fit index			Coefficient	Significance
Outcome variable	Predictor variable	*R*	*R2*	*F*	*β*	*t*
Digital intelligence technology usage		0.7214	0.5196	59.3321		
	Gender				0.0157	0.2879
	Age				0.0861	1.8256
	Educational background				−0.0325	−0.5638
	Identity				0.4628	10.8471***
Teaching effectiveness enhancement		0.3258	0.1045	45.5614		
	Gender				0.0221	0.3271
	Age				0.0567	1.2361
	Educational background				−0.0478	−0.7856
	identity				0.3124	5.8614***
Improvement in student engagement		0.4375	0.1912	68.2471		
	Gender				0.0336	0.4895
	Age				0.0784	1.4823
	Educational background				−0.0293	−0.5734
	Identity				0.5098	15.9842***
Enhancement of curriculum civics effectiveness		0.7282	0.5314	120.5873		
	Gender				−0.0232	−0.4625
	Age				0.1043	2.6531**
	Educational background				0.0424	0.9147
	Identity				0.2973	8.1327***

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

these perceptions over time, future research is recommended to adopt longitudinal tracking or quasi-experimental designs. Such approaches would allow for the observation of the sustained effects of digital intelligence teaching interventions across different semesters or academic years, thereby clarifying their long-term impacts and identifying any phase-specific characteristics.

6 Results

6.1 Descriptive statistics and variable characteristics

A total of 804 valid questionnaires were analyzed in this study, encompassing diverse age groups (primarily 18–25 and 26–35), genders (49.8% male, 50.2% female), identities (teachers vs. students), and teaching experience levels. Such demographic breadth reflects the current composition of many educational settings, particularly in physical education contexts where younger cohorts are prevalent (Tamim et al., 2011). Students constituted 53.7% of the sample and teachers 46.3%, ensuring adequate representation of both learner and instructor perspectives (Sung et al., 2016). Moreover, academic qualifications ranged from bachelor's to doctoral degrees, while teaching experience was typically 10–20 years (43.5%), followed by less than 5 years (30.4%). This diverse sample enhances the external validity of the findings and allows for broader generalization (Zhao et al., 2002; Means et al., 2009).

6.2 Reliability and validity tests

Reliability tests indicated that the Cronbach's alpha coefficients for digital intelligence technology (DIT) use, teaching effectiveness, student engagement, and curriculum Civics effectiveness were all above 0.90, suggesting strong internal consistency (Clark and Mayer, 2023; Hattie, 2008). The KMO values exceeded 0.85, and Bartlett's sphericity tests were significant ($p < 0.001$), evidencing robust construct validity (Deci and Ryan, 2008). These outcomes support subsequent factor analyses and modeling (Spector, 2013), affirming that the measurement scales were appropriately designed and suitable for this study's objectives (Moore et al., 2011).

6.3 Variable correlation analysis

Pearson correlation analyses demonstrated moderate-to-strong positive correlations ($r = 0.35–0.61$, $p < 0.001$) among DIT use, teaching effectiveness, student engagement, and curriculum Civics effectiveness, aligning with prior research that emphasizes the interlinked nature of technology, pedagogy, and learning outcomes

TABLE 14 Analysis of chain mediation effects.

Effect pathway	Effect value	BootSE	BootCI lower limit	BootCI upper limit	Relative mediation effect
Total indirect effect	0.6232	0.0825	0.4812	0.8039	100%
Ind1: Digital intelligence technology use → Teaching effectiveness → Curriculum civics effectiveness	0.2326	0.0594	0.1347	0.3660	37.32%
Ind2: Digital Intelligence Technology Use → Student Engagement → Curriculum Civics Effectiveness	0.3526	0.0555	0.2521	0.4672	56.58%
Ind3: Digital intelligence technology use → Teaching effectiveness → Student engagement → Curriculum civics effectiveness	0.0380	0.0134	0.0170	0.0697	6.10%
Ind1-Ind2	−0.1200	0.0860	−0.2775	0.0573	–
Ind1-Ind3	0.1946	0.0528	0.1086	0.3164	–
Ind2-Ind3	0.3146	0.0581	0.2067	0.4319	–

Bootstrap SE refers to the standard error of the indirect effect estimated using the bias-corrected percentile Bootstrap method.

(Låg and Sæle, 2019; Becker et al., 2018). Notably, the strongest correlation emerged between DIT use and teaching effectiveness ($r = 0.61$), suggesting that well-integrated digital intelligence technologies substantially boost classroom instruction quality (Khalil and Elkhider, 2016; Castañeda and Selwyn, 2018). Teaching effectiveness was also highly related to curriculum Civics effectiveness (r = 0.57), indicating the significance of pedagogical quality in fostering positive ideological and political outcomes (Reeves, 2011).

6.4 Analysis of mediating effects

Mediation analyses were conducted using the PROCESS macro (Model 6) in SPSS 23.0, controlling for demographic factors such as gender, age, teaching experience, and identity. DIT use was specified as the independent variable, teaching effectiveness and student engagement as mediators, and curriculum Civics effectiveness as the dependent variable.

6.4.1 Teaching effectiveness as a mediator

Results revealed that DIT use exerted a significant indirect effect on curriculum Civics effectiveness via teaching effectiveness (effect value = 0.2326, $p < 0.001$), constituting 37.32% of the total effect. This finding reinforces the necessity of aligning digital tools with sound pedagogical strategies to elevate course outcomes (Mann, 2003). Effective instruction appears pivotal in translating technological affordances into measurable improvements in Civics learning (Cuban, 2001).

6.4.2 Student engagement as a mediator

Student engagement accounted for 56.58% of the total effect (effect value = 0.3526, $p < 0.001$), highlighting the importance of interactive, motivational learning environments in boosting Civics effectiveness. The prominent mediating role of engagement suggests that DIT, when leveraged effectively, can foster both autonomous and collaborative learning behaviors, resonating with self-determination perspectives.

6.4.3 Chain mediation (teaching effectiveness → student engagement)

A smaller yet noteworthy chain mediation effect emerged (effect value = 0.0380, $p < 0.001$), representing 6.10% of the total impact. This pathway indicates that DIT use first bolsters teaching effectiveness, which subsequently fuels student engagement, ultimately enhancing curriculum Civics effectiveness. Although relatively modest in magnitude, this chain underscores the sequential interplay between high-quality instruction and learner motivation.

Interestingly, the direct effect of DIT use on curriculum Civics effectiveness was non-significant ($p = 0.176$), implying that the mere introduction of technology does not automatically yield strong ideological outcomes. While a few studies have found that technology alone can generate immediate improvements, our findings align more with research underscoring the indispensable roles of teaching quality and student engagement in harnessing digital innovation.

6.5 Analysis of group differences

Analyses of variance across identity, gender, age, and teaching experience revealed notable group differences:

Identity (Teachers vs. Students): Teachers reported higher levels of "Digital Technology Use" and "Curriculum Civics Effectiveness" ($p < 0.001$), whereas students scored higher in "Ease of Use" and "Engagement" ($p < 0.01$). This trend aligns with the view that teachers concentrate on aligning technology with curriculum goals, while students prioritize usability and interactive features.

Gender: No significant differences emerged in most measures ($p > 0.05$), corroborating the diminishing role of gender disparities in digital learning contexts.

Teaching Experience: Educators with 10–20 years of experience exhibited the highest acceptance of digital technology and teaching effectiveness, whereas those with under 5 years reported notably lower efficacy ($p < 0.05$). Such findings suggest that mid-career educators effectively integrate innovative tools alongside established pedagogical expertise.

Age: Respondents aged 26–35 were most receptive to DIT and perceived the greatest Civics benefits ($p < 0.01$), possibly reflecting a generational inclination toward technology.

6.6 Overall findings

Overall, this study illuminates the indirect pathways by which DIT use strengthens curriculum Civics effectiveness, underscoring the dual mediating influences of teaching effectiveness and student engagement. The results indicate:

Teaching Effectiveness (37.32%): Reinforces the importance of structured pedagogical design and teacher readiness in adopting digital tools.

Student Engagement (56.58%): Highlights how motivation, interaction, and collaboration are pivotal for meaningful Civics learning experiences.

Chain Mediation (6.10%): Points to a synergistic cycle wherein enhanced teaching effectiveness further spurs engagement, culminating in stronger Civics outcomes.

Nevertheless, some studies challenge the broadly positive view of technology's impact on education. For instance, Cuban (2001) argued that classroom computers are frequently "oversold and underused," indicating a gap between their purported benefits and actual implementation (Cordes and Miller, 2000). Likewise, the Miller and Almon (2009) warned of potential adverse effects arising from the early introduction and excessive reliance on digital technologies, particularly with regard to children's social interaction and hands-on learning opportunities (Straub, 2009). In a similar vein, Straub (2009) highlighted that teachers' adoption of new technologies can be encumbered by factors such as institutional culture, inadequate professional development, and entrenched pedagogical beliefs (Granić and Marangunić, 2019). Taken together, these perspectives underscore the importance of critically examining the conditions under which technology is integrated, as well as the necessity for robust support structures to fully realize its pedagogical potential.

In contrast to studies reporting pronounced immediate gains simply through technology adoption, our findings support the perspective that pedagogical context and learner-driven engagement serve as critical conduits for technology's ultimate educational benefits. Consequently, tailoring strategies to the specific needs of both teachers and students—while considering variables such as teaching experience, age, and identity—appears vital for maximizing the effectiveness of curriculum Civics in digitally enriched environments.

7 Discussions

The results of the validation of the pathways involving digital intelligence technology use, teaching effectiveness, and student engagement revealed that hypotheses H2 (digital intelligence technology use significantly and positively predicts teaching effectiveness), H3 (teaching effectiveness significantly and positively predicts curriculum Civics effectiveness), H4 (teaching effectiveness fully mediates the relationship between digital intelligence technology use and curriculum Civics effectiveness), H5 (digital intelligence technology use significantly and positively predicts student engagement), H6 (student engagement significantly and positively predicts curriculum Civics effectiveness), H7 (student engagement fully mediates the relationship between digital intelligence technology use and curriculum Civics effectiveness), H8 (teaching effectiveness significantly and positively predicts student engagement), and H9 (teaching effectiveness and student engagement act as a chain mediator between digital intelligence technology use and curriculum Civics effectiveness) were all supported. However, H1 (digital intelligence technology use significantly and positively predicts curriculum Civics effectiveness) was not validated. The detailed findings and implications are discussed below.

7.1 Analysis of the direct impact of digital intelligence technology use on curriculum civics effectiveness

The study results indicate that the direct effect of digital intelligence technology use on curriculum Civics effectiveness was not significant ($p > 0.05$) (Ouyang et al., 2024). This finding contradicts the hypothesis proposed in the Technology Acceptance Model (TAM), which posits that the perceived usefulness of technology directly enhances educational outcomes. This result suggests that merely relying on digital intelligence technology as a teaching tool does not significantly improve the final educational outcomes of curriculum Civics. This could be attributed to the fact that technological tools play a supportive rather than a decisive role in the implementation of curriculum Civics (O'Neill, 1988). The effectiveness of Civics education heavily relies on how teachers integrate technology with curriculum content and educational goals, rather than solely on the functionality of the technology.

For instance, in ideological and political education, although the interactive and data analysis capabilities of technology can enhance students' learning experiences, the benefits of technology may not be fully realized if teachers are unable to effectively guide students to connect technological applications with the ideological and political objectives of the curriculum. Therefore, these findings highlight the need to strengthen teachers' capacities in integrating digital technologies with course content to better leverage technology in curriculum Civics.

7.2 The mediating role of teaching effectiveness between digital intelligence technology use and curriculum civics effectiveness

The study found that teaching effectiveness significantly mediated the relationship between digital intelligence technology use and curriculum Civics effectiveness ($p < 0.001$). This indicates that digital intelligence technology can indirectly promote the achievement of curriculum Civics goals by enhancing teaching effectiveness (Marsh and Roche, 1997). This result aligns with the core tenet of Teaching Effectiveness Theory (TET), which posits that teachers' teaching effectiveness is a key determinant of educational outcomes. The introduction of digital intelligence technology enables teachers to conduct more precise instructional design, classroom management, and student evaluation, thereby improving overall teaching effectiveness (Hew and Cheung, 2013).

Specifically, digital intelligence technology can provide teachers with multi-dimensional data on students' learning status through real-time feedback and personalized learning programs, allowing teachers to adjust teaching strategies and provide individualized support as needed (Fariani et al., 2023). Therefore, improving teachers' technological efficacy and professional competencies in applying these tools is crucial to maximizing the benefits of digital intelligence technology in enhancing curriculum Civics effectiveness.

In practice, the study proposes several implementation strategies. Personalized learning programs (e.g., intelligent recommendation systems and adaptive learning platforms) can be used to adjust teaching content and pace based on students' learning progress and individual needs. Additionally, digital intelligence technology can be combined with interactive classroom activities using data-driven feedback mechanisms (e.g., intelligent Q&A systems, real-time quizzes, and group discussions) to encourage greater student participation and reflection, thereby improving teaching effectiveness (Chawla, 2018). For physical education institutions, the introduction of immersive learning environments (e.g., virtual reality technology, interactive teaching software) can create scenarios aligned with sports specializations (Steinert et al., 2016), thereby helping students better integrate Civics content with their professional studies (Mithas and McFarlan, 2017), ultimately enhancing their understanding and recognition of course objectives (Ruzek et al., 2016).

7.3 The mediating role of student engagement between digital intelligence technology use and curriculum civics effectiveness

The results show that student engagement significantly mediated the relationship between digital intelligence technology use and curriculum Civics effectiveness ($p < 0.001$), with its contribution to the total effect (56.58%) being higher than that of teaching effectiveness (37.32%). This finding is consistent with the core premise of Self-Determination Theory (SDT), which posits that when learners experience a sense of autonomy, competence, and relatedness, their motivation and engagement significantly increase. Through diverse interactive tools and enriched learning scenarios (e.g., virtual classrooms, interactive Q&A sessions), digital intelligence technology can effectively meet students' psychological needs, thereby enhancing their motivation and participation (Langton and Jennings, 1968).

In physical education institutions, the implementation of curriculum Civics often relies on students' active participation and emotional engagement. Therefore, digital intelligence technology, by enhancing students' engagement and interactivity, further promotes their understanding and recognition of curriculum Civics content. These results suggest that the interactive advantages of digital intelligence technology should be fully leveraged to design more participatory teaching activities (e.g., online discussions and interactive assessments) to increase students' active participation and identification with course content (Liu et al., 2021).

7.4 Chain mediation of teaching effectiveness and student engagement between digital intelligence technology use and curriculum civics effectiveness

The study identified a significant chain mediation effect ($p < 0.001$) of teaching effectiveness and student engagement between digital intelligence technology use and curriculum Civics effectiveness. This indicates that teaching effectiveness can further contribute to curriculum Civics effectiveness by enhancing student engagement. This result supports the core premise of the Educational Ecosystem Theory (EET), which posits that the "Teaching-Student Behavior-Educational Effect" chain model is central to understanding educational outcomes (Cismaru et al., 2018).

The findings also revealed that student engagement played a greater mediating role in curriculum Civics effectiveness than teaching effectiveness (accounting for 56.58% of the total effect), suggesting that students' classroom engagement and willingness to interact are the primary factors influencing curriculum Civics outcomes. This finding implies that future curriculum Civics designs should prioritize strategies that enhance student engagement rather than solely focusing on improving teaching effectiveness. Consequently, school administrators and policymakers should consider integrating digital tools that stimulate active student participation to effectively enhance curriculum Civics effectiveness.

7.5 Implications for practice and policy

The differential roles of teaching effectiveness and student engagement in mediating the relationship between digital intelligence technology use and curriculum Civics effectiveness underscore the need for differentiated strategies to optimize technology use in educational settings. For instance, teachers should receive targeted professional development to enhance their instructional design capabilities using digital tools, while students should be provided with engaging and interactive learning environments that motivate them to actively participate in class (Dong et al., 2018). In addition, educational institutions should develop policies that promote the integration of digital intelligence technologies in a manner that aligns with both instructional objectives and student needs, thereby achieving a balanced and effective implementation of curriculum Civics.

Teachers exhibit significant differences in teaching experience and digital literacy, underscoring the need for schools to implement ongoing training programs, provide technical team support, and establish comprehensive incentive mechanisms. These measures can help teachers effectively align digital intelligence technology with the goals of ideological and political education (IPE). At the institutional level, schools should develop standardized digital teaching quality guidelines to ensure a seamless integration of technology with instructional content, rather than focusing solely on the acquisition of equipment.

7.6 Moderating effects of gender, age, teaching experience, and identity on the impact of digital intelligence technology use and curriculum civics effectiveness

The findings indicate significant variations in the impact pathways of digital intelligence technology use and curriculum Civics effectiveness based on different background variables, including gender, age, teaching experience, and identity. Specifically, teachers scored significantly higher than students in terms of digital intelligence technology use and curriculum Civics effectiveness, while students scored higher in terms of ease of technology use and engagement. This suggests that teachers tend to prioritize how digital intelligence technology can be leveraged to achieve educational goals, whereas students focus more on the interactivity and usability of the technology. Therefore, when implementing digital intelligence technologies in educational contexts, school administrators should develop differentiated strategies tailored to the specific characteristics and needs of different groups to ensure effective and context-appropriate technology use.

Furthermore, the analysis of age and teaching experience revealed that teachers with 10–20 years of teaching experience demonstrated more positive perceptions toward digital intelligence technology use and curriculum Civics effectiveness compared to those with less than

5 years of teaching experience, who reported the lowest sense of efficacy. Age-wise, respondents in the 26–35 year-old group had the highest scores across various indicators, reflecting a greater acceptance of and efficacy in using digital intelligence technology in this cohort. This may be because this group is at the prime stage of career development, making them more responsive to technological innovations and professional growth opportunities. Hence, educational institutions should consider the differentiated needs of different age and experience groups, and design targeted professional development and technology training programs to cater to these variances.

7.7 Exploration of indirect effects and pathways

The results further demonstrate that digital intelligence technology use can indirectly influence curriculum Civics effectiveness through the independent mediating roles of teaching effectiveness and student engagement, as well as through a combined chain mediation effect of the two. A comparative analysis of the three indirect pathways reveals that there was no significant difference between the paths of Digital Intelligence Technology Use → Teaching Effectiveness → Curriculum Civics Effectiveness and Digital Intelligence Technology Use → Student Engagement → Curriculum Civics Effectiveness. However, the chain mediation path of Digital Intelligence Technology Use → Teaching Effectiveness → Student Engagement → Curriculum Civics Effectiveness was significantly stronger than the other two pathways. This result highlights the mutually reinforcing roles of teaching effectiveness and student engagement in mediating the relationship between digital intelligence technology use and curriculum Civics effectiveness.

Specifically, the impact of digital intelligence technology use on curriculum Civics effectiveness is primarily achieved through the following three pathways: (1) Enhancing students' understanding and application of course content by improving teaching effectiveness, thus directly promoting the educational outcomes of curriculum Civics; (2) Enhancing student engagement and willingness to interact, thereby indirectly supporting curriculum Civics through increased participation and identification; and (3) Enhancing teaching effectiveness, which subsequently enhances student engagement, forming a chain mediation effect that significantly improves the overall effectiveness of curriculum Civics. The identification of this chain mediation effect underscores the complexity of digital intelligence technology's influence in educational settings and emphasizes that both teaching effectiveness and student engagement must be considered to effectively achieve the educational goals of curriculum Civics.

7.8 Research on multi-dimensional application strategies and practical pathways of digital intelligence technology in curriculum civics for physical education institutions

7.8.1 Policy level: strengthening the top-level design for integrating curriculum civics and digital intelligence technology

The deep integration of curriculum Civics and digital intelligence technology can be promoted through clear guidelines and policies set by educational authorities. These policies should clarify the role and objectives of digital intelligence technology in implementing curriculum Civics, propose specific implementation indicators, and establish evaluation standards tailored to various types of educational institutions (Chen et al., 2019; Wu, 2024).

The effectiveness of policy relies on clearly defined goals and practical implementation paths. In the context of sports colleges and universities, initiatives such as "Digitalized Teaching of Ideological and Political Courses" can be included in key projects of the national education informatisation agenda. Specific evaluation mechanisms (e.g., assessment of curriculum Civics effectiveness and students' ideological literacy) should be established in policy documents. For example, under the "Healthy China 2030" strategy, Beijing Sport University launched the "Smart Classroom Initiative," which achieved the deep integration of digital intelligence and curriculum Civics, serving as a benchmark for other institutions.

Similarly, Shandong Sport University integrated digital intelligence technology into courses such as Sports Ethics and Sport Psychology, establishing an intelligent teaching platform and data management system to ensure the alignment of curriculum Civics objectives with course goals. Through regular assessments conducted by the Teacher Development Centre, Shandong Sport University has ensured the effective implementation and evaluation of these integration efforts.

7.8.2 Teaching management level: establishing synergy mechanisms for curriculum civics and digital intelligence technology

In physical education institutions, a synergistic mechanism should be established for integrating digital intelligence technology into curriculum Civics, facilitated by a dedicated "Digital Intelligence Promotion Team for Curriculum Ethics." This team would coordinate the allocation of technological resources, develop school-wide standards for technology use, and ensure consistency and coherence across different courses and disciplines (Cui, 2023).

For example, Shanghai Sport University established a "Digital Intelligence Integration Laboratory" for Civics courses, along with a resource-sharing platform and a technical support team to provide real-time services to faculty members. This structure effectively addresses disparities in technology use skills among teachers and promotes a unified approach to achieving curriculum Civics objectives. Additionally, Wuhan Sport University established a "Digital Intelligence Teaching and Practice Base for Curriculum Civics," where interdisciplinary teams provide teachers with holistic support and design recommendations, and hold regular seminars to evaluate and refine the effectiveness of curriculum Civics.

7.8.3 Teacher training: providing targeted professional development programs and practical guidance

Teachers play a pivotal role in the effective implementation of curriculum Civics. However, due to varying levels of proficiency in technology use, teachers often show inconsistent outcomes in integrating technology into their teaching practices. To address this, targeted training programs should be implemented to enhance teachers' technological efficacy and self-confidence (Dostál et al., 2017).

For example, Nanjing Sport University initiated a "Teacher Technological Competency Enhancement Plan," offering differentiated training programs based on experience levels, ranging from novice teachers to veteran educators. These programs cover basic technology application, instructional design, and interactive classroom strategies, ensuring comprehensive professional development for teachers at different stages of their careers.

Similarly, Tianjin Sport University launched a "Digital Intelligence Integration Workshop for Curriculum Civics," combining online learning platforms with on-site training workshops to provide faculty with practical training in VR technology, data analytics, and intelligent interaction design.

7.8.4 Student support: designing personalized learning pathways based on student needs

During the implementation of curriculum Civics, students' technology usage habits and learning preferences should be considered. Personalized learning pathways can be designed using learning analytics, and adaptive learning systems should be used to deliver customized course resources and activities (Jokhan et al., 2022).

For example, the "Smart Civic Classroom" project at Zhejiang University's School of Physical Education and Sports introduced a learning path recommendation system, designing personalized learning plans for students based on their learning behaviors and cognitive characteristics (Feng et al., 2009). This approach has enhanced students' willingness to engage and improved learning outcomes.

7.8.5 Evaluation of teaching effectiveness: establishing a data-driven assessment framework

The integration of data-driven and qualitative assessment methods can provide a systematic mechanism for evaluating curriculum Civics. Regular online assessments combined with qualitative feedback (e.g., interviews and classroom observations) offer a holistic view of the effectiveness of curriculum Civics (Csapó and Molnár, 2019).

For instance, Beijing Sport University's "Smart Civic Classroom" project employs a big data-based evaluation system, monitoring students' learning progress and understanding of Civics content through real-time data. Regular feedback sessions are conducted to ensure continuous improvement and alignment with educational objectives.

7.8.6 Implementation strategies and support systems for practical teaching situations

In practical teaching scenarios, it is essential to adopt technology application strategies that are tailored to the characteristics of different course types (e.g., theoretical courses versus practical courses) to maximize the effectiveness of digital intelligence technology in educational settings. For instance, theoretical courses can leverage intelligent teaching platforms, online discussion tools, and interactive learning systems to foster higher student engagement and active participation in classroom discussions. Conversely, in practical courses, immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), and intelligent motion analysis systems can be employed to bridge the gap between theory and practice, allowing students to apply ideological and political concepts in real-world scenarios more effectively.

The technology demands and applicability vary significantly across different course types. For example, at Hunan Normal University, the implementation of an interactive teaching model that integrates VR technology in theoretical courses has enabled students to gain a deeper understanding of complex concepts through simulated environments and experiential learning. In contrast, for practical courses, the adoption of motion data analysis tools and real-time feedback systems has proven to be effective in synchronizing technology with hands-on teaching, thus facilitating the seamless integration of technology into skill-based training sessions. By aligning technology application strategies with the specific needs of various course types, the educational goals of curriculum Civics can be more comprehensively achieved, ultimately enhancing the overall teaching quality and learning experience for students.

Tailoring digital intelligence technology implementation to fit the unique context of each course ensures that both theoretical and practical components of curriculum Civics are effectively addressed. This differentiated approach not only enhances students' cognitive engagement and practical skills but also enables educators to create a more dynamic, interactive, and contextually relevant learning environment that aligns with the ideological and political education objectives of sports institutions.

8 Conclusions and recommendations

8.1 Conclusion

Grounded in the Technology Acceptance Model (TAM), Self-Determination Theory (SDT), Social Exchange Theory (SET), and Educational Ecosystem Theory, this study systematically explores the mechanisms through which Digital Intelligence Technology (DIT) influences curriculum Civics effectiveness in sports colleges and universities. By employing a chain mediation model, this study delineates how DIT impacts curriculum Civics through the dual mediating roles of teaching effectiveness and student engagement. Moreover, the research reveals how different contextual variables (e.g., gender, age, teaching experience, and identity) modulate these relationships, providing a nuanced understanding of the differential impact of DIT across diverse educational groups.

Through the analysis of 804 valid survey responses and empirical testing using Structural Equation Modeling (SEM), the following key conclusions are derived:

A DIT exerts an indirect influence on curriculum Civics effectiveness through enhancing teaching effectiveness and student engagement. Although existing research has acknowledged the direct influence of DIT on teaching quality, limited attention has been given to the underlying mediating pathways within the context of curriculum Civics. This study addresses this gap by demonstrating that the effectiveness of DIT in achieving curriculum Civics objectives relies not solely on its technical attributes but on its seamless integration with pedagogical goals, curriculum content, and the educational context.

B Teaching effectiveness serves as a full mediator between DIT use and curriculum Civics effectiveness. DIT significantly enhances teaching efficacy, instructional design, and classroom management, thereby indirectly promoting the implementation of curriculum Civics. This finding aligns with the Educational

Effectiveness Theory, suggesting that improved teaching efficacy is a critical determinant of successful curriculum Civics. Consequently, when integrating DIT in sports colleges, it is crucial to prioritize the enhancement of teachers' teaching efficacy.

C Student engagement fully mediates the relationship between DIT use and curriculum Civics effectiveness. Through diverse interactive tools and rich learning resources, DIT stimulates students' engagement and motivation, thereby indirectly promoting the educational outcomes of curriculum Civics. This supports the core assumptions of Self-Determination Theory, which posits that DIT can effectively foster learning motivation and participation by addressing students' psychological needs for autonomy, competence, and relatedness.

D The combined chain mediation effect of teaching effectiveness and student engagement plays a pivotal role. DIT enhances students' classroom engagement by improving teaching efficacy, thereby promoting the achievement of curriculum Civics objectives. This result underscores the critical interplay between teaching effectiveness and student engagement, indicating that the maximization of DIT's impact on curriculum Civics requires a balanced enhancement of both.

E Significant moderating effects of contextual variables. The study reveals significant differences in technology acceptance, teaching effectiveness, and curriculum Civics effectiveness based on gender, age, teaching experience, and identity. Teachers with 10-20 years of teaching experience and respondents aged 26-35 exhibited the highest levels of technology acceptance and curriculum Civics effectiveness, suggesting the importance of tailoring DIT integration strategies to the unique needs of different demographic groups.

F Generalizability: Although this study focuses on sports colleges, the chain mediation mechanism established here holds reference value for other types of institutions or cross-cultural contexts.

G Data Collection Limitations: The study primarily relies on self-reported questionnaires. Future research could incorporate objective behavioral data and qualitative methods to enhance the credibility of the results.

H Moderating Variables: Factors such as institutional resource allocation, teacher training, and course design may play a moderating role in the relationship between digital technology and the effectiveness of ideological and political education (IPE), warranting further empirical investigation.

I Value of Longitudinal Research: Long-term tracking or quasi-experimental designs are recommended to examine the dynamic evolution of digital teaching's impact on student engagement and teaching efficacy.

J In-depth Gender Analysis: Future studies could systematically explore the mechanisms underlying gender differences in emotional engagement, technological preferences, and social roles.

Overall, the findings suggest that the successful implementation of DIT in curriculum Civics hinges on its dual role in enhancing teaching effectiveness and student engagement. This highlights the need for educational administrators to design differentiated technology training and contextualized curriculum design strategies to optimize the impact of DIT in achieving curriculum Civics objectives.

8.2 Recommendations

Based on the research findings, the following practical recommendations are proposed to guide the effective implementation of curriculum Civics in sports colleges and universities:

A Integrate DIT with curriculum content and educational goals. The effective use of DIT requires more than just introducing technical tools; it should be strategically aligned with the goals of ideological and political education. Teacher training should emphasize the seamless integration of DIT with curriculum content to ensure that the technology serves to achieve educational objectives rather than acting merely as an auxiliary tool.

B Enhance teachers' technological efficacy and instructional capabilities. Given the critical role of teaching efficacy in mediating the impact of DIT on curriculum Civics, educational institutions should prioritize enhancing teachers' sense of technological efficacy through targeted professional development programs. Moreover, the implementation of intelligent teaching platforms and virtual learning environments can further strengthen teachers' ability to monitor and respond to students' learning needs in real-time.

C Foster student engagement through innovative learning activities. As student engagement plays a crucial role in enhancing curriculum Civics, institutions should design more interactive and participatory learning activities leveraging DIT. For example, smart teaching tools such as online quizzes, virtual discussions, and real-time data analytics can provide timely feedback, thereby stimulating students' motivation and willingness to actively participate.

D Develop differentiated technology application strategies. The study reveals that perceptions and impacts of DIT vary significantly based on gender, age, and teaching experience. Consequently, institutions should tailor their technology integration strategies to accommodate these differences. For example, younger teachers may benefit from training that focuses on improving their teaching efficacy, while experienced teachers may need more personalized support to incorporate DIT seamlessly into their existing pedagogical practices.

E Prioritize the alignment of technology with ideological and political goals. The success of curriculum Civics implementation depends not only on the technical attributes of DIT but also on its ability to effectively convey core ideological and political values. Schools should clearly define the specific mechanisms by which DIT contributes to achieving curriculum Civics goals and ensure that these mechanisms are reinforced through appropriate teacher training and curriculum design.

8.3 Research limitations and future directions

Despite its contributions, this study has several limitations:

A Limited generalizability due to the sample composition. The study sample was primarily drawn from sports colleges and universities, which may limit the generalizability of the findings to other educational contexts. Future research should expand the sample to include a broader range of institutions to validate the applicability of the findings across diverse educational settings.

B Cross-sectional design and lack of longitudinal analysis. This study relied on cross-sectional data, which may not capture the dynamic evolution of DIT's impact on curriculum Civics. Future research should employ longitudinal designs to examine how DIT influences educational outcomes over time.

C Omission of potential mediating and moderating variables. Future studies should consider additional variables such as teachers' beliefs, technology trust, and classroom context to further elucidate the complex mechanisms by which DIT affects curriculum Civics effectiveness.

D Focus on context-specific strategies. Given the variations in DIT's impact on different course types (e.g., theoretical versus practical), future research should explore how context-specific strategies can optimize the integration of DIT in various educational scenarios.

In summary, this study not only advances the theoretical understanding of the mechanisms underlying DIT's impact on curriculum Civics but also offers actionable guidance for the effective implementation of DIT in sports colleges and universities. Future research should continue to explore these pathways and develop context-specific strategies to ensure the successful integration of DIT in curriculum Civics across diverse educational contexts.

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.

Author contributions

ZW: Writing – original draft, Writing – review & editing. XB: Conceptualization, Investigation, Software, Writing – original draft, Writing – review & editing. SH: Data curation, Methodology, Conceptualization, Supervision, Writing – review & editing. ZJ: Conceptualization, Investigation, Software, Writing – original draft, Writing – review & editing. ZH: Conceptualization, Investigation, Software, Writing – original draft, Writing – review & editing. WW: Data curation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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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.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

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References

Abulibdeh, A., Zaidan, E., and Abulibdeh, R. (2024). Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: challenges, opportunities, and ethical dimensions. *J. Clean. Prod.* 437:140527. doi: 10.1016/j.jclepro.2023.140527

Becker, S. A., Brown, M., Dahlstrom, E., Davis, A., DePaul, K., Diaz, V., et al. (2018). NMC horizon report: 2018 higher. *education* Edn. Louisville, CO: Educause.

Burns, M. K., Warmbold-Brann, K., and Zaslofsky, A. F. (2015). Ecological systems theory in*School psychology review*. *Sch. Psychol. Rev.* 44, 249–261. doi: 10.17105/spr-15-0092.1

Castañeda, L., and Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *Int. J. Educ. Technol. Higher Educ.* 15, 15, 1–10. doi: 10.1186/s41239-018-0109-y

Chawla, D. S. (2018). The need for digital intelligence. *Nature* 562, S15–S16. doi: 10.1038/d41586-018-06848-6

Chen, L., Chen, P., and Lin, Z. (2020). Artificial intelligence in education: a review. *IEEE Access* 8, 75264–75278. doi: 10.1109/ACCESS.2020.2988510

Chen, S., Guo, L., Wang, Z., Mao, W., Ge, Y., Ying, X., et al. (2019). Current situation and progress toward the 2030 health-related sustainable development goals in China: a systematic analysis. *PLoS Med.* 16:e1002975. doi: 10.1371/journal.pmed.1002975

Chen, P., and Hu, M. (2024). Research on effective strategies of "curriculum civics and politics" in English teaching in higher vocational colleges in the internet era. *Appl. Math. Nonlinear Sci.* 9:20241037. doi: 10.2478/amns-2024-1037

Chiu, T. K. F., Moorhouse, B. L., Chai, C. S., and Ismailov, M. (2023). Teacher support and student motivation to learn with artificial intelligence (AI) based chatbot. *Interact. Learn. Environ.* 32, 1–17. doi: 10.1080/10494820.2023.2172044

Cismaru, D. M., Gazzola, P., Ciochina, R. S., and Leovaridis, C. (2018). The rise of digital intelligence: challenges for public relations education and practices. *Kybernetes* 47, 1924–1940. doi: 10.1108/K-03-2018-0145

Clark, R. C., and Mayer, R. E. (2023). E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning[M]. Hoboken, NJ: John Wiley & sons.

Cordes, C, and Miller, E. Fool's gold: a critical look at computers in childhood. (2000)

Cropanzano, R., Anthony, E. L., Daniels, S. R., and Hall, A. V. (2017). Social exchange theory: a critical review with theoretical remedies. *Acad. Manag. Ann.* 11, 479–516. doi: 10.5465/annals.2015.0099

Cropanzano, R., and Mitchell, M. S. (2005). Social exchange theory: an interdisciplinary review. *J. Manag.* 31, 874–900. doi: 10.1177/0149206305279602

Csapó, B., and Molnár, G. (2019). Online diagnostic assessment in support of personalized teaching and learning: the eDia system. *Front. Psychol.* 10:1522. doi: 10.3389/fpsyg.2019.01522

Cuban, L. (2001). Oversold and underused: Computers in the classroom[Z]. Cambridge, MA: Harvard University Press.

Cui, W. (2023). Research on management path and operation mechanism construction of civic education in colleges and universities in the era of artificial intelligence. *Appl. Math. Nonlinear Sci.* 9, 0314–0322. doi: 10.2478/amns-2024-0314

Davis, F. D., Bagozzi, R., and Warshaw, P. (1989). Technology acceptance model. *J Manag Sci* 35, 982–1003.

Deci, E. L., and Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Can. Psychol.* 49, 14–23. doi: 10.1037/0708-5591.49.1.14

Deci, E. L., and Ryan, R. M. (2012). Self-determination theory. *Handbook Theories Soc. Psychol.* 1, 416–437.

Dong, B., Zou, Z., Song, Y., Hu, P., Luo, D., Wen, B., et al. (2020). Adolescent health and healthy China 2030: a review. *J. Adolesc. Health* 67, S24–S31. doi: 10.1016/j.jadohealth.2020.07.023

Dong, B., Zou, Z., Song, Y., Hu, P., Luo, D., Wen, B., et al. (2018). Adolescent health and healthy China 2030: a cross-sectional study. *Lancet* 392:S63. doi: 10.1016/S0140-6736(18)32692-8

Dostál, J, Wang, X, Steingartner, W, and Nuangchalerm, P. Digital intelligence - new concept in context of future of school education. CERI Proceedings. IATED, Seville, Spain (2017).

Fariani, R. I., Junus, K., and Santoso, H. B. (2023). A systematic literature review on personalised learning in the higher education context. *Technol. Knowl. Learn.* 28, 449–476. doi: 10.1007/s10758-022-09628-4

Feng, M., Heffernan, N., and Koedinger, K. (2009). Addressing the assessment challenge with an online system that tutors as it assesses. *User Model. User-Adap. Inter.* 19, 243–266. doi: 10.1007/s11257-009-9063-7

Gautam, P., Singh, B., Singh, S., Bika, S. L., and Tiwar, R. P. i. (2024). Education as a soft power resource: a systematic review. *Heliyon* 10:e23736. doi: 10.1016/j.heliyon.2023.e23736

Gauttam, P., Singh, B., and Chattu, V. K. (2021). Higher education as a bridge between China and Nepal: mapping education as soft power in Chinese foreign policy. *Societies* 11:81. doi: 10.3390/soc11030081

Granić, A., and Marangunić, N. (2019). Technology acceptance model in educational context: a systematic literature review. *Br. J. Educ. Technol.* 50, 2572–2593. doi: 10.1111/bjet.12864

Hattie, J. (2008). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. London: Routledge.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling[EB/OL].

Hew, K. F., and Cheung, W. S. (2013). Use of web 2.0 technologies in K-12 and higher education: the search for evidence-based practice. *Educ. Res. Rev.* 9, 47–64. doi: 10.1016/j.edurev.2012.08.001

Jani, S. H. Md., Shahid, S. A. Md., Thomas, M., Francis, P., and Jislan, F. (2018). Using teaching effectiveness scale as measurement for quality teaching. *Int. J. Acad. Res. Bus. Soc. Sci.* 8, 1394–1404. doi: 10.6007/IJARBSS/v8-i9/4704

Jokhan, A., Chand, A. A., Singh, V., and Mamun, K. A. (2022). Increased digital resource consumption in higher educational institutions and the artificial intelligence role in informing decisions related to student performance. *Sustain. For.* 14:2377. doi: 10.3390/su14042377

Khalil, M. K., and Elkhider, I. A. (2016). Applying learning theories and instructional design models for effective instruction. *Adv. Physiol. Educ.* 40, 147–156. doi: 10.1152/advan.00138.2015

Kohnke, L., Moorhouse, B. L., and Zou, D. (2023). ChatGPT for language teaching and learning. *RELC J.* 54, 537–550. doi: 10.1177/00336882231162868

Låg, T., and Sæle, R. G. (2019). Does the flipped classroom improve student learning and satisfaction? A systematic review and meta-analysis. *AERA Open* 5:2332858419870489. doi: 10.1177/2332858419870489

Langton, K. P., and Jennings, M. K. (1968). Political socialization and the high school civics curriculum in the United States. *Am. Polit. Sci. Rev.* 62, 852–867. doi: 10.2307/1953435

Liu, H., Kulturel-Konak, S., and Konak, A. (2021). Key elements and their roles in entrepreneurship education ecosystem: comparative review and suggestions for sustainability. *Sustainability* 13:10648.

Luo, Y. (2024). The time value and practice path of the integration of sports Spirit into ideological and political teaching in colleges and universities. *J. Sport Psychol.* 33, 287–294.

Ma, Q., and Liu, L. (2005). The technology acceptance model: a meta-analysis of empirical findings[M]//Mahmood M a. advances in end user computing. *IGI Global* 16, 112–128. doi: 10.4018/978-1-59140-474-3.ch006

Mann, S. J. (2003). E-learning in the 21st century-a framework for research and practice. *Innov. Educ. Teach. Int.* 40:313.

Marsh, H. W., and Roche, L. A. (1997). Making students' evaluations of teaching effectiveness effective: the critical issues of validity, bias, and utility. *Am. Psychol.* 52, 1187–1197. doi: 10.1037/0003-066X.52.11.1187

Means, B, Toyama, Y, Murphy, R, Bakia, M., and Jones, K. Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Washington, D.C.: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development (2009).

Miller, E, and Almon, J. (2009). *Alliance for childhood[J]*. College Park, MD: Alliance.

Mithas, S., and McFarlan, F. W. (2017). What is digital intelligence? *IT Professional* 19, 3–6. doi: 10.1109/MITP.2017.3051329

Moore, J. L., Dickson-Deane, C., and Galyen, K. (2011). E-learning, online learning, and distance learning environments: are they the same? *Internet High. Educ.* 14, 129–135. doi: 10.1016/j.iheduc.2010.10.001

Ndukwe, I. G., and Daniel, B. K. (2020). Teaching analytics, value and tools for teacher data literacy: a systematic and tripartite approach. *Int. J. Educ. Technol. High. Educ.* 17, 1–31. doi: 10.1186/s41239-020-00201-6

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., and Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educ. Technol. Res. Dev.* 71, 137–161. doi: 10.1007/s11423-023-10203-6

O'Neill, G. P. (1988). Teaching effectiveness: a review of the research. *Can. J. Educ.* 13:162. doi: 10.2307/1495174

Ouyang, S., Zhang, W., Xu, J., Mat Rashid, A., How, S. P., and Bin Hassan, A. (2024). Unmasking the challenges in ideological and political education in China: a thematic review. *Heliyon* 10:e29176. doi: 10.1016/j.heliyon.2024.e29176

Pace, J. L., and Hemmings, A. (2007). Understanding Authority in Classrooms: a review of theory, ideology, and research. *Rev. Educ. Res.* 77, 4–27. doi: 10.3102/003465430298489

Pedro, F, Subosa, M, Rivas, A. Artificial intelligence in education: Challenges and opportunities for sustainable development. Perú: Ministerio de Educación (2019).

Rangel-de Lázaro, G., and Duart, J. M. (2023). You can handle, you can teach it: systematic review on the use of extended reality and artificial intelligence Technologies for Online Higher Education. *Sustain. For.* 15:3507. doi: 10.3390/su15043507

Reeves, T. C. (2011). Can educational research be both rigorous and relevant. *Educ. Designer* 1, 1–24.

Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., and Pianta, R. C. (2016). How teacher emotional support motivates students: the mediating roles of perceived peer relatedness, autonomy support, and competence. *Learn. Instr.* 42, 95–103. doi: 10.1016/j.learninstruc.2016.01.004

Spector, J. M. (2013). Emerging educational technologies and research directions. *J. Educ. Technol. Soc.* 16, 21–30.

Steinert, Y., Mann, K., Anderson, B., Barnett, B. M., Centeno, A., Naismith, L., et al. (2016). A systematic review of faculty development initiatives designed to enhance teaching effectiveness: a 10-year update: BEME guide no. 40. *Med. Teach.* 38, 769–786. doi: 10.1080/0142159X.2016.1181851

Straub, E. T. (2009). Understanding technology adoption: theory and future directions for informal learning. *Rev. Educ. Res.* 79, 625–649. doi: 10.3102/0034654308325896

Sung, Y. T., Chang, K. E., and Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: a meta-analysis and research synthesis. *Comput. Educ.* 94, 252–275. doi: 10.1016/j.compedu.2015.11.008

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., and Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning. *Rev. Educ. Res.* 81, 4–28. doi: 10.3102/0034654310393361

Tschannen-Moran, M., Hoy, A. W., and Hoy, W. K. (1998). Teacher efficacy: its meaning and measure. *Rev. Educ. Res.* 68, 202–248. doi: 10.3102/00346543068002202

Wu, Q. (2024). New thoughts on the construction of the curriculum system of civic and political education for college students in the information age. *Innovations* 7:8.

Zhao, Y., Pugh, K., Sheldon, S., and Byers, J. L. (2002). Conditions for classroom technology innovations. *Teach. Coll. Rec.* 104, 482–515. doi: 10.1111/1467-9620.00170

Zhoc, K. C. H., Webster, B. J., King, R. B., Li, J. C. H., and Chung, T. S. H. (2019). Higher education student engagement scale (HESES): development and psychometric evidence. *Res. High. Educ.* 60, 219–244. doi: 10.1007/s11162-018-9510-6