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Developing scientific entrepreneurship and complex thinking skills: creating narrative scripts using ChatGPT

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The increased access to artificial intelligence (AI) applications has made it possible to develop more engaging and complex educational activities for students in different disciplines. This research explored expanding university students' knowledge of scientific entrepreneurship skills using an Artificial Intelligence application. The students participated in a training experience using the conversational ChatGPT language model to generate narrative scripts for various topics on scientific discoveries and technological advances to create new products or services that offer cost-effective solutions based on science. The experience was designed employing the i4C model (identify, ideate, invent, inform). The study used a two-sample design with repeated measurements based on a pre-test and post-test. One hundred five graduate students from two master's degree programs at the Bolivarian University of Ecuador participated during the 2022–2023 academic period. The results indicate that the students notably improved in acquiring the knowledge necessary for scientific entrepreneurial skills. The study concluded that applying AI ChatGPT with a narrative scripting strategy can create new learning opportunities for students.

KEYWORDS

higher education, ChatGPT, complex thinking, educational innovation, narrative script

1 Introduction

The emergence of digital applications has allowed the development of creative and motivating academic activities (Cabero-Almenara et al., 2022); one is the creation of narrative scripts (Avello-Martínez et al., 2020) in the digital environment. These are interactive and visual stories that can capture student interest as they combine various information formats, such as text, images, and videos, that can be published on two-dimensional viewing platforms such as web pages or for immersive activities in virtual or augmented reality (Pavlou, 2019; Doolani et al., 2020; Skult and Smed, 2020). Thus, digital narrative scripts are pertinent strategies for classroom implementations (Koenitz, 2016; Mariani and Ciancia, 2023).

The digital narrative is also a form of complex discourse (Orellana et al., 2022) that all students must practice at various times in their training to communicate the progression of events in a plot (Snow, 2017). Narrative discourse is present in thinking, teaching, and learning (Hess, 2010), so it is necessary to develop the ability to improve communication among the actors in a training activity.

The detailed study of narrative in literature has highlighted the importance of several crucial components that together contribute to the effectiveness and power of a story (Labov and Waletzky, 1997). One of these fundamental aspects is coherence within the macrostructure of the narrative, which refers to the overall structure and flow of narrative discourse. This structure is not arbitrary, but rather follows a pattern that facilitates understanding, engagement and retention by the reader or listener.

The macrostructure is broken down into key stages. The first stage is the beginning, which sets the tone of the story, introducing the main characters, setting, and context. This beginning is crucial because it provides the first impression of the narrative and sets the audience's expectations (Orellana et al., 2022). Then follows the initial event, a moment that triggers the main plot of the narrative and sets subsequent events in motion. This is the spark that starts the action and is essential to capturing the audience's continued interest (Lavrysh et al., 2023).

Next, actions constitute the sequence of events that develop as a response or consequence of the initial event. This phase is vital for character development and plot advancement, providing the main body of the narrative and allowing characters to demonstrate their evolution and depth through their reactions and decisions in the face of the challenges presented (Rosnaeni et al., 2020). The climax represents the point of maximum tension and conflict in the narrative, where the protagonists face their greatest obstacles. It is the climactic moment that determines the outcome of the plot and is often the most remembered and emotionally charged aspect of the story (Hokanson et al., 2018).

The resolution brings closure to the story, resolving the conflicts presented and answering the key questions. This stage is essential for leaving the audience with a feeling of satisfaction and completeness, providing a logical and coherent conclusion to the plot and character arcs. Together, these stages form the backbone of any successful narrative, ensuring that the story flows logically and engagingly from beginning to end, finally, the cohesion refers to the internal linguistic structure, which includes conjunctions, subjects, and other grammatical elements (Justice and McGinty, 2009; Hiver et al., 2020).

In the digital environment, narrative scripts have had great relevance among content designers who constantly publish videos on social media; the scripts sometimes have instructional elements associated with them (de Souza and Rodrigues, 2022). The primary quality of these narratives lies in the fact that their authors are not necessarily communication professionals but people with access to knowledge and general-purpose software that can be found on any digital device (Navio-Marco et al., 2022).

In education, storytelling is an essential tool, allowing the effective and engaging transmission of knowledge and learning to students and opening up possibilities for their participation in learning (Mariani and Ciancia, 2019). Thus, digital storytelling has become an increasingly popular educational tool (Rubio-Hurtado et al., 2022), as it facilitates learning experiences to be designed through the creation, for example, of educational videos with high visual quality and engaging content (Del Moral et al., 2018), transforming educational dynamics in a more participatory and personalized approach (Koenitz, 2018).

The use of digital narratives in training activities improves their quality and the motivation and interest of students in learning (van Aswegen et al., 2019), some have mentioned that these narratives should be short, between 3 and 6 min, and represent how events are perceived and reflected upon (Nygren and Blom, 2001). They also must transmit experiences by combining narrating voice, a sequence of static or dynamic images, and, optionally, background music (Lambert, 2013), i.e., multimodal texts that amalgamate information from three channels: textual, auditory, and visual (Alonso et al., 2013; Miller et al., 2020).

In educational practice, the use of narrative learning strategies is common, especially at the primary education level (Rubio-Hurtado et al., 2022), as they foster skills to organize ideas and create a story to share the results of an activity carried out in the school environment, thereby also invigorating the development of lifelong learning skills and critical and creative thinking (Hiver et al., 2020). In higher education, digital narratives improve the educational process by boosting students' creativity (Hung, 2019). The use of digital narratives in university practices has several advantages: (a) they can be presented in conventional formats such as videos; (b) they can be published in multiple internet spaces such as social networks and websites; (c) various digital technologies can be used; (d) the creation process allows deepening the understanding of a topic; (e) digital narratives allow expressing complex ideas audiovisually; and (f) they foster reflection, creativity, critical thinking and organizational skills (Di Blas, 2022).

Despite the benefits offered by digital storytelling in education, it is essential to recognize that creating a compelling narrative can present considerable challenges, especially for those students who lack experience in text production (Hurtado-Mazeyra et al., 2023). The ideation and scripting process requires specific and possibly intimidating skills (Lavrysh et al., 2023). However, students who do not have experience can benefit from using AI-based tools. For example, technologies such as ChatGPT can assist students in generating content and provide creative suggestions for constructing intriguing and coherent narratives (Tan, 2020; Nazari et al., 2021). In addition, research has shown that integrating artificial intelligence into narrative creation can significantly improve process efficiency and final product quality (Gillani et al., 2023; Hwang and Chen, 2023).

Therefore, this study aimed to implement a training experience using a ChatGPT AI application as a support tool to generate narrative scripts to strengthen higher education students' learning of scientific entrepreneurship. In this research, the entrepreneurship approach is not only applied to the ideation and creation of new companies, but also to promote an entrepreneurial attitude that allows students to identify opportunities, solve problems and make decisions in an innovative and effective way (García-González and Ramírez-Montoya, 2023).

Scientific entrepreneurship in education refers to using the knowledge generated in universities for the creation of new companies by teachers and researchers who have developed scientific thinking (Aldridge et al., 2014), it is also associated with the capacity of students to use scientific knowledge and skills such as research, critical thinking, problem solving and effective communication, to create innovative and sustainable solutions to address real problems (Yu and Du, 2021).

Promoting the learning of this type of entrepreneurship in universities allows business education to be integrated into professional education (Wu et al., 2018), and thereby create innovative awareness in young people in order to create regional competitive advantages (Ma et al., 2020). Scientific entrepreneurship can be translated into various products such as the creation of scientific research projects, technological design and development, and the publication of creative experiences based on the scientific method (Yoganandan and Vasan, 2022). The above requires not only the collaboration of academia, but also creating connections between companies and the government to project the benefits of entrepreneurship in society, the economy and education.

The study employed a pedagogical method called i4C (George-Reyes C. E. et al., 2023), which uses a process of identification, ideation, invention, and information to unleash entrepreneurship skills. The question that guided the development of this research was: What is the scaling of scientific, entrepreneurship knowledge of students who participated in a training experience utilizing ChatGPT and the creation of narrative scripts?

1.1 Artificial intelligence in education

Several studies have demonstrated the potential of artificial intelligence in the field of education (Ariyaratne et al., 2023; Berger and Schneider, 2023; Cingillioglu, 2023; García-González and Ramírez-Montoya, 2023; Halaweh, 2023). It has been argued that digital AI tools and applications can improve the efficiency and quality of teaching by allowing students to receive personalized, real-time feedback (Chen et al., 2020; Gao, 2021), as well as to create and improve the quality of educational content (Pavlik, 2023), especially in distance education (Knox, 2020).

One AI application is ChatGPT, a Large Language Model (LLM) designed to generate coherent and contextual responses in written conversations (Open AI, 2023). It relies on machine learning and artificial intelligence to understand text, answer questions, and converse with users. Its main feature is generating narratives through machine learning algorithms handling large amounts of text and triggered by text or questions called "prompts" (Scharth, 2022). The expectation generated since its launch has permeated teaching practice (Jeon and Lee, 2023), given it is affirmed that its applications can favorably impact the writing of texts and serve as an input to produce didactic resources (Cooper, 2023; Hu, 2023).

Some research examining the use of this tool has indicated that ChatGPT has the potential to improve learning experiences (Alneyadi and Wardat, 2023), however, further exploration is needed to evaluate its long-term impact on diverse educational contexts (Alneyadi and Wardat, 2024), other studies affirm that the implementation of LLM in education can threaten integrity, so it is necessary to establish agile and ethical integration strategies that maintain rigorous pedagogical, research and evaluation standards (Tarisayi, 2024).

Research converges on the fact that ChatGPT can assume four general roles: interlocutor, content provider, teaching assistant, and evaluator (Berger and Schneider, 2023; Farrokhnia et al., 2023), as an interlocutor, ChatGPT serves as an interactive conversation partner, capable of engaging in real-time dialogues with users, which can encourage learning through discussion, allowing users to explore ideas and concepts in depth (Lee et al., 2024). In the role of content provider, it acts as a source of information and knowledge, since it can generate explanations on a wide range of topics, using the tool to obtain creative ideas for projects or research (Mahapatra, 2024).

Regarding your role as a teaching assistant, you can complement teaching by providing additional educational support by creating teaching materials, offering additional explanations, and answering students' questions (Punar Özçelik and Yangın Ekşi, 2024), and finally in your role as evaluator, ChatGPT has the ability to design and score a wide range of assessment instruments, including questionnaires and rubrics in various formats, offering educators customizable and effective tools to measure student performance (Steiss et al., 2024).

Its operation is based on four pillars: (1) machine learning, which allows learning from large sets of natural language data without the need to explicitly program each rule of grammar, language use or context; (2) natural language generation, to produce responses that sound human and coherent, which involves creating complete sentences and paragraphs that flow logically and maintain cohesion; (3) text comprehension, to interpret the meaning, intention and underlying context of the interactions. This capability is critical to allowing the system to respond relevantly and accurately to user input; and (4) adaptability, which is the ability to learn from new information and experiences and improve your performance over time. This allows responses to be adjusted according to emerging language trends (Lim et al., 2023).

Respecting its impact on education, research has shown that its use can strengthen teaching practice because it can identify and organize various resources for quality pedagogical decisions (Haluza and Jungwirth, 2023) and cultivate students' research skills (Susnjak, 2022). Among its main contributions is promoting student participation and collaboration, allowing them to obtain answers to discuss topics by posing questions (Hwang and Chen, 2023); it offers more agile access to information than traditional search engines (Farrokhnia et al., 2023) and even synthesizes the most relevant contributions (Cascella et al., 2023).

As for its contribution to the creation of narratives in higher education, some studies have mentioned that ChatGPT can improve writing skills, identify grammatical errors in a text, and summarize information (Johinke et al., 2023). This makes the tool an ally for students to save time and effort in the rapid generation of texts (Ariyaratne et al., 2023; Halaweh, 2023); thus, as a complex language model, it can aid in story writing (Lo, 2023; Rahman and Watanobe, 2023). Through its ability to generate coherent and relevant text, ChatGPT can help students structure their narratives due to its potential to generate ideas, offer assistance in creating narrative structures, generate the dialogues in a narrative, and assist in the writing and editing of written work (Pavlik, 2023).

2 Method

In this research, a quasi-experimental design was used because it was not possible to carry out a random assignment of participants; we intentionally sought to have the majority of students studying subjects related to academic writing (Althubaiti and Althubaiti, 2024). This design is commonly used in educational contexts, where groups of students may receive different interventions based on school logistics, preferences, or educational needs (Shi and Cheung, 2024).

The research employed the i4C method (George-Reyes C. E. et al., 2023) to create a training experience that aimed to develop a narrative script with the support of the ChatGPT application. The script served as input for the design of a scientific entrepreneurship project. The method imbricates design and complex thinking and consists of four phases: identify, ideate, invent, and inform (i4C). "Identify" means that students must analyze the environment based on scientific research to identify opportunities for scientific entrepreneurship that may arise from educational problems. The above is considered an important input for writing the narrative.

The ideation phase involves generating ideas collaboratively with the help of ChatGPT. Phase 3, inventing, translates into the construction of a narrative script, i.e., a textual prototype that will be transformed into a textual element. Finally, the fourth phase focuses on the ability to inform textual prototyping systematically, effectively, clearly, and persuasively. Figure 1 shows the i4C method.

2.1 Participants

For the sampling of participants in the training experience "Design of narrative scripts for the construction of scientific entrepreneurship proposals" at the Bolivarian University of Ecuador, a non-probabilistic convenience sampling method was used (Novielli et al., 2023). This method was chosen given that the participants were graduate students already enrolled in two specific programs, which facilitated their access and participation.

A training experience called *Design of narrative scripts for the construction of scientific entrepreneurship proposals* was developed and implemented at the Bolivarian University of Ecuador at the postgraduate level. One hundred five students (64 women and 41 men) in the master's degree in education, specifically focusing on Digital Environments (Group $a = 62$; 28 men and 34 women) and the Master's Degree in Educational Management (Group $b = 43$; 19 men and 24 women) participated. Both groups used the online modality during the 2022–2023 academic period.

2.2 Design and implementation of the digital narratives course

The training experience was designed and implemented through videoconferencing for the synchronous sessions and a web page to perform the asynchronous activities. The tutor had an introductory session with the students to explain the method's intention, the learning path's description, the number of sessions, how ChatGPT would be used, and the expected deliverable. Figure 2 shows the induction that the students received, this was developed in a face-to-face session with three moments: (1) the preparation for the course that consisted of the registration of the participants, the verification that everyone could access the videoconference sessions, the website and the resources, (2) the engaging with the i4C method in which its purpose and stages were explained, and (3) engaging to learn about the agenda and topics of the course.

The training experience had eight sessions from September to November 2023. A tutor led all the synchronous sessions through an online videoconferencing platform. The activities and learning products occurred asynchronously using the website as a work scenario, always with the asynchronous mentoring of the tutor. The course had four topics related with the scientific entrepreneurship: (1) Identify, (2) Ideate, (3) Invent, and (4) Inform, each with content aimed at strengthening skills to build a narrative script with the support of ChatGPT. In each topic, students were instructed about using ChatGPT for the introductory activities, primarily how to design questions called prompts to interact with the generative language artificial intelligence system. The AI tool was also used to develop activities involving case studies and collaborative actions. A deliverable was the product of each topic and a digital narrative about a scientific entrepreneurship issue. Figure 3 illustrates the structure of the course.

2.3 Instrument

To measure the scaling of the knowledge achieved in scientific entrepreneurship at the end of the training experience, we applied an

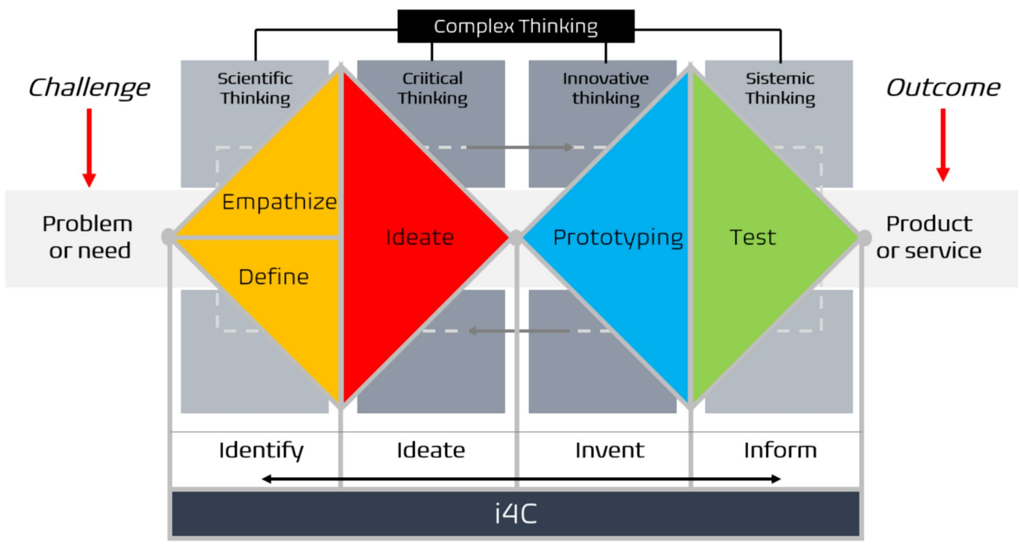

FIGURE 1
Appr components of the i4C methodology.

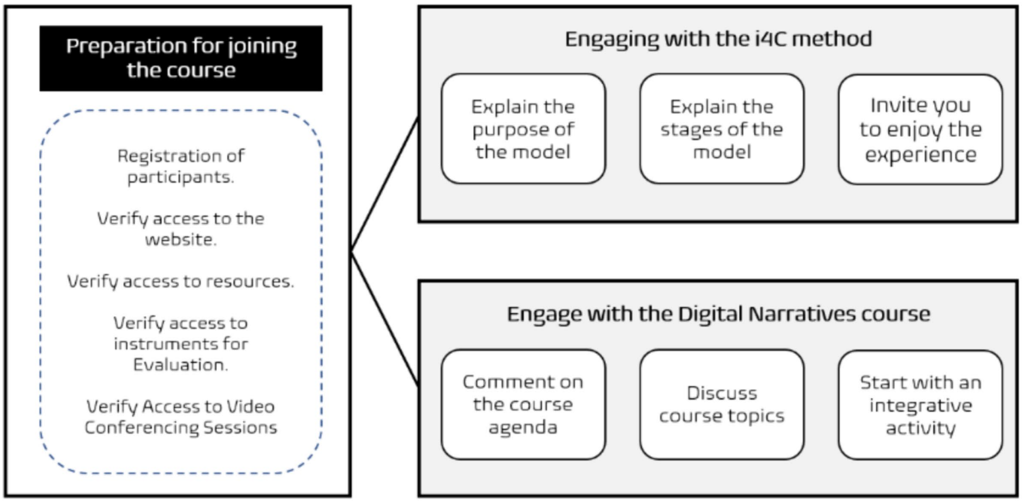

FIGURE 2
Engagement strategy with the participants.

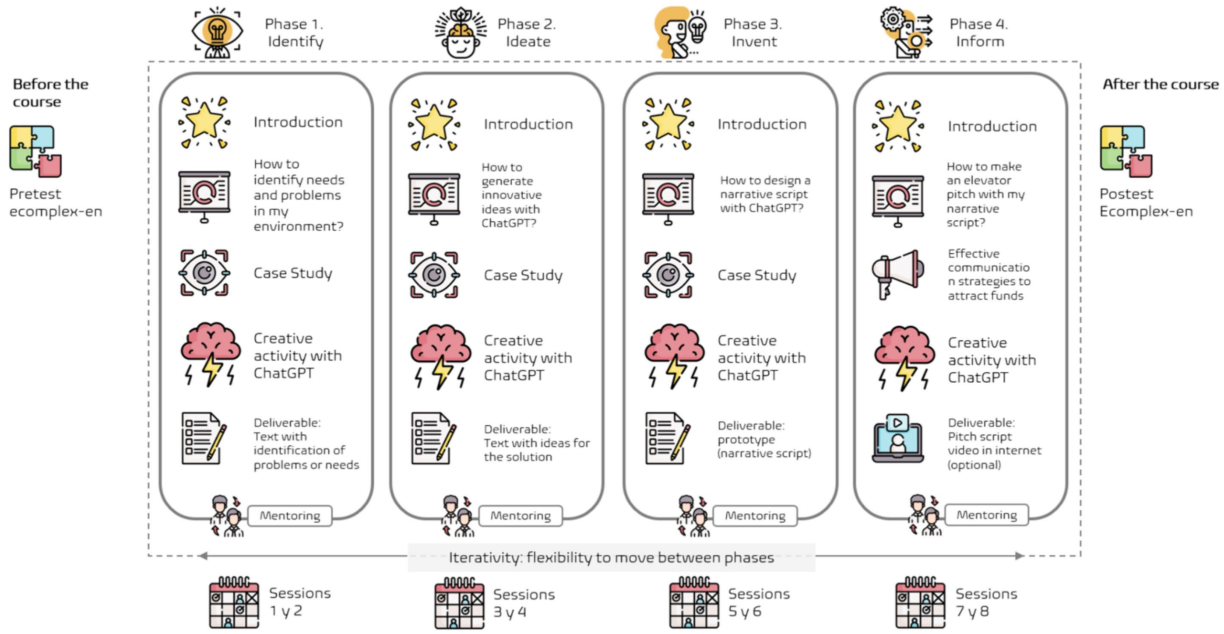

FIGURE 3
Interaction and flow of course activities.

instrument called *ecomplex-em* (George-Reyes C. et al., 2023). This instrument was developed from various theoretical-empirical references related to scientific entrepreneurship (Vázquez-Parra et al., 2023; Alonso-Galicia et al., 2024), as well as complex thinking, it comprised 23 items grouped into eight dimensions (see Table 1), the response scale was Likert type with 4 options: (1) totally disagree, (2) disagree, (3) agree, and (4) totally agree. As can be seen in Figure 3, was applied before the implementation of the course and after its completion (i.e., pre-test and post-test).

3 Results

A descriptive analysis determined the normal distribution of all items. The asymmetry and kurtosis indicators showed no extreme values for asymmetry or kurtosis in the range of |2.00| (Bandalos and Finney, 2001), so the sample was assumed to have a normal distribution. Table 2 shows that the asymmetry is negative in the pre-test for both groups and for the post-test in group 1, i.e., there is a concentration of higher scores at the right end of the distribution,

TABLE 1 Dimensions and items of the ecomplex-em instrument.

Dimension	No.	Item
Technical knowledge and experience in the field	Q1	I have the disciplinary knowledge necessary to participate in a scientific entrepreneurial project.
	Q2	I have experience collaborating on or leading a scientific entrepreneurial project.
	Q3	My professional training allows me to collaborate on scientific entrepreneurial projects.
Technology trend analysis and Market understanding	Q4	I can identify the information sources for technological trends.
	Q5	I can understand which trends link to the needs of scientific entrepreneurship.
	Q6	I can choose among the various technological trends which ones apply to my scientific entrepreneurial project.
Development of technology-based products/services	Q7	I have collaborated on developing services based on science and technology.
	Q8	I have led the development of products based on science and technology.
	Q9	I can develop scientific entrepreneurship ideas aimed at solving scientific-technological problems.
Management and protection of intellectual property	Q10	I can differentiate what can be registered as intellectual property and what cannot.
	Q11	I know the procedure for registering intellectual property.
	Q12	I can design strategies to register the intellectual property of the various components of a scientific undertaking.
Agile and slim design methods	Q13	I can complete the stages of a scientific endeavor in a short time.
	Q14	I can integrate the tasks of a work team to design project stages.
	Q15	I can work through the project segmentations and adapt the scientific undertaking on the fly.
Digital marketing and growth hacking	Q16	I know how to design strategies with the minimum expense and effort and increase the volume of users, revenues, or project impact.
	Q17	I can apply methodologies to analyze user and market behavior data to create growth strategies.
	Q18	I have the ability to find out-of-the-box solutions to the most common challenges.
Technology adoption and design of user experience	Q19	I know methodologies to evaluate the adoption of technology for a scientific venture.
	Q20	I know methodologies to evaluate a user's experience with scientific ventures.
Data-based decision-making and analyses	Q21	I can design metrics and data to guide decisions to formulate a scientific undertaking.
	Q22	I can construct logical, systematic, qualitative, and quantitative processes to determine the most important factors in developing a scientific undertaking.
	Q23	I know information management models to guide decision-making.

TABLE 2 Statistical analysis of normality.

Variable	Mean	EE	Std. Dev.	Median	Asymmetry	Kurtosis
PreG1	2.8856	0.0407	0.1950	2.8710	−0.09	−1.04
PreG2	2.9494	0.0385	0.1844	2.9302	−0.00	−0.86
PosG1	3.3878	0.0187	0.0896	3.3871	−0.18	−0.31
PosG2	3.4580	0.0289	0.1384	3.4651	0.72	1.84

suggesting that most of the participants initially had relatively high performance before starting the course. This could be due to various factors, such as previous educational background, subject matter experience, or skills.

However, in the group 2 posttest, the situation was different due to a positive score in the asymmetry, which means that after the course, there was a shift towards higher scores at the right end of the distribution. This suggests that the course may have had a more positive effect on improving the performance of those participants who initially had lower performance. Kurtosis is a statistical measure that describes the shape of the data distribution relative to the normal distribution. In this context, negative kurtosis indicates that the data distribution is relatively flat and wide, with lighter tails than the normal distribution, while positive kurtosis suggests a more pointed distribution with heavier tails. The negative kurtosis in the pre-tests of both groups indicates that, before the start of the course, the scores were relatively dispersed but concentrated in the central region of the distribution.

The above indicates that most participants had similar levels of performance before the course intervention, with less presence of extreme values. Kurtosis was negative in the Group 1 posttest, suggesting that the course may have had a heterogeneous impact on these participants. On the other hand, positive kurtosis in the Group 2 posttest indicates that, after the course, there was more variability in scores, possibly because some participants experienced significant improvements and others had lower performance. The presence of extreme values suggests a diversity of responses.

Figure 4 shows an item analysis for the pre-test and post-test where, in the pre-test, there was a higher concentration of outliers, particularly in items Q1, Q9, Q11, Q12, Q21, and Q22, indicating that some participants had significantly different responses than the rest. Q21 (I can design metrics and data to guide decisions to formulate a

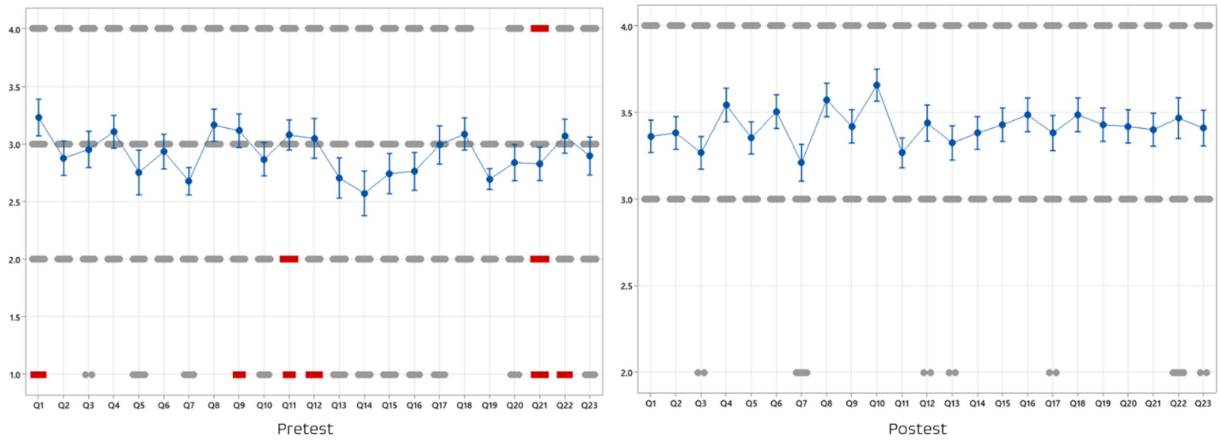

FIGURE 4
Outlier analysis for pretest and posttest.

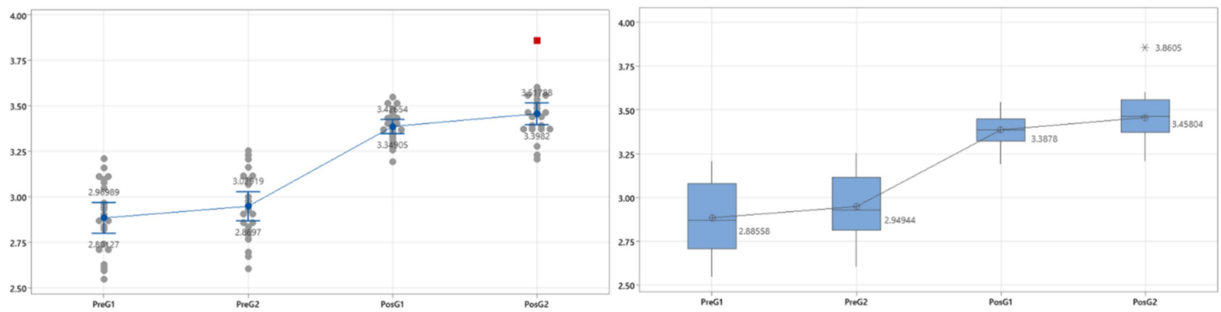

FIGURE 5
Comparison of means between pre-test and post-test by groups.

scientific undertaking) had a minimum value of 1 and a maximum of 4; this wide variability in the responses suggests that the participants had diverse perceptions and opinions concerning the importance and understanding of the task of designing metrics and data in a scientific undertaking.

Analyzing the items in the posttest was essential to examine how participation in the course influenced the understanding of the topics addressed. The results revealed a significant change in the distribution of responses, evidencing a decrease in the concentration of outliers compared to the pre-test. No perceptions were observed below the "agree" and "strongly agree" options, suggesting a widespread improvement in the understanding of scientific entrepreneurial skills among participants after the course intervention. This allowed us to affirm that the course positively impacted students' understanding and perception of scientific entrepreneurial skills.

To delve into the search for outliers, we made a new comparison between the pre-test and the post-test by group. Figure 5 confirms that there are differences between the means. The means were higher in the post-test (G1 = 3.3878; G2 = 3.4580) than in the pre-test (G1 = 2.8856; G2 = 2.9494), suggesting that the course contributed positively to developing entrepreneurship skills. However, notably, in the Group 2 posttest, one score was well above all the means (M = 3.8605); this higher value indicates that, in Group 2, some participants achieved exceptionally high scores compared to the rest of the participants in the same group and with the general average. This is another indicator that some participants experienced a particularly positive impact from the course, demonstrating a significantly higher level of improvement.

A detailed analysis was conducted using the Student's *t*-test for the two samples to identify possible significant differences. The results in Table 3 reveal a moderate positive Pearson correlation of 0.2826, indicating a general upward trend between pre-test and post-test scores. To confirm the existence of statistically significant differences, we applied Tukey's coefficient I ($T\alpha = 0.21$) to verify whether the observed variations were significant, considering a sampling difference of 0.5 as a reference base. The results indicated a statistically significant difference, with a value that reflects a considerable variation in the mean between the pre-test and the post-test (0.4977). It is important to note that this result is significant at a 95% confidence level ($p = 0.05$). Statistical evidence supports the conclusion that the pre-test mean is significantly lower than the post-test average, providing a solid basis for stating that the training experience had a positive and significant impact on the development of the skills assessed.

An analysis of variance (ANOVA) of a fixed-effect factor was performed to validate the disparities in results between the pre-test and post-test. The results in Table 4 reveal a critical value (Fc) of

TABLE 3 Analysis of the *t*-test (pre-test y post-test).

	Pre	*Post*	*Sample difference (sd)*	*TukeyMethod Tα = 0.21*
Mean	2.9271	3.4248	0.5	Si Tα < sd = Statistically significant difference exists.
Variance	0.0322	0.0107		
Pearson Correlation	0.2826			

TABLE 4 One-factor ANOVA analysis.

Evaluation	Count	Sum	Percentage	Variance
Pre	23	67.11627907	2.91809909	0.034459
Post	23	78.3255814	3.405460061	0.007858

ANOVA						
Source of variation	Sum of squares	Degrees of liberty	Mean squared	*F*	*p*-value	*F* critical
Between the groups	2.849689652	1	2.849689652	132.5862	0.0000	4.0617
Inside the groups	0.945696712	44	0.021493107			
Total	3.795386363	45				

4.06170 and an F coefficient of 132.5862. The F > Fc relationship indicates that the observed disparities are not random but statistically significant. This data indicates that participating in the scientific entrepreneurial course using digital narratives positively participation with improvements in students' entrepreneurial skills. The high value of the F-coefficient suggests that the variations in results between the pre-test and post-test are pronounced enough to be considered beyond attributable to chance. The ANOVA analysis confirms the existence of significant differences and provides a solid statistical basis to support the claim that the course intervention positively influenced the development of participants' entrepreneurial skills.

Finally, we analyzed the correlation coefficients between the pre-test and post-test for the two groups. Figure 6 shows that the coefficient in the pre-test for Group 1 (PreG1) and Group 2 (PreG2) was 0.747. This correlation indicates a strong and positive relationship between the two groups. Concerning the coefficient in the pre-test of Group 2 (PreG2) and the post-test of Group 1 (PostG1) (0.231), although positive, it is weaker than the previous one. However, in the posttests of Group 1 (PosG1) and Group 2 (PosG2), the coefficient was 0.711, referencing a strong relationship and indicative of consistent patterns of positive performance among the course participants, both within the same group and between groups.

4 Discussion

Analysis of the results, illustrated in Figure 4, indicates that after the implementation of ChatGPT, a decrease in the variability of students' scores in the 'Postest' compared to the 'Pretest' is observed. This homogenization of the responses, evidenced by shorter error bars in the 'Postest', suggests a consolidation in the understanding of the concepts evaluated. Furthermore, mean scores tend to be higher in the 'Posttest' for most questions, which points to a significant improvement in students' knowledge. These changes are consistent with the hypothesis that the ChatGPT intervention has had a positive effect on the understanding of scientific entrepreneurship among participants.

The analysis in Figure 4 reflects consolidation and homogenization in the participants' understanding of scientific entrepreneurship concepts. The decrease in outliers suggests that the course, using the ChatGPT tool, managed to bring together and standardize the perceptions and knowledge of the students. The reduction in dispersion indicates greater consistency in interpreting entrepreneurial skills, suggesting that the intervention successfully provided a more uniform and shared understanding of these concepts.

These findings support the usefulness of the ChatGPT tool as a practical resource for improving the understanding and application of concepts related to scientific entrepreneurship. The reduction of outliers and the homogenization in the perception of entrepreneurial skills point to the effectiveness of the research approach, highlighting the importance of integrating artificial intelligence tools such as ChatGPT in training and developing specific skills. Although the study found differences between the means, these were positive, as shown in Figure 5.

The reduction of outliers and homogenization of the data are visually observed in the box plots through the decrease in the interquartile range and the presence of fewer extreme values post-intervention. Furthermore, the scatter plot with the ascending trend line suggests an increase in the mean scores of the groups after the intervention. This can be interpreted as an improvement in the perception of business skills among participants after using the ChatGPT tool.

Differences between pre- and post-intervention group means are reflected in the graphs with higher centered data points in PosG1 and PosG2 compared to PrecG1 and PrecG2. Therefore, the effectiveness of ChatGPT as a tool to improve the understanding and application of business concepts in scientific entrepreneurship is statistically supported. The positive changes in metrics reflected in the graphs support the integration of artificial intelligence tools in business skills development, although further analysis is recommended to determine the statistical significance of the findings.

The increase suggests that the course contributed positively to developing entrepreneurial skills; some participants even perceived a highly positive impact. This allows us to consider that most students who used ChatGPT perceived it as a valuable tool for entrepreneurial

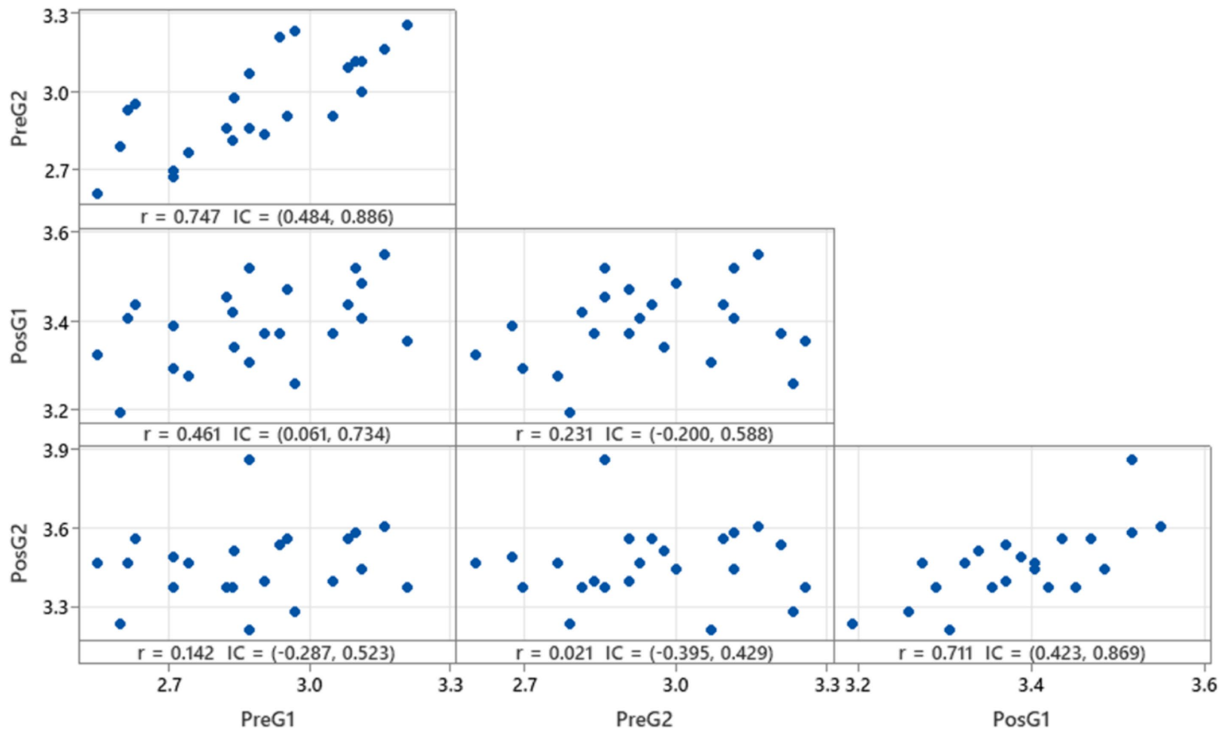

FIGURE 6
Correlation between pre-test and post-test by groups.

education (George-Reyes and Avello-Martínez, 2021). This aligns with the findings in similar studies that showed the tool improved students'ability to generate new ideas and structure the plot of a story (Pavlik, 2023; Rahman and Watanobe, 2023).

On the other hand, Tables 3, 4 and Figure 6 showed the results of complementary analyses aimed at finding significant differences. These analyses provided information to understand the improvements observed between the pre-test and the post-test, which validated the effectiveness of the training approach and suggested the relevance and usefulness of digital narratives as a key component in forming entrepreneurial skills. Notably, the i4C method (George-Reyes C. et al., 2023) used to design the scientific entrepreneurship course with ChatGPT showed its usefulness for generating narrative scripts and triggering individual and collaborative creativity. Thus, this method should be considered an enabler to create formative experiences based on complexity and the development of critical thinking.

5 Conclusion

Although there is greater access to artificial intelligence (AI) applications that can be used in more attractive and complex educational activities, there is a specific gap in the implementation or effectiveness of these applications in the educational context. The aspects that this investigation conducted are contributing to empirical evidence of the effectiveness of AI applications in improving educational results in various disciplines.

Respectfully, this study has demonstrated the practical value of ChatGPT as a support tool for students training in the formation of knowledge about scientific entrepreneurship. The results indicated that most students improved their knowledge of the topic and that ChatGPT was a valuable asset in their storytelling efforts. The results underline the relevance of designing training experiences based on three premises: (1) the use of digital applications based on artificial intelligence can positively impact the development of knowledge of scientific entrepreneurship, (2) developing narrative scripts with the support of ChatGPT is an effective strategy to improve students' perceptions of their entrepreneurial skills, and (3) formative experiences should use interventional methods such as i4C (George-Reyes C. et al., 2023) that incorporate elements such as critical, scientific, systemic and innovative thinking, which, in turn help develop students' complex thinking.

The lines of research that emerge from this study are limited to the three premises mentioned, either individually or with overlaps. However, variables must be added that delve into important issues such as ethical considerations when using artificial intelligence applications, the assessment of the digital literacies that allow tools such as ChatGPT to be used intentionally for better results, the responsibility to avoid over-dependence upon it, and the safeguarding of continuing individual creativity.

Among the limitations of the study, it is important to highlight that the measurement of students' perception of their knowledge in scientific entrepreneurship may not reflect their real knowledge or their ability to apply it in practical situations. Furthermore, self-perception is subject to cognitive biases, such as the overconfidence effect, which could influence the results. Another limiting factor is the study's reliance on using a single tool, ChatGPT, without considering other forms of e-learning or instructional resources that students might be using in parallel.

The research was also based on a pretest-posttest design without a control group, which prevents establishing a firm causality between the use of ChatGPT and the perceived improvements. The absence of a control group means that other external factors or events that could have contributed to the improvement in students' perception cannot be ruled out.

The study focused on the perception of specific skills linked to scientific entrepreneurship and familiarity with the use of artificial intelligence tools such as ChatGPT. Therefore, it did not cover other critical aspects of entrepreneurship, such as practical skills, decision making, risk management, and innovation, among others. The complexity of these skills and their teaching cannot be fully captured through perceived knowledge alone, suggesting the need for future research that incorporates more objective and varied measures of performance.

Future lines of research could be directed toward conducting longitudinal studies that follow students over time to observe knowledge retention and long-term application of learned skills in real entrepreneurship contexts. It would also be beneficial to expand the sample to different institutions and cultural contexts to improve the generalizability of the findings.

Another important line of research would be to examine the relationship between the perception of knowledge and actual competence in scientific entrepreneurship. This could involve developing practical, objective assessments that measure students' ability to apply their knowledge in simulated or real entrepreneurship scenarios.

Investigating individual differences, such as motivation, self-discipline, and learning strategies, could provide a deeper understanding of how these variables moderate the impact of tools like ChatGPT on learning. Finally, it would be essential to investigate the impact of repeated and long-term use of ChatGPT on the development of soft and hard skills in entrepreneurship, including decision making, critical thinking, and the ability to innovate and manage change.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The databases used are free access and must be requested from the main author.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article. All information provided by human participants was collected with their consent (https://comiteinstitucionaletica.tec.mx/es/formatos). The implementation was regulated and approved by the Tecnológico de Monterrey Ethics Committee-IFE-2024-001 and supervised by the interdisciplinary research group R4C with the technical support of the Writing Lab of the Institute for the Future of Education of the Tecnológico de Monterrey, Mexico. All information recovered was protected in accordance with the criteria established in the Federal Law on Protection of Personal Data Held by Private Parties in force in Mexico.

Author contributions

CG-R: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. EV: Writing – review & editing. RA-M: Writing – review & editing, Resources, Investigation, Conceptualization. EL-C: 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.

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References

Aldridge, T. T., Audretsch, D., Desai, S., and Nadella, V. (2014). Scientist entrepreneurship across scientific fields. *J. Technol. Transfer.* 39, 819–835. doi: 10.1007/s10961-014-9339-x

Alneyadi, S., and Wardat, Y. (2023). ChatGPT: revolutionizing student achievement in the electronic magnetism unit for eleventh-grade students in emirates schools. *Contemp. Educ. Technol.* 15. doi: 10.30935/cedtech/13417

Alneyadi, S., and Wardat, Y. (2024). Integrating ChatGPT in grade 12 quantum theory education: an exploratory study at emirate school (UAE). *Int. J. Inform. Educ. Technol.* 14, 398–410. doi: 10.18178/ijiet.2024.14.3.2061

Alonso, I., Molina, S., and Porto, D. (2013). Multimodal digital storytelling: integrating information, emotion and social cognition. *Rev. Cognit. Linguist.* 11, 369–387. doi: 10.1075/rcl.11.2.10alo

Alonso-Galicia, P. E., Vázquez-Parra, J. C., Castillo-Martínez, I. M., and Ramírez-Montoya, M. S. (2024). Development of complex thinking in entrepreneurship training: a gender approach. *Educ. Knowledge Soc.* 25:e29382. doi: 10.14201/eks.29382

Althubaiti, A., and Althubaiti, S. M. (2024). Flipping the online classroom to teach statistical data analysis software: a quasi-experimental study. *SAGE Open* 14. doi: 10.1177/21582440241235022

Ariyaratne, S., Iyengar, K. P., Nischal, N., Chitti Babu, N., and Botchu, R. (2023). A comparison of ChatGPT-generated articles with human-written articles. *Skeletal Radiol.* 52, 1755–1758. doi: 10.1007/s00256-023-04340-5

Avello-Martínez, R., Lavonen, J., and Zapata-Ros, M. (2020). Coding and educational robotics and their relationship with computational and creative thinking. A compressive review. *Revist. Educ. Distanc.* 20, 1–21. doi: 10.6018/red.413021

Bandalos, D. L., and Finney, S. J. (2001). "Item parceling issues in structural equation modeling" in New developments and techniques in structural equation modeling. eds. G. A. Marcoulides and R. E. Schumacker (Lawrence Erlbaum Associates Publishers), 269–296.

Berger, U., and Schneider, N. (2023). How ChatGPT will change research, education, and healthcare? [Wie wird ChatGPT Forschung, Lehre und Gesundheitsversorgung verändern?] PPmP. *Psychother. Psychosom. Med. Psychol.* 73, 159–161. doi: 10.1055/a-2017-8471

Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Guillén-Gámez, F. D., and Gaete, A. (2022). Competencias digitales de estudiantes universitarios: creación de un modelo causal desde un enfoque PLS-SEM. *Campus Virtuales* 11, 167–179. doi: 10.54988/cv.2022.1.1008

Cascella, M., Montomoli, J., Bellini, V., and Bignami, E. (2023). Evaluating the feasibility of ChatGPT in healthcare: an analysis of multiple clinical and research scenarios. *J. Med. Syst.* 47:33. doi: 10.1007/s10916-023-01925-4

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

Cingillioglu, I. (2023). Detecting AI-generated essays: the ChatGPT challenge. *Int. J. Inf. Learn. Technol.* 40, 259–268. doi: 10.1108/IJILT-03-2023-0043

Cooper, G. (2023). Examining science education in ChatGPT: an exploratory study of generative artificial intelligence. *J. Sci. Educ. Technol.* 32, 444–452. doi: 10.1007/s10956-023-10039-y

de Souza, V. M., and Rodrigues, A. (2022). Digital storytelling as a methodology for articulating the structure of responsible research and innovation axes. *Digital Educ. Rev.* 42, 50–64. doi: 10.1344/der.2022.42.50-64

Del Moral, M., Villalustre, L., and Piñeiro, M. (2018). Percepción docente del desarrollo emocional y creativo de los escolares derivado del diseño colaborativo de digital storytelling. *Educ. XX1* 21, 345–374. doi: 10.5944/educxx1.20202

Di Blas, N. (2022). Authentic learning, creativity and collaborative digital storytelling: lessons from a large-scale case study. *Educ. Technol. Soc.* 25, 80–104.

Doolani, S., Owens, L., Wessels, C., and Makedon, F. (2020). vIS: an immersive virtual storytelling system for vocational training. *Appl. Sci.* 10:8143. doi: 10.3390/app10228143

Farrokhnia, M., Banihashem, S. K., Noroozi, O., and Wals, A. (2023). A SWOT analysis of ChatGPT: implications for educational practice and research. *Innov. Educ. Teach. Int.* 61, 460–474. doi: 10.1080/14703297.2023.2195846

Gao, J. (2021). Exploring the feedback quality of an automated writing evaluation system. *Int. J. Emerg. Technol. Learn.* 16, 322–330. doi: 10.3991/ijet.v16i11.19657

García-González, A., and Ramírez-Montoya, M. S. (2023). Social entrepreneurship competency in higher education: an analysis using mixed methods. *J. Soc. Entrep.* 14, 91–109. doi: 10.1080/19420676.2020.1823872

George-Reyes, C. E., and Avello-Martínez, R. (2021). Alfabetización digital en la educación. Revisión sistemática de la producción científica en Scopus. *Revist. Educ. Distanc.* 21, 1–21. doi: 10.6018/red.444751

George-Reyes, C. E., López-Caudana, E., and Lavonen, J. (2023). Complex and design thinking: proof-of-concept to validate the i4C methodology for improving scientific entrepreneurship skills. *Onomázein* 62, 148–168.

George-Reyes, C., Suárez-Brito, P., and López-Caudana, E. (2023). Medición de emprendimiento social, tecnológico y científico desde el pensamiento complejo.

Gillani, N., Eynon, R., Chiabaut, C., and Finkel, K. (2023). Unpacking the "black box" of AI in education. *Educ. Technol. Soc.* 26, 99–111.

Halaweh, M. (2023). ChatGPT in education: strategies for responsible implementation. Contemporary. *Educ. Technol.* 26, 1–11. doi: 10.30935/cedtech/13036

Haluza, D., and Jungwirth, D. (2023). Artificial intelligence and ten societal megatrends: an exploratory study using GPT-3. *Systems* 11. doi: 10.3390/systems11030120

Hess, K. (2010). Saber lengua: lenguaje y metalenguaje en los años escolares. México: El Colegio de México.

Hiver, P., Zhou, S., Tahmouresi, S., Sang, Y., and Papi, M. (2020). Why stories matter: exploring learner engagement and metacognition through narratives of the L2 learning experience. *System* 91:102260. doi: 10.1016/j.system.2020.102260

Hokanson, B., Clinton, G., and Kaminski, K. (2018). Educational technology and narrative: Springer International Publishing.

Hu, K. (2023). ChatGPT sets record for fastest-growing user base - analyst note. Reuters. Available at: https://www.reuters.com/technology/chatgpt-sets-record-fastest-growing-user-base-analyst-note-2023-02-01/

Hung, S. (2019). Creating digital stories: EFL learners' engagement, cognitive and metacognitive skills. *J. Educ. Technol. Soc.* 22, 26–37.

Hurtado-Mazeyra, A., Alejandro-Oviedo, O. M., Núñez-Pacheco, R., and Cabero-Almenara, J. (2023). El Digital Storytelling en la modalidad 2D y con realidad aumentada para el desarrollo de la creatividad en la educación infantil. *RED* 23, 1–25. doi: 10.6018/red.536641

Hwang, G., and Chen, N.-S. (2023). Editorial position paper: exploring the potential of generative artificial intelligence in education: applications, challenges, and future research directions. *Educ. Technol. Soc.* 26.

Jeon, J., and Lee, S. (2023). Large language models in education: a focus on the complementary relationship between human teachers and ChatGPT. *Educ. Inf. Technol.* 28, 15873–15892. doi: 10.1007/s10639-023-11834-1

Johinke, R., Cummings, R., and Di Lauro, F. (2023). Reclaiming the technology of higher education for teaching digital writing in a post-pandemic world. *J. Univ. Teach. Learn. Pract.* 20. doi: 10.53761/1.20.02.01

Justice, L., and McGinty, A. S. (2009). Read it again-Prek! Ohio State University.

Knox, J. (2020). Artificial intelligence and education in China. *Learn. Media Technol.* 45, 298–311. doi: 10.1080/17439884.2020.1754236

Koenitz, H. (2016) Design strategies for interactive digital narratives, In TVX'16: Proceedings of the ACM International Conference on Interactive Experiences for TV and Online Video

Koenitz, H. (2018). Thoughts on a discipline for the study of interactive digital narratives. *Lecture Notes Comput. Sci.*, 36–49. doi: 10.1007/978-3-030-04028-4_3

Labov, W., and Waletzky, J. (1997). Narrative analysis: Oral versions of personal experience. *J. Narrative Life History* 7, 3–38. doi: 10.1075/jnlh.7.02nar

Lambert, J. (2013). Digital storytelling: capturing lives, creating community: Routledge.

Lavrysh, Y., Leshchenko, M., and Tymchuk, L. (2023). Development of metacognitive skills through digital narratives in higher education. *Revista Electrón. Investig. Educ.* 25, 1–15. doi: 10.24320/redie.2023.25.e07.5028

Lee, H. Y., Chen, P. H., Wang, W. S., Huang, Y. M., and Wu, T. T. (2024). Empowering ChatGPT with guidance mechanism in blended learning: effect of self-regulated learning, higher-order thinking skills, and knowledge construction. *Int. J. Educ. Technol. High. Educ.* 21. doi: 10.1186/s41239-024-00447-4

Lim, W. M., Gunasekara, A., Pallant, J. L., Pallant, J. I., and Pechenkina, E. (2023). Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators. *Int. J. Manag. Educ.* 21:100790. doi: 10.1016/j.ijme.2023.100790

Lo, C. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. *Educ. Sci.* 13:410. doi: 10.3390/educsci13040410

Ma, C., Liu, C., and Xie, R. (2020). Structural, innovation and efficiency effects of environmental regulation: evidence from China's carbon emissions trading pilot. *Environ. Resour. Econ.* 75, 741–768. doi: 10.1007/s10640-020-00406-3

Mahapatra, S. (2024). Impact of ChatGPT on ESL students' academic writing skills: a mixed methods intervention study. *Smart Learn. Environ.* 11. doi: 10.1186/s40561-024-00295-9

Mariani, I., and Ciancia, M. (2019). Character-driven narrative engine: storytelling system for building interactive narrative experiences, In Proceedings of the 2019 DiGRA international conference: Game, play and the emerging Ludo-mix, 1–19.

Mariani, I., and Ciancia, M. (2023). Design for narrative change. A pedagogical model for interactive digital narratives. *Int. J. Art Design Educ.* 42, 384–401. doi: 10.1111/jade.12468

Miller, R., Liu, K., and Ball, A. (2020). Critical counter-narrative as transformative methodology for educational equity. *Rev. Res. Educ.* 44, 269–300. doi: 10.3102/0091732X20908501

Navio-Marco, J., Ruiz-Gómez, L. M., Arguedas-Sanz, R., and López-Martín, C. (2022). The student as a prosumer of educational audiovisual resources: a higher education hybrid learning experience. *Interact. Learn. Environ.* 32, 1–18. doi: 10.1080/10494820.2022.2091604

Nazari, N., Shabbir, M., and Setiawan, R. (2021). Application of artificial intelligence powered digital writing assistant in higher education: randomized controlled trial. *Heliyon* 7:e07014. doi: 10.1016/j.heliyon.2021.e07014

Novielli, J., Kane, L., and Ashbaugh, A. R. (2023). Convenience sampling methods in psychology: a comparison between crowdsourced and student samples. *Can. J. Behav. Sci.* doi: 10.1037/cbs0000394

Nygren, L., and Blom, B. (2001). Analysis of short reflective narratives: a method for the study of knowledge in social workers' actions. *Qual. Res.* 1, 369–384. doi: 10.1177/146879410100100306

Open AI. (2023). ChatGPT: optimizing language models for dialogue. Available at: https://openai.com/blog/chatgpt/

Orellana, P., Valenzuela, M., Pezoa, J., and Villalón, M. (2022). Competencia Narrativa: Evidencias de Validez para la Estandarización de su Evaluación en Niños Chilenos. *Psykhe* 31, 1–18. doi: 10.7764/psykhe.2020.22067

Pavlik, J. (2023). Collaborating with ChatGPT: considering the implications of generative artificial intelligence for journalism and media education. *J. Mass Commun. Educ.* 78, 84–93. doi: 10.1177/10776958221149577

Pavlou, I. (2019). Art Technology integration: digital storytelling as a transformative pedagogy in primary education. *Int. J. Art Design Educ.* 39, 195–210. doi: 10.1111/jade.12254

Punar Özçelik, N., and Yangın Ekşi, G. (2024). Cultivating writing skills: the role of ChatGPT as a learning assistant—a case study. *Smart Learn. Environ.* 11. doi: 10.1186/s40561-024-00296-8

Rahman, M., and Watanobe, Y. (2023). Chatgpt for education and research: opportunities, threats, and strategies. *Appl. Sci.* 13:5783. doi: 10.3390/app13095783

Rosnaeni, R., Zuhri, M., and Nur, H. (2020). Students' metacognitive awareness and reading comprehension of narrative texts. *Indonesian J. English Educ.* 7, 73–86. doi: 10.15408/ijee.v7i1.17027

Rubio-Hurtado, M. J., Fuertes-Alpiste, M., Martínez-Olmo, F., and Quintana, J. (2022). Youths' posting practices on social Media for Digital Storytelling. *J. New Approaches Educ. Res.* 11, 97–113. doi: 10.7821/naer.2022.1.729

Scharth, M. (2022). The ChatGPT chatbot is blowing people away with its writing skills. The University of Sydney. Available at: https://www.sydney.edu.au/news-opinion/news/2022/12/08/the-chatgpt-chatbot-isblowing-people-away-with-its-writing-skil.html

Shi, J., and Cheung, A. C. K. (2024). The impacts of a social emotional learning program on elementary school students in China: a quasi-experimental study. *Asia Pacific Educ. Res.* 33, 59–69. doi: 10.1007/s40299-022-00707-9

Skult, N., and Smed, J. (2020). "Interactive storytelling in extended reality: concepts for the design" in Game user experience and player-centered design. ed. B. Bostan (Springer), 449–469.

Snow, C. E. (2017). The role of vocabulary versus knowledge in children's language learning: a fifty-year perspective. *Infancia Aprendizaje* 40, 1–18. doi: 10.1080/02103702.2016.1263449

Steiss, J., Tate, T., Graham, S., Cruz, J., Hebert, M., Wang, J., et al. (2024). Comparing the quality of human and ChatGPT feedback of students' writing. *Learn. Instr.* 91:101894. doi: 10.1016/j.learninstruc.2024.101894

Susnjak, T. (2022). ChatGPT: the end of online exam integrity? *arXiv*. doi: 10.48550/arXiv.2212.09292

Tan, S. (2020). Artificial intelligence in education: rise of the machines. *J. Appl. Learn. Teach.* 3, 129–133. doi: 10.37074/jalt.2020.3.1.17

Tarisayi, K. S. (2024). ChatGPT use in universities in South Africa through a socio-technical lens. *Cogent Educ.* 11. doi: 10.1080/2331186X.2023.2295654

van Aswegen, S., Swart, E., and Oswald, M. (2019). Developing metacognition among young learners by using stories. *S. Afr. J. Educ.* 39, 1–12. doi: 10.15700/saje.v39n2a1531

Vázquez-Parra, J. C., Cruz-Sandoval, M., Molina-Sotelo, C., Molina-Sotelo, D., Carlos-Arroyo, M., and Welti-Chanes, J. (2023). Social entrepreneurship and complex thinking: an exploratory, educational innovation proposal for acquiring and scaling competencies. *Higher Educ. Skills Work Based Learn.* 14, 694–710. doi: 10.1108/HESWBL-06-2023-0165

Wu, Y. J., Yuan, C. H., and Pan, C. I. (2018). Entrepreneurship education: an experimental study with information and communication technology. *Sustain. For.* 10:691. doi: 10.3390/su10030691

Yoganandan, G., and Vasan, M. (2022). Evaluating the quality of scientific research papers in entrepreneurship. *Qual. Quant.* 56, 3013–3027. doi: 10.1007/s11135-021-01254-z

Yu, X., and Du, B. (2021). Optimization of innovation and entrepreneurship policy of scientific and technological entrepreneur talent using regional competitive advantage theory. *Front. Psychol.* 12. doi: 10.3389/fpsyg.2021.726334