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The effects of generative AI on collaborative problem-solving and team creativity performance in digital story creation: an experimental study

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Abstract
As the demand for higher-order thinking skills continues to rise in the 21st century, the integration of Generative Artificial Intelligence (GAI) into educational practices has emerged as a promising tool. However, its full potential in enhancing collaborative problem-solving and team creativity within educational contexts, particularly in Digital Storytelling (DST), remains insufficiently explored. This study investigated the effects of GAI tools, including ChatGPT, Midjourney, and Runway, on university students' Collaborative Problem-Solving (CPS) skills, Team Creativity Performance (TCP), and their perceptions of GAI's role in DST creation. Employing a mixed-methods approach, the study utilized pre- and post-surveys along with semi-structured interviews to assess these outcomes. Over a 20-week DST training program, sixty university students were randomly assigned to either an experimental group creating their DST with the aid of GAI tools or a conventional group designed DST via traditional methods. Results indicated that the integration of GAI tools in DST creation significantly enhanced students' CPS skills. Furthermore, the experimental group demonstrated better performance in team creativity, particularly in the user experience and novelty dimensions. It also revealed that while students generally held a positive attitude toward the use of GAI in DST creation, they also expressed concerns about potential cognitive offloading, over-reliance on GAI technology, and the lack of emotional support. This study offers valuable insights for educators and researchers seeking to incorporate GAI technologies into DST creation as a way to foster collaborative learning and creativity in educational settings.

Keywords Digital storytelling, Generative artificial intelligence, Collaborative problem-solving, Team creativity, Higher education

Introduction

As higher education evolves amidst the rapid technological advancements in the 21st century, generative artificial intelligence (GAI) has emerged as a transformative innovation with the potential to reshape educational practices and learning outcomes (Barrett

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& Pack, 2023). This increasing integration of GAI-driven technologies has necessitated shifts in pedagogical paradigms, urging education systems to reconsider how to equip learners with the essential competencies for success in an increasingly complex and dynamic world. In this context, individuals are required to adapt continuously, critically evaluate information, and effectively leverage emerging technologies. Such demands underscore the need to cultivate 21st-century skills such as problem-solving, creativity, critical thinking, collaboration, and communication (Kennedy & Sundberg, 2020). Among these, collaborative problem-solving and creativity stand out as crucial for fostering innovation and adaptability in modern society. However, traditional educational approaches have often struggled to adequately develop these skills (Kim et al., 2019; Thornhill-Miller et al., 2023). To address this challenge, scholars have advocated for the integration of innovative technologies into pedagogy, with digital storytelling (DST) emerging as a particularly promising approach. By combining narrative techniques with multimodal elements (e.g., text, images, audio, and video), DST offers an engaging and dynamic learning experience that promotes cognitive development, creativity, and reflective practice (Chen, 2024; Khoo et al., 2023; Lin et al., 2024). The DST design process requires learners to engage in collaborative meaning-making, communication, and creative expression, thereby equipping them with the skills necessary to navigate novel and complex challenges. Research consistently supports that DST not only enhances engagement and motivation but also cultivates essential skills like critical thinking (Hung et al., 2012). Additionally, DST facilitates literacy development across multiple domains by promoting interactions with diverse content forms (Chan, 2019; Yang et al., 2020).

Despite the pedagogical benefits of DST, conventional practices face challenges in educational settings, particularly in the areas of technological integration and cognitive load management (Ginting et al., 2024). The DST creation process often requires learners to use complex multimedia software, integrate various digital elements, and balance multiple cognitive tasks, which can detract from the intended cognitive and creative outcomes. Although digital tools have become increasingly accessible, the technological and temporal demands associated with DST production continue to pose barriers to its scalability in educational settings (Prabowo et al., 2025). Additionally, constraints such as limited course durations and difficulties in sourcing appropriate materials further hinder the widespread adoption of DST-based approaches aimed at developing 21st-century skills such as collaboration and creativity. To overcome these challenges inherent in traditional DST production and foster the development of essential 21st-century skills, GAI, exemplified by tools like ChatGPT, Midjourney, and Runway, offers a promising solution. GAI's ability to autonomously generate texts, images, and videos potentially reduces the cognitive and technical burdens that often impede students throughout the DST creation process. By automating tasks (e.g., create narrative content, visualize elements), GAI enables students to concentrate on more creative and analytical aspects of DST, such as refining narrative structures, developing characters, and integrating multimedia elements in meaningful ways (Cao et al., 2023; Zolezzi et al., 2024). This shift allows students to allocate more cognitive resources to problem-solving, critical reflection, and collaborative engagement, potentially enhancing their learning experience through GAI tools (Gonzalez et al., 2023). For instance, ChatGPT can support text-based content creation, while Midjourney enables students to visualize complex ideas without requiring advanced design expertise. Runway facilitates the creation of dynamic motion graphics and animations. Collectively, these advanced GAI tools offer the potential to streamline the DST production process, allowing students to collaborate effectively across various locations. By enabling learners to work synchronously, GAI enhances dynamic knowledge exchange and promotes innovative group interactions (An et al., 2025).

While emerging research has highlighted the benefits of GAI in education, much of the existing literature has primarily focused on its applications in language learning, engineering education, and learning analytics (Shanshan & Sen, 2024; Tai & Chen, 2024). In contrast, the potential of GAI to enhance DST creation performance remains underexplored. Previous studies have demonstrated that DST can improve academic achievement, critical thinking, and narrative skills (Yang & Wu, 2012). However, the potential of GAI tools to enhance key 21st-century skills through DST creation—particularly collaborative problem-solving and team creativity performance—has not been fully examined. Emerging evidence suggests that GAI's potential role in DST fields to enhance narrative intelligence and writing self-efficacy among undergraduate students (Pellas, 2023). Nevertheless, the methodological frameworks for analyzing the GAI's impact on collaborative learning and creativity in DST fields remain in their early stages. As this field continues to evolve, it is crucial to develop robust methodologies that ensure reliable, scalable, and ethical integration of GAI into educational environments. Thus, this study addresses these gaps by investigating how GAI tools, specifically ChatGPT, Midjourney, and Runway, can be leveraged to support DST creation and enhance key 21st-century competencies. To achieve this, the study proposed an innovative GAI-assisted DST approach that integrates problem-based learning as a guiding methodology. Specifically, this study aims to answer the following research questions:

RQ1 Do students who use different forms of GAI integration for DST creation demonstrate better collaborative problem-solving skills compared to those using traditional methods?

RQ2 Do students who use different forms of GAI integration for DST creation exhibit better team creativity performance compared to those using traditional methods?

RQ3 What are students' perceptions of using GAI technologies in their DST creation process?

By addressing these research questions, this study contributes to the ongoing efforts to establish a structured methodology for the integration of GAI into the DST field. Ultimately, it provides both practical and theoretical insights into GAI's role in fostering creativity and collaboration in educational settings. The methodological framework developed through this study lays the groundwork for future studies on GAI's applications in education, thereby advancing the discourse on GAI's practices in higher education.

Literature review

Digital storytelling (DST)

DST is an evolving pedagogical tool that integrates traditional storytelling technologies with multimodal digital elements like text, images, music, and video to create engaging narratives. Lambert (2006) identified seven elements that contribute to meaningful DST: personal perspective, dramatic question, emotional content, audio, music, economy, and rhythm. Robin (2006) further categorized DST into three types of content: personal, historical, and didactic stories. These aspects allow DST to function as a rich, interactive learning platform. Grounded in constructivist pedagogy, DST encourages learners to actively participate in their learning by selecting topics, writing scripts, and integrating multimedia elements into their narratives. This process not only enhances learners' creativity but also promotes deeper engagement and critical reflection (Chen & Yeh, 2025; Isaacs et al., 2024).

The application of DST in various educational contexts is widely recognized, with numerous studies highlighting its effectiveness in enhancing learners' critical thinking, problem-solving skills and creativity (Chu et al., 2025; Hwang et al., 2023). For example, DST encourages pre-service teachers to engage in critical thinking by involving them in tasks such as planning, designing, and problem-solving while creating digital stories (Isaacs et al., 2024). Additionally, DST has been shown to stimulate creativity and higher-order thinking skills, as evidenced by Kaptan and Cakir (2024), who used DST sharing sessions to foster reflection and idea generation among students. In biology education, a recent study by Bilici and Yilmaz (2024) revealed that students engaged in collaborative DST activities experienced improvements in academic achievement, critical thinking, co-regulation, and narrative skills. In language education, DST has also proven to be effective in improving students' reading, writing, listening, and speaking skills (Lim et al., 2022). Furthermore, DST contributes to increased self-efficacy, positive attitudes toward learning, and enhanced communication skills, all of which are crucial for language learners (Yan et al., 2024; Simsek et al., 2024). DST also plays a crucial role in teacher education, helping educators present complex content engagingly while facilitating their computational thinking and digital literacy (Cetin, 2021; Haslaman et al., 2024; Sarica & Usluel, 2016). Overall, the findings highlighted the value of DST as an innovative educational approach in enhancing content knowledge and essential competencies, ultimately promoting holistic learning outcomes. It also enables educators to effectively incorporate technological advancements into their pedagogical practices, thereby enriching the learning experience for students.

Generative artificial intelligence(GAI)

GAI is a specialized branch of Artificial Intelligence (AI) technologies designed to generate new content using advanced models such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) (Balasubramaniam et al., 2024). These models use advanced algorithms to learn patterns and generate diverse forms of media, including text, images, audio, videos, and code. Some examples of GAI tools include ChatGPT, Midjourney, and Runway. The capability of these GAI tools to handle complex prompts and generate high-quality outputs has led to their widespread adoption across diverse fields such as education, medicine, and media. In the educational context, tools like ChatGPT have emerged as particularly influential since its release in November 2022. ChatGPT, which simulates human-like conversational abilities, has been shown to enhance cognitive and learning outcomes, including academic performance and 21st-century skills such as problem-solving and digital literacy (Essel et al., 2024; Shahzad et al., 2024). Additionally, studies have demonstrated that ChatGPT supported writing proficiency in language learning contexts and positively impacted non-cognitive domains such as attitude and willingness to engage in learning tasks (Chan & Hu, 2023; Escalante et al., 2023; Yan, 2023). Beyond its student-centric benefits, ChatGPT is also a valuable tool for teacher professional development by providing personalized instructional content, innovative ideas, and strategic methodologies (Chang & Hwang, 2024; Yeh, 2024). Despite these advantages, GAI tools like ChatGPT also present some limitations. One primary concern is its tendency to generate incorrect or misleading information, raising questions about reliability and content accuracy (Ngo, 2023). Samala et al. (2024) emphasized the dual nature of GAI in education, advocating for its careful and responsible integration to mitigate risks while maximizing pedagogical benefits. Moreover, emerging literature raised concerns regarding cognitive offloading, where students become overly reliant on AI-generated content, potentially impairing critical thinking and autonomy. Gerlich (2025) found that frequent use of AI tools negatively correlated with critical thinking skills, suggesting that excessive reliance on AI can reduce the necessity for deep cognitive engagement and independent problem-solving. These findings underscore the importance of pedagogical approaches that use AI as an augmentation tool rather than a replacement for student cognition.

Beyond traditional education, GAI has made contributions to creative content generation, particularly in fields such as product design, where it improves creativity and products quality (Bartlett & Camba, 2024). In the realm of DST, GAI has proven to be particularly effective, as studies have highlighted how GAI tools have positively influenced students' narrative skills and writing self-efficacy (Pellas, 2023). Its application in instructional videos has also been explored. Netland et al. (2025) found that while learners slightly favored human-created teaching videos for engagement, GAI-generated videos facilitated comparable knowledge acquisition. This underscores GAI's ability to generate instructional videos while preserving the quality of the learning experience. Additionally, Wen and Laporte (2024) highlighted how GAI-generated voice narration and background music can enhance the emotional depth and engagement of stories. Recently, a study by Chen and Yang et al. (2024) found that university educators perceive the adoption of GAI as a promising avenue for fostering creativity and high-quality multimedia production.

Despite the advancements in GAI tools, the research on developing university students' essential 21st-century skills like collaborative problem-solving skills and team creativity performance in the context of DST, has not been fully explored. This highlights a gap in empirical research, underscoring the need for further studies examining how GAI can support DST creation and its impact on these skills, thereby offering insights into how these technologies can be leveraged to improve teaching practices.

Collaborative problem-solving (CPS)

Collaborative problem-solving (CPS) is widely recognized as an essential component in 21st-century skills and has been extensively considered across many teaching and learning practices (Luengo-Aravena et al., 2024). CPS refers to a process in which individuals or groups engage in collective efforts to achieve shared objectives (Chen & She et al., 2024). When learners encounter complex tasks, they usually rely on the group's collective capabilities to coordinate actions, generate creative ideas, and reach consensus, ultimately completing the tasks successfully. Numerous studies have reported the positive impacts of CPS on students' academic performance, social skills, and teamwork abilities (Chopade et al. 2018; Lu & Xie, 2023; Notari et al., 2014). Previous research has also demonstrated that CPS skills of team members affect collaboration effectiveness (Andrews & Rapp, 2015), with groups composed of individuals with strong CPS skills achieving better learning outcomes (Mao et al., 2024).

The process of DST creation normally involves a series of complex tasks that require learners to coordinate various design activities, such as producing, organizing, presenting, and solving diverse problems (Yu & Wang, 2025). CPS is particularly effective in this context, as it fosters peer interaction, facilitates idea exchange, and enables participants to collaboratively address authentic design challenges. Studies have demonstrated that CPS activities within the DST creation significantly enhanced students' learning outcomes (Uslu & Uslu, 2021). For example, Hung et al. (2012) found that group-based DST creation activities were effective in improving motivation, attitude and problem-solving tendencies among students. Recent research has increasingly focused on providing students with opportunities to practice CPS through DST creation. For instance, Bilici and Yilmaz (2024) found that collaborative DST activities had a positive impact on high school students' academic achievement and critical thinking skills compared to traditional methods. Given the collaborative nature of the DST creation, fostering CPS through GAI-assisted methods in the DST field has become an emerging trend. This approach holds promise for enhancing both creative and cognitive dimensions of student learning, thereby positioning GAI tools as a valuable resource for supporting CPS in educational contexts.

Team creative performance (TCP)

Team creative performance (TCP) refers to the team's ability to collaboratively generate innovative, original, and practical solutions to complex problems (Paulus & Nijstad, 2003). Unlike individual creativity, TCP emphasizes collaboration, where team members combine their diverse knowledge and skills to achieve superior outcomes and synergistic efforts (Sawyer, 2017). In the context of DST, TCP is critical as it allows teams to leverage individual expertise in a unified effort to tackle creative challenges and generate innovative and engaging DST products. Existing research on teamwork as a creative solution in DST has revealed the positive impact of collaborative DST on fostering creativity among students (Tisoglu et al., 2022). For example, a study by Chen et al. (2023) found that students who participated in DST workshops not only improved in scientific creativity but also reported high satisfaction with the development of teamwork and social skills.

To align the evaluation of TCP with current trends in DST creation, this study adopted a comprehensive TCP assessment framework proposed by Liu et al. (2023). This framework includes four dimensions: novelty, relevance, user experience, and sustainability, which together provide a holistic evaluation of TCP in complex, collaborative contexts. Novelty assesses the originality and innovation of the creative process, which is essential for DST projects aiming to introduce unique narrative techniques or innovative multimedia integration. Relevance focuses on the practical applicability of the creative solutions, ensuring that DST aligns with the intended information and context. User experience evaluates how effectively the DST engages its users, considering factors such as authenticity, cultural immersion, and audience connection. Finally, sustainability considers the long-term viability of the creative output, considering environmental, cultural, and economic factors that ensure the DST's continued relevance and integrity. In summary, this framework offers a comprehensive approach for evaluating TCP in a DST context, enabling an in-depth analysis of both the DST's creative process and the final products. It reflects the iterative and collaborative nature of DST, ensuring that creative solutions are innovative, contextually relevant, and sustainable, which ultimately supports the overarching goals of DST in educational settings.

Methodology

To explore the impact of the proposed approach on university students' DST creation performance, a mixed-methods design was conducted, incorporating both quantitative and qualitative methods throughout the experimental process. As depicted in Fig. 1, the independent variable was defined as the method used to create DST, specifically comparing different forms of GAI integration with traditional digital tools. The dependent variables were CPS and TCP. In this study, CPS and TCP were used as the primary variables for quantitative analysis, while students' perspectives of using GAI tools in DST creation were examined using both quantitative and qualitative approaches. All participants were randomly assigned to either the experimental group or the control group. The experimental group used various GAI tools for collaborative DST creation, whereas the control group worked with traditional digital tools, such as Photoshop (PS), After Effects (AE), and Premiere Pro (PR), to produce their DST products collaboratively.

Participants

A total of 60 university students, aged 20 to 23 (M = 21.12; SD = 0.76), from two classes at a normal university in China participated in this study. Among the participants, 21 students were male and 39 were female, majoring in Educational Technology. The two classes were randomly assigned to either the experimental group (10 males and 20 females) or the control group (11 males and 19 females), with 30 students in each group. To facilitate the DST creation process, students in each group were further divided into six small groups, with five members per group. All students had prior exposure to GAI tools, with everyone student having heard of ChatGPT, and most having tried it for scriptwriting. However, only a few were familiar with other GAI tools (e.g., Midjourney,

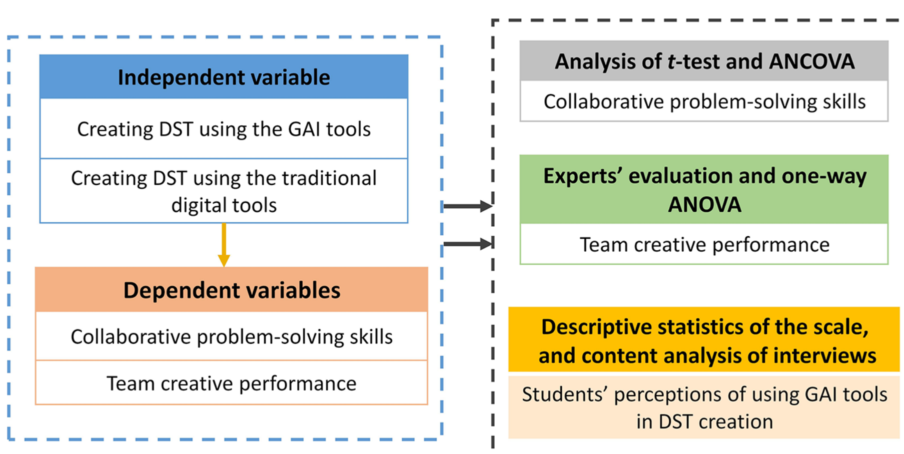

Fig. 1 The research structure of the study

and Runway) commonly used in DST creation. Informed consent was obtained from all participants prior to participation.

Design of the digital stories

A curriculum entitled "Digital story design and development" was specifically developed to equip university students with the essential knowledge and skills needed to effectively integrate digital technologies into their DST practices. The curriculum was structured around Robin and Pierson's (2005) four stages for creating DST: namely, (1) define, collect, and decide; (2) select, import, and create; (3) decide, write, record and finalize; and (4) demonstrate, evaluate, and replicate. These phases provided a comprehensive framework for guiding students through the process of refining and enhancing their DST products. In this study, the structure of the curriculum included six key projects: (A) Story scenario creation, (B) Storyboard design and creation, (C) Static image production, (D) Animation design and development, (E) Editing, recording and finalization, and (F) Sharing and publishing stories. Each project was designed to address both theoretical and practical problems, and the students need to complete their DSTs through CPS tasks while utilizing various digital tools.

The practice of DST projects for students' CPS tasks was structured around the problem-based learning (PBL) procedure: Identify the goal; Gather information; Define the problem; Generate solutions; Evaluate solutions; and Make a decision, which was adapted from Hong & Choi's (2015) design stages for solving design problems. These stages were seamlessly integrated into the DST development process, highlighting the interconnected nature of CPS skills and the DST approach. The PBL method was embedded into each project of the curriculum to actively students engage with the content, foster collaboration among peers, and solve the creative and technical problems associated with DST creation in collaborative settings. Table 1 shows the curriculum plan for the DST projects and CPS tasks.

The curriculum was organized by three professors with diverse professional backgrounds: one with expertise in DST design, another specializing in the application of GAI tools, and a third professor with a background in educational technology. This multidisciplinary approach ensured a well-rounded framework for both theoretical learning and practical application in the development of DST projects.

During the learning activities, the experimental group employed multiple GAI tools to support various stages of the DST projects. A summary of the key GAI tools utilized in the DST creation process is presented in Table 2.

The GAI tools used in the curriculum, including ChatGPT, Midjourney, and Runway, served as collaborative GAI-driven platforms that facilitated both the creation and refinement of DST projects while enhancing students' higher-order thinking skills. ChatGPT facilitated collaborative story development by enabling students to generate, refine, and enhance narrative drafts through real-time brainstorming and iterative feedback, ensuring active contributions from all team members in structuring a cohesive narrative (see Fig. 2a). Midjourney supported the collaborative generation of high-quality static images based on text-based prompts, allowing students to refine visual elements through prompt adjustments and image manipulations (see Fig. 2b). This iterative process encouraged students to collaboratively evaluate the visual outputs of DST and achieve consensus on the final design for their DST. Runway was employed to create and

Table 1 Course plan of the experiment

Robin's approach	Project name	Content	CPS tasks
Stage 1	**Project A**: Story scenario writing	1. The definition, structure of the DST 2. The application scenarios and skills in writing script	**Goals**: Create a well-structured DST script. • Teams consider a story topic. • Teams develop a well-structured DST narrative. • Refine the DST script to align the objectives through using digital tools.
Stage 2	**Project B**: Storyboard design and creation	1. The definition, role functions, and application scenarios of storyboards 2. The design of characters 3. The basic principles of visual narrative	**Goals**: Generate a storyboard that represents DST. • Teams design storyboards for each scene and divide roles for character design and scene composition. • Iterative DST's improvements using digital tools.
	Project C: Static image production	The basic principles and techniques of character design, environment design, color design, and illustration design.	**Goals**: Deliver a cohesive set of static images aligned with narrative. • Teams create character and related elements designs. • Iterate DST's images using digital tools.
Stage 3	**Project D**: Animation design and development	1. The definition, classification, and application scenarios of animation in various DST 2.The visual style and narrative rhythm of DST	**Goals**: Produce a fluid, cohesive animation that enhances the DST. • Teams animate static images, focusing on narrative rhythm and visual style. • Iterate the DST's animation process using digital tools.
	Project E: Editing, recording and finalization	The definition, techniques, and application scenarios of voice-over and editing	**Goals**: Deliver a polished, well-edited final DST product. • Teams edit the DST and record voice-overs, ensuring synchronization with visuals. • Iterate the final DST products using digital tools.
Stage 4	**Project F**: Sharing and publishing stories	1. Presentation and publication of the final DST products 2. Gather peer feedback and reflect on the potential improvements	**Goals**: Present and evaluate the final DST product for peer feedback and publication. • Teams present final DST products, gather feedback from peers, and evaluate the feedback. • Teams decide on any necessary refinements to the DST. • Once adjustments are made, teams publish their DST on a selected platform.

Table 2 Key GAI tools used to develop DST products

Name	Functionality	Used Model	URL
ChatGPT	Text-to-text	GPT-4o	https://openai.com/chatgpt/
Midjourney	Text-to-image	Midjourney model Version 6	https://www.midjourney.com/home
Runway	Image-to-video	Gen-2	https://runwayml.com/

manipulate animations, enhancing the visual impact of the static images (see Fig. 2c). By adjusting animation parameters such as object motion and scene transitions in real time, students were able to achieve smooth and dynamic animations. Furthermore, CapCut was introduced to support the final editing and audio-visual synchronization stages of the DST creation process. CapCut enabled students to generate voice-overs using text-to-speech features, which were then synchronized with the visual elements of their DST, allowing for a seamless integration of multimedia components (see Fig. 2d). These tools not only facilitated the technology creation of DST materials but also played a critical role in developing students' collaborative problem-solving and group creative thinking skills. Figure 2 provides a detailed overview of a step-by-step process of creating a

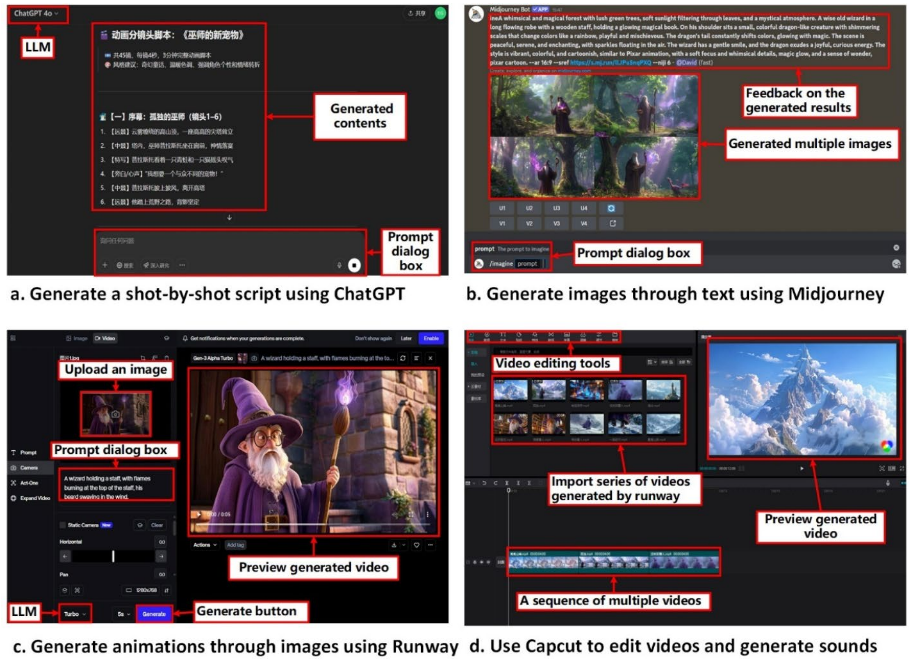

Fig. 2 The experimental group using GAI tools for DST creation

Fig. 3 An example of the experimental group's DST product entitled "Wizard's new pet"

GAI-assisted DST, demonstrating how each DST product evolved from the initial concept to its final product.

From our collection of GAI-assisted DST products, the experimental group produced six DST videos, each centered on a different narrative theme: "Why do bears have short tails?", "Lunch time", "Warm home", "The wizard's new pet", and "Beaver tail". These videos ranged in length from 2 min 52 s to 5 min 6 s, representing the diverse thematic approaches, narrative structures, and creative processes employed by the students. Each DST product was developed collaboratively, incorporating the use of GAI tools like ChatGPT, Midjourney, and Runway. These tools facilitated the students' experimentation and refinement of their storytelling, visuals, and animations. Figure 3 presents a specific example from one of the DST projects produced by the experimental group. For other DST projects created by the experimental group, refer to Appendix I.

In contrast, students in the control group were instructed to use traditional digital tools such as PS, AE, web-based search engines, and other conventional software to complete their DST projects. These students were provided with the necessary materials and received training on how to effectively use these tools for various aspects of DST creation, including image editing, animation, and sound synchronization. The control group manually developed each element of their stories, from story texts, visuals, animations, and voice-overs without the assistance of GAI tools. This process required students to rely on their technical skills in software manipulation, creative design, and manual editing to construct their DST products. Their completed DST projects from the control group covered the same topics as those in the experimental group, and both groups received instruction from the same teacher, ensuring consistency in content and instructional support. Despite using different digital tools, both groups followed similar themes, making the comparative analysis between the outcomes from GAI-assisted and conventionally created DST products both meaningful and valid. The detailed DST creation activities from both groups align with the various phases of the DST creation process, as outlined in Appendix II.

Measuring tools

Collaborative problem-solving skills

The CPS questionnaire was developed based on the measures of Chen et al. (2020). It consisted of 17 items in five subscales, namely, participation (3 items) (Example item: I asked others for help when I met difficulty), perspective taking (3 items) (Example item: Collaborating with others is more effective in finding solutions than by oneself), social regulation (3 items) (Example item: If classmates have any problems, I have the duty to help them), task regulation (4 items) (Example item: I knew clearly about the objectives of the lesson), and learning and knowledge building (4 items) (Example item: When I cannot solve the problems, I will reflect on the learning), with a 5-point Likert scale. The Cronbach's alpha values of the subscales and overall CPS are 0.85, 0.80, 0.82, 0.82, 0.85, and 0.87, respectively.

Team creative performance

The TCP evaluation scale employed in this study was developed based on Liu et al. (2023), including four dimensions: sustainability, user experience, novelty, and relevance. Each dimension was evaluated using two to three criteria rated on a ten-point scale ("1" for very poor and "10" for very good). The total score was calculated by averaging the criteria scores for each dimension, with sustainability and user experience each accounting for 30%, and novelty and relevance each accounting for 20%. The evaluation of TCP was conducted by three experts: two specialists in educational technology and the other in DST research. The analysis of the intra-class correlation (ICC) ($ICC = 0.89 > 0.8$) of their grading results indicated high consistency in the DST rating among the experts.

Student perceptions of the use of GAI tools

To assess students' perceptions of using GAI tools in DST creation, a modified scale was used based on Chan and Hu (2023). The scale consisted of 18 items, organized into three dimensions: knowledge of GAI tools (6 items), willingness to use GAI tools (8 items), and concerns about GAI use (4 items). Each item was rated on a five-point Likert scale ("1" for strongly disagree and "5" for strongly agree). The Cronbach's alpha values for the subscales were 0.83 for knowledge, 0.84 for willingness, and 0.83 for concerns, while an overall scale alpha of 0.86, demonstrating strong internal consistency.

Semi-structured interviews

To complement the quantitative findings, semi-structured interviews were conducted with students after the experiment. The interviews aimed to explore students' perceptions of using GAI tools for DST creation. The interview results provided additional information to explain the findings and can serve as a reference for future improvement of GAI-assisted DST approaches. The interview includes two open-ended questions: "How is the GAI-assisted DST creation approach different from the traditional approach? Is it helpful for your design?" "What are the advantages and disadvantages of using GAI tools for DST creation? Please specify".

Procedure

As depicted in Fig. 4, the procedure spanned 20 weeks with 120-minute sessions per week. In the first week, students from both groups signed the consent forms and completed a pre-questionnaire measuring their CPS skills. During the following two weeks, all participants were introduced to the DST projects, during which they selected their topics and received an overview of the tasks ahead. After this, both groups entered the DST production phase, where they had 15 weeks to finish their assigned DST projects.

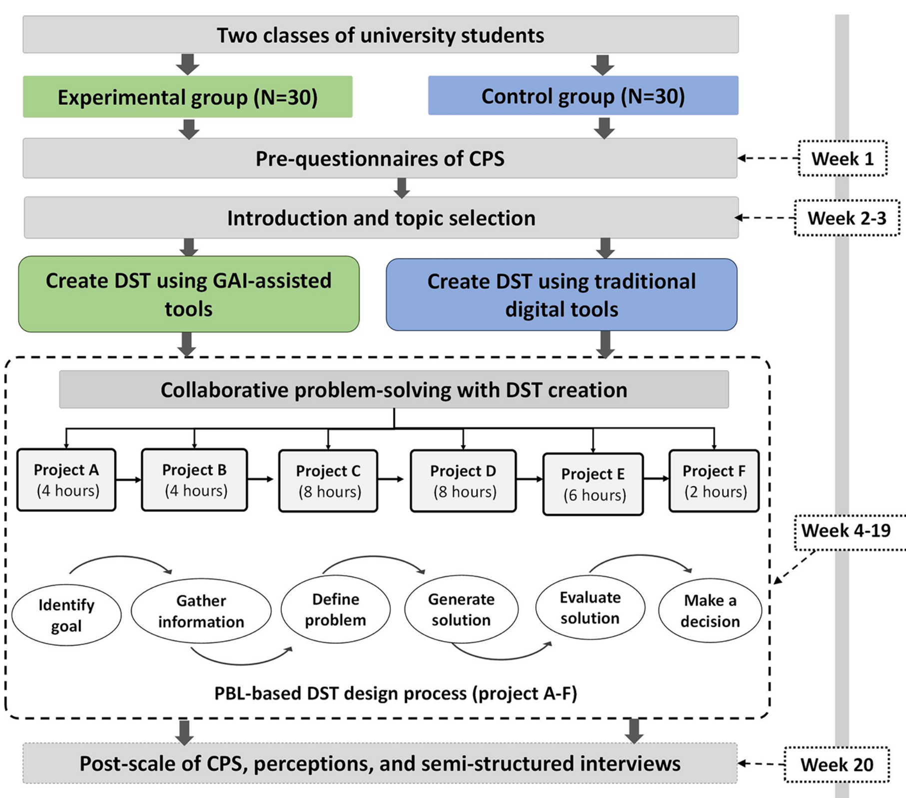

Fig. 4 The procedure

From the fourth week to the nineteenth week, participants worked through various aspects of DST creation process, including scripting, storyboarding, static image generation, animation development, and final editing. The experimental group adopted a GAI-assisted approach for DST creation (see Fig. 5), while the control group utilized traditional digital tools for the same DST tasks. Both groups followed the same CPS tasks and completed the same DST-related projects via a PBL-based method but with different technological support. In the twentieth week, participants from both groups completed the post-questionnaires of CPS and perceptions. Additionally, 10 students from the experimental group were randomly selected to complete the semi-structured interviews to capture their perceptions and experiences of GAI's use in the DST creation process.

Results

Collaborative problem-solving skills

To determine the differences in CPS within students of two groups, a paired sample *t*-test was conducted. The normal distribution tests were conducted to assess the normality of the CPS scores in both groups. The normality tests for the pretest and posttest scores of both groups showed no significant deviations from a normal distribution ($p > 0.05$), indicating that the data was normally distributed, and *t*-tests were appropriate for further analysis. As shown in Table 3, the paired sample *t*-test results showed significant improvements in CPS skills for both the control ($t = 3.53$, $p < 0.01$) and experimental groups ($t = 6.44$, $p < 0.001$). The effect sizes were 0.64 for the control group and 1.18 for the experimental group, indicating moderate and strong effects, respectively. The results indicated that the students who utilized GAI tools for DST creation showed significantly better improvements in all sub-dimensions of CPS as well as the general CPS scores (see Fig. 6).

To further analyze the CPS scores between the two groups, Covariance analysis was conducted using the pretest CPS scores as the covariate. The homogeneity of the Levene between the two groups was also conducted and findings showed homogeneity was met. As shown in Table 4, there was a significant difference between the two groups in students' overall CPS scores ($F = 10.69$, $p < 0.01$) with a large effect size ($\eta^2 = 0.16$), and its sub-dimensions including participation ($F = 5.41$, $p < 0.05$), perspective taking ($F = 5.20$, $p < 0.05$), social regulation ($F = 7.05$, $p < 0.01$), task regulation ($F = 4.67$, $p < 0.05$), and learning and knowledge building ($F = 5.18$, $p < 0.05$). The results indicated that students who employed GAI tools for DST creation achieved higher collaborative problem-solving skills than those using traditional methods.

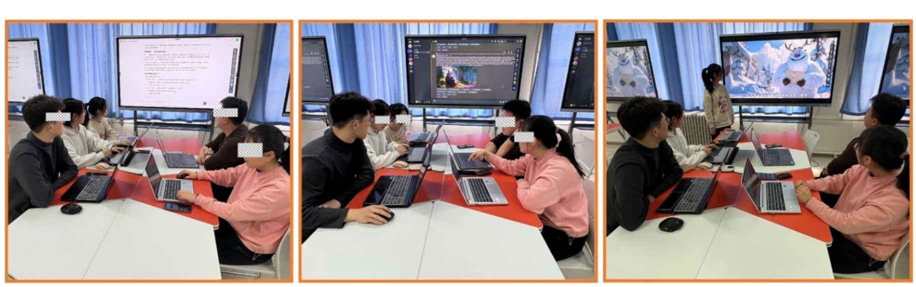

Fig. 5 The experimental group's in-class collaboration activities

Table 3 Paired sample *t*-test analysis results of CPS in two groups

Variable	Control group						Experimental group					
	Pretest		Post-test		Paired *t*-test	Effect size	Pretest		Post-test		Paired *t*-test	Effect size
	M	*SD*	*M*	*SD*	*t*	Cohen's *d*	*M*	*SD*	*M*	*SD*	*t*	Cohen's *d*
Participation	3.68	0.35	3.93	0.53	2.10*	0.38	3.73	0.50	4.22	0.40	4.25***	0.78
Perspective taking	3.66	0.44	3.89	0.45	2.17*	0.40	3.69	0.50	4.18	0.52	3.99***	0.73
Social regulation	3.62	0.44	3.83	0.44	2.04*	0.37	3.67	0.50	4.17	0.52	3.57**	0.65
Task regulation	3.68	0.38	3.95	0.43	2.29*	0.42	3.68	0.39	4.21	0.51	4.19***	0.77
Learning and knowledge building	3.65	0.31	3.91	0.55	2.10*	0.38	3.71	0.35	4.20	0.51	3.99***	0.74
General CPS	3.66	0.22	3.90	0.34	3.53**	0.64	3.70	0.22	4.20	0.34	6.44***	1.18

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Cohen's $d < 0.2$ small effect size, $0.2 <$ Cohen's $d < 0.8$ moderate effect size, Cohen's $d > 0.8$ large effect size

Team creative performance

To examine the differences in TCP between students in the two groups, a One-way ANOVA was conducted. Prior to this analysis, the homogeneity assumption for Levene's test was met, and the assumptions for ANOVA were satisfied. As shown in Table 5, for the novelty, the experimental group had a mean score of 7.20 (SD = 0.45), significantly higher than the control group, which had a mean score of 5.80 (SD = 0.62). For relevance, the experimental group scored 7.40 (SD = 0.29), while the control group scored 6.55 (SD = 0.60). In terms of user experience, the experimental group scored 7.27 (SD = 0.19), compared to the control group's 6.47 (SD = 0.28). For sustainability, the experimental group had a mean score of 7.70 (SD = 0.27), while the control group scored 6.97 (SD = 0.57). For the general TCP, the experimental group scored 29.57 (SD = 0.95), whereas the control group scored 25.78 (SD = 0.52). According to the ANOVA results, there was a significant difference between the general TCP of the students in the two groups ($F = 64.51$, $p < 0.001$), including the novelty ($F = 16.68$, $p < 0.01$), relevance ($F = 8.26$, $p < 0.05$), user experience ($F = 28.58$, $p < 0.001$), and sustainability ($F = 6.65$, $p < 0.05$). These results indicated that students who employed GAI tools for DST creation exhibited better TCP than those with traditional methods.

Student perceptions of the use of GAI tools

Table 6 presents the descriptive statistics results on students' perceptions of the benefits and potential challenges associated with GAI tools in DST creation. Regarding the knowledge of GAI tools, students exhibited a strong awareness of GAI's limitations, particularly its reliance on statistical patterns (M = 4.38, SD = 0.67) and its potential for factual inaccuracies (M = 4.25, SD = 0.74). Moreover, they also recognized a critical understanding of GAI-generated biases (M = 4.13, SD = 0.56) and the lack of emotional intelligence in GAI outputs (M = 4.18, SD = 0.64), suggesting that students recognize both the affordances and constraints of GAI integration in DST fields. In terms of willingness to use GAI tools, students expressed strong enthusiasm for integrating GAI tools into their DST creation process, acknowledging GAI's ability to generate unique insights (M = 4.48, SD = 0.60) and enhance digital competence (M = 4.40, SD = 0.59). Additionally, GAI tools were perceived as highly beneficial for improving efficiency (M = 4.45, SD = 0.71) and providing personalized feedback (M = 4.38, SD = 0.59), reinforcing the notion that AI can serve as a cognitive and creative enabler in DST creation. However, students expressed slightly less confidence in GAI's effectiveness in anonymous student support services (M = 3.88, SD = 0.69), suggesting that while GAI is valued for academic enhancement (e.g., improving efficiency), its application in non-academic support roles (e.g., emotional support) remains uncertain, possibly due to concerns about emotional intelligence, personalization, and ethical considerations.

Regarding concerns about GAI's adoption, moderate worry about over-reliance (M = 3.38, SD = 0.98) was observed, with students acknowledging the risk of diminished problem-solving autonomy when GAI tools are heavily integrated into the DST process. However, concerns regarding GAI limiting social interaction (M = 2.68, SD = 1.00) and hindering the development of transferable skills such as teamwork and leadership (M = 2.65, SD = 1.08) were relatively low, suggesting that students do not perceive GAI tools as a major barrier to interpersonal skill development.

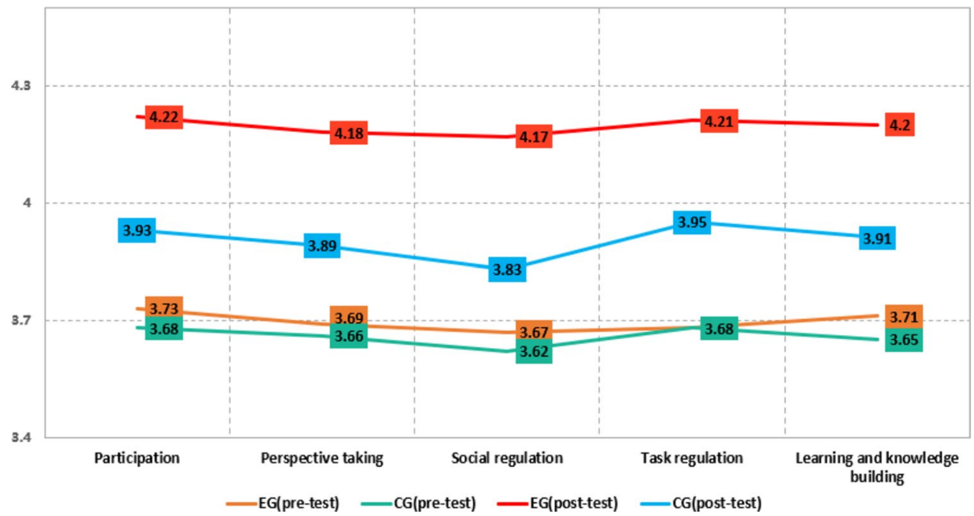

Fig. 6 Mean CPS scores across pretest and post-test for the two groups

Table 4 Covariance analysis results of CPS in two groups

Variable	Control group	Experimental group	ANCOVA	
	Adj. M	Adj. M	F	Partial $\eta 2$
Participation	3.93	4.22	5.41*	0.09
Perspective taking	3.89	4.18	5.20*	0.08
Social regulation	3.83	4.17	7.05**	0.11
Task regulation	3.95	4.20	4.67*	0.08
Learning and knowledge building	3.90	4.21	5.18*	0.08
General CPS	3.90	4.20	10.69**	0.16

*$p<0.05$, **$p<0.01$, ***$p<0.001$; $\eta 2>0.01$ small effect size, $\eta 2>0.059$ moderate effect size, $\eta 2>0.138$ large effect size

Table 5 One-way ANOVA analysis results of team creative performance

Variable	Control group		Experimental group		ANOVA	
	M	*SD*	*M*	*SD*	*F*	Partial $\eta 2$
Novelty	5.80	0.62	7.20	0.45	16.68**	0.68
Relevance	6.55	0.60	7.40	0.29	8.26*	0.51
User experience	6.47	0.28	7.27	0.19	28.58***	0.78
Sustainability	6.97	0.57	7.70	0.27	6.65*	0.45
General TCP	25.78	0.52	29.57	0.95	64.51***	0.86

*$p<0.05$, **$p<0.01$, ***$p<0.001$; $\eta 2>0.01$ small effect size, $\eta 2>0.059$ moderate effect size, $\eta 2>0.138$ large effect size

Interview results

After the DST projects, 10 students from the experimental group were randomly selected for a 30-minute qualitative interview to explore their experiences with GAI tools. Figure 7 presents a thematic map describing the identified themes and key insights from these interviews. Overall, students recognized the advantages of GAI tools and highlighted their role in enhancing DST projects' efficiency, fostering deeper reflection and interaction, and improving DST projects' quality. However, concerns regarding over-reliance on GAI and ethical considerations also emerged.

Several recurring themes emerged from the interviews, providing insights into both the advantages and challenges of using GAI tools in the DST projects:

Table 6 Knowledge, willingness to use, and concerns about using GAI tools for DST creation

Dimensions	Statements	M	SD
Knowledge	I understand GAI tools have limitations in their ability to handle complex tasks	4.33	0.76
	I understand GAI tools can generate output that is factually inaccurate	4.25	0.74
	I understand GAI tools can generate output that is out of context or inappropriate	4.10	0.87
	I understand GAI tools can exhibit biases and unfairness in their output	4.13	0.56
	I understand GAI tools may rely too heavily on statistics, which can limit their usefulness in certain contexts	4.38	0.67
	I understand GAI tools have limited emotional intelligence and empathy, which can lead to output that is insensitive or inappropriate	4.18	0.64
Willingness	I envision integrating GAI tools into my teaching and learning practices in the future	4.45	0.64
	Students must learn how to use GAI tools well for their careers	4.30	0.56
	I believe GAI tools can improve my digital competence	4.40	0.59
	I believe GAI tools can help me save time	4.45	0.71
	I believe GAI tools can provide me with unique insights and perspectives that I may not have thought of myself	4.48	0.60
	I think GAI tools can provide me with personalized and immediate feedback and suggestions for my assignments	4.38	0.59
	I think GAI tools is a great tool as it is available 24/7	4.33	0.66
	I think GAI tools is a great tool for student support services due to anonymity	3.88	0.69
Concerns	Using GAI tools to complete assignments undermines the value of university education	2.95	1.06
	GAI tools will limit my opportunities to interact with others and socialize while completing coursework	2.68	1.00
	GAI tools will hinder my development of generic or transferable skills such as teamwork, problem-solving, and leadership skills	2.65	1.08
	I can become over-reliant on GAI tools	3.38	0.98

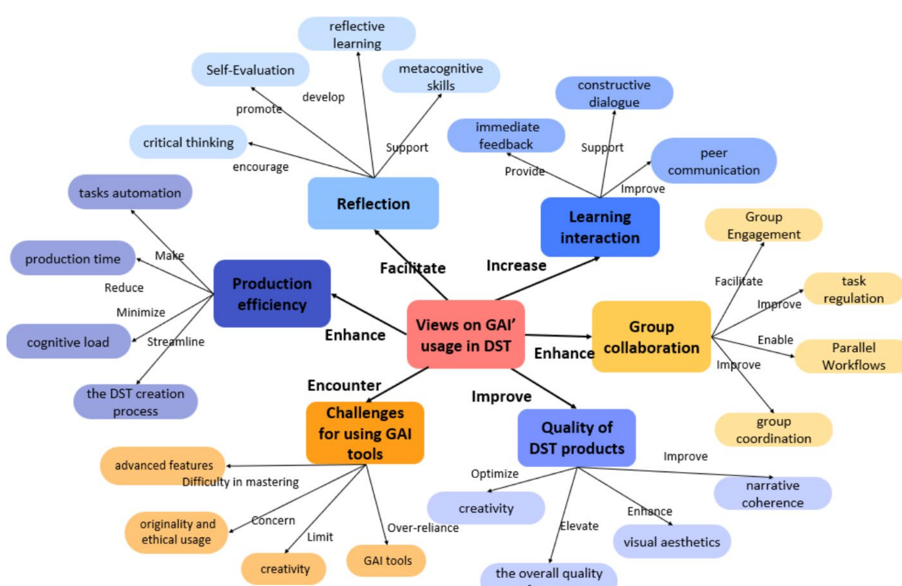

Fig. 7 The thematic map of the semi-structured interviews

(1) **Enhanced DST production efficiency**. Students appreciated GAI tools streamlined the DST process by reducing workload and accelerating content creation. For example, one student said: *ChatGPT helped me reduce a lot of manual writing and improved my efficiency."* Another remarked: *"Using Midjourney saved a lot of time, especially when generating the images."*

(2) **Improved quality of DST products.** Students highlighted the contribution of GAI tools to the overall quality of their DST products. These tools enhanced narrative flow and visual coherence, resulting in more professional outputs. One student explained, "*The images generated by Midjourney improved the visual quality of our work, making it looks more professional.*" Another student commented, "*ChatGPT helped smooth out our DST, noticeably improving the final story content.*"

(3) **Facilitated reflection**. Students reported that GAI tools encouraged reflective thinking by prompting them to evaluate their DST work critically. For example, one participant shared, "*ChatGPT's feedback made me reflect more on my creation instead of completing it without thinking.*" Another added, "*Using GAI tools made me think more regarding the logic and details of DST.*"

(4) **Increased learning interaction**. Students stated that GAI tools facilitated more group behaviors by providing immediate feedback and content generation. As one student explained, "*Midjourney gave us more opportunities to discuss in groups*." "*With GAI tools, our group discussions became more constructive, and everyone was more engaged.*"

(5) **Improved group collaboration.** Many students expressed that GAI tools facilitated group collaboration by streamlining task management and enabling simultaneous work on different aspects of the DST projects. One student remarked, "*ChatGPT allowed us to handle different tasks simultaneously, making group collaboration more efficient*."

(6) **Concerns about over-reliance on GAI tools.** Some students worried about over-reliance on GAI, which might limited their creativity and lead to ethical dilemmas related to the originality of GAI-generated content. As one student explained, "*Sometimes I feel too reliant on GAI tools, which may limit my creativity.*" Another student remarked, "*Learning how to use Midjourney effectively is difficult, especially with its advanced functions.*"

Discussion

Impact on collaborative problem-solving skills

This study demonstrated that the integration of different forms of GAI tools into DST creation significantly enhanced university students' collaborative problem-solving skills, addressing the first research question. This could be attributed to the students' collaborative efforts in solving complex tasks such as scriptwriting, storyboard, and image design, as well as interacting with both peers and GAI tools (e.g., ChatGPT, Midjourney, and Runway). The use of multiple GAI tools facilitated a wide range of interactions, fostered dynamic and multi-way communication during the co-creation of the DST process, thereby promoting effective teamwork and problem-solving. The interaction with ChatGPT played a crucial role in fostering creative storytelling by helping students generate diverse and innovative solutions, which were not as readily achievable in the traditional group setting. Based on the interviews, one participant explained, "*The ChatGPT helped* *us bring out creative ideas that we hadn't thought of on our own, which kept the collaboration moving forward.*" Additionally, Runway contributed to creating motion graphics, which helped refine ideas and foster collaboration. Real-time feedback from these GAI tools provided constant opportunities for collaboration, allowing team members to refine their ideas immediately. As one student noted, "*When someone suggested an idea, ChatGPT would instantly provide a related suggestion, and we could immediately discuss and revise it together.*" This continuous interaction between group members and GAI tools ensured that all team members contributed meaningfully to the problem-solving process. Additionally, the ability of GAI tools to provide instant feedback fostered an ongoing reflective process, enabling students to evaluate and adjust their decisions regularly. As one student said, "*The instant feedback from ChatGPT made us rethink our choices. It wasn't just about accepting the ChatGPT's suggestion but discussing it and deciding whether it made sense for our project.*" This iterative reflection fostered critical thinking, aligning with existing research on the importance of feedback loops in collaborative learning for enhancing problem-solving skills (Alazmi, 2023). Moreover, the task distribution capabilities of GAI tools, coupled with real-time feedback, improved the coordination within the group. For example, GAI-generated prompts and ideas allowed the group to break down complex tasks, delegate responsibilities more efficiently, and synchronize their efforts throughout the DST creation process, ultimately enhancing collective problem-solving.

Our findings also found that GAI-assisted DST approach enhanced sub-dimensions of CPS among students, including participation, perspective-taking, social regulation, task regulation, and learning and knowledge building. GAI tools provided more context interaction and real-time feedback, enabling group members to engage in frequent and meaningful collaborative dialogues. These dynamic exchanges allowed students to better rehearse essential skills such as articulating thoughts, evaluating solutions, and reaching consensus efficiently. Moreover, GAI tools like Midjourney contributed to the instant visual process by generating images that the group could iterate on, which helped streamline communication and foster shared understanding among team members. This capability enhanced participation and task regulation, as team members were able to contribute actively and coordinate their efforts more effectively throughout the DST creation process. The improvement in perspective-taking was particularly evident during the DST composition process. DST, with its flexible structure, allows for the exploration of story ideas and creative imagination from multiple viewpoints. Communication with ChatGPT enabled participants to engage with the story from various perspectives, such as the protagonist's point of view, which enhanced their ability to consider different perspectives and broaden their narrative approach. This shift in perspective-taking was essential for crafting more nuanced and multifaceted stories. Additionally, GAI tools supported social regulation by helping group members coordinate their efforts and adjust their interactions. Interview results further supported these findings. One student mentioned, "*ChatGPT helped our group stay organized. Whenever we faced disagreements, it suggested neutral solutions and helped us move forward without unnecessary conflicts*." This finding aligns with existing research indicated that GAI tools can promote social-regulated learning (Huang & Lin, 2024).

In addition, the control group still showed significant improvement in CPS skills via traditional methods, particularly in contexts requiring manual evaluation and deliberation. This can be attributed the fact that although GAI tools could streamline the problem-solving process, traditional tools could foster deeper critical thinking and more independent decision-making by requiring students to manually engage with each stage of problem-solving process (Zhai et al., 2024). In other words, when students have reached the evaluation stage, they need to collaboration to make a decision without the immediate support of technological feedback. This reveals that a hybrid approach, combining both GAI tools and traditional methods, may offer the best balance between efficient collaboration and critical evaluation.

Impact on team creative performance

In response to the second research question, this study demonstrated that the integration of GAI tools in DST creation significantly enhanced university students' team creativity performance, particular in the sub-dimensions of novelty and user experience. The improvement in novelty was particularly pronounced during the divergent stages of DST co-creation. For instance, during scriptwriting, ChatGPT played a critical role by facilitating the seamless integration of various ideas into group discussions. It generated innovative prompts that inspired teams to produce more diverse and creative DST scripts. Based on the interview results, one student said, "*ChatGPT helped us come up with more creative ideas than we could have thought of on our own. It gives us prompts that we never considered, which helped us push the boundaries of our story.*" In addition, Midjourney and Runway further enhanced collaboration by enabling all group members to access and interact with materials such as texts, images, and videos in real-time, thus promoting a more collaborative and interactive environment. This simultaneous access to resources fostered a shared and comprehensive approach, allowing team members to contribute ideas, get feedback, and explore multiple perspectives together. The enhanced collaboration and diversity of ideas boosted the overall creativity of the group, aligning with prior research suggesting that AI tools enhance creativity by promoting divergent and expansive thinking (Tala et al. 2024).

The positive impact of GAI tools was also evident in user experience during DST activities. For instance, during the stage of static image creation, Midjourney provided an intuitive interface that allowed students to easily navigate various elements of their DST projects. One student noted, "*Midjourney made us so easy to experiment with different visuals, we could see the changes of images and get feedback right away.*" This ease-of-use features fostered active participation from all group members, which led to a more collaborative and integrated creative process. Moreover, the feedback provided by ChatGPT improved the user experience by enabling immediate iteration and adjustment of ideas. As one participant observed, "*ChatGPT give us suggestions instantly and we could make changes, which speed up our DST creation process.*" The abilities of Midjourney to visualize, ChatGPT to generate narrative contents, and Runway to assist with motion graphics simultaneously made the DST design process more engaging and interactive. This integration of multiple GAI tools enhanced the creative flow, allowing for seamless adjustments across different media formats, ultimately contributing to higher levels of user satisfaction. As research has shown, continuous feedback loops enhance both the quality and relevance of creative outputs (Kerr & Kelly, 2024). In terms of sustainability, GAI tools supported long-term creative processes by allowing students to continuously build upon and improve their ideas. GAI tools enabled the team to reflect on their progress and make iterative adjustments, ensuring that their DST outputs were relevant and sustainable over time. Based on interviews, one student mentioned, "*The GAI tools helped us revisit and improve our work multiple times, making sure that it stayed relevant and evolved as we worked on it*."

While the benefits of GAI tools in improving team creative performance are evident, it is important to recognize the potential risks associated with over-reliance on GAI-generated content. Interview results revealed that some students felt that GAI-generated DST products lacked emotional depth and authenticity typically found in human-generated ideas. One student expressed, "*The ChatGPT was great for generating ideas, but sometimes the outputs felt a bit robotic or lacked emotion*." This finding highlighted the need for a balanced approach, where GAI tools are used to enhance technical creativity and efficiency, but human creativity and emotional resonance remain central to the final DST products. Therefore, it is crucial to ensure that GAI-generated outputs do not overshadow the human touch, which is vital for preserving the artistic integrity and emotional depth of DST.

Impact on students' attitudes towards using GAI tools

As for the third question, the findings of this study indicated that students hold a high level of awareness regarding the GAI's limitations, a strong willingness for integration, and moderate concerns about dependency and skill development in the context of DST creation. Students demonstrated better understanding of GAI's constraints, particularly its reliance on statistical patterns, susceptibility to factual inaccuracies, and potential biases. This suggests that students engage critically with GAI-generated content rather than passively accepting outputs, reinforcing the importance of AI literacy in education. These results align with prior research emphasizing the need students to develop critical evaluation skills when interacting with AI tools (Li et al., 2025). The study also revealed that students had a high willingness to adopt GAI tools, particularly for enhancing efficiency, digital competence, and personalized learning experiences. Students acknowledged the benefits of GAI's ability to streamline DST content creation, generate unique insights, and provide immediate feedback. This result was supported by prior studies on AI's role in facilitating engagement and cognitive development in digital environments (Li et al., 2024). The strong agreement of GAI tools for improving creativity and problem-solving skills suggests that students perceive these tools as cognitive enhancers rather than substitutes for independent thinking. However, the relatively lower perception of GAI's role in anonymous student support services may reflect ethical and privacy concerns, warranting further exploration into GAI-mediated student interactions and support mechanisms. Additionally, while enthusiasm for GAI integration is evident, students expressed concerns regarding over-reliance and the potential impact on transferable skills must be addressed. Students expressed concerns that GAI tools may diminish teamwork, problem-solving, and leadership skills. This result aligns with recent studies on cognitive offloading and AI dependency (Wang et al., 2025). These concerns suggest the need for carefully structured GAI-assisted learning approaches that balance technological support with active student engagement and higher-order thinking.

Conclusion

This study proposed and implemented a GAI-assisted DST creation within a PBL method, focusing on university students' CPS and TCP. The study findings revealed that the university students who utilized GAI tools for DST creation significantly outperformed in both CPS and TCP when compared to those using traditional methods. Moreover, students expressed a positive attitude toward the use of GAI tools in DST creation, particularly valuing its role in enhancing efficiency and creativity, they also raised concerns about cognitive offloading, over-reliance on GAI technology, and the lack of emotional support provided by GAI tools. These findings offer actionable strategies and insights for teachers, educators, and researchers to enhance the adoption of GAI-assisted DST creation. By leveraging the features of GAI tools, students can effectively collaborate, access, and generate diverse digital materials, and express their ideas more freely, resulting in a richer and more productive DST design experience.

Theoretical implications and practical contributions

The study provides several theoretical contributions to the understanding of GAI's adoption in DST creation among university students. The novelty of this study lies in its pioneering approach to integrate multiple GAI tools, specifically ChatGPT, Midjourney, and Runway, into the DST creation process. While existing studies have explored GAI's role in generating short teaching videos (Netland et al., 2025), this study extends the scope by incorporating a combination of GAI tools in a collaborative and creative environments for DST production. The study highlights the potential of these tools to facilitate synchronous collaboration, where team members can work together to generate digital materials and interact with multimedia elements in real-time, thereby enhancing creativity, problem-solving skills, and group coordination. Moreover, the integration of GAI tools in DST contributes to computer-supported collaborative learning (CSCL) by demonstrating how GAI-powered tools can enhance real-time communication, task regulation, and social cohesion within learning groups. It further advances theoretical perspectives on GAI-supported learning environments, demonstrating how GAI can serve as both a cognitive scaffold and a creative enabler. By leveraging GAI-generated content, students engage in dynamic and multimodal learning, where human-GAI collaboration fosters idea generation, conceptual refinement, and collective meaning-making. This study thus contributes to the growing understanding of how GAI tools can enhance collaborative problem-solving and creativity, offering valuable insights into the synergistic relationship between GAI, creativity, and collaborative learning in digitally mediated educational contexts.

From a practical perspective, this research provides a structured methodology for integrating GAI tools into DST, thus contributing to the broader discourse on GAI-enhanced pedagogical practice. By demonstrating how GAI-assisted DST creation enhance CPS and TCP, this research offers concrete implications for educators, instructional designers, and policymakers seeking to navigate the evolving role of GAI in education. For educators, this study highlighted the potential of GAI to create student-centred learning environments that facilitate real-time content generation, iterative feedback, and multimodal engagement in collaborative tasks. However, successful implementation requires pedagogical strategies that balance GAI assistance with the need for student autonomy, ensuring that learners critically engage with GAI-generated content rather than relying on it passively. For instructional designers, this research emphasizes the importance of developing scaffolded learning environments that integrate GAI tools while remaining aligned with constructivist and inquiry-based learning principles. Designers should focus on creating flexible learning experiences that allow students to benefit from GAI's capabilities while preserving opportunities for critical reflection and independent thought. As for policymakers, the findings underscore the need for ethical and equitable frameworks for GAI's integration in education, addressing concerns about cognitive offloading and over-reliance on GAI technology. It is crucial to address these issues by ensuring that GAI's adoption promotes responsible usage and balances technological assistance with opportunities for the development of critical thinking and human interaction in educational contexts.

Limitations and future directions

This study has certain limitations and offers recommendations for future researchers. First, the study was limited to a single environment in China's universities. It used a relatively small sample, which may restrict the generalizability of the results to different educational settings or demographic groups. Future research could explore the impact of GAI tools in different educational settings, involving larger and more varied sample sizes. Research should also focus on the application of GAI tools across diverse disciplines, such as STEM or social sciences, to better understand their broader applicability and potential. Second, the study primarily utilized three kinds of GAI tools: ChatGPT, Midjourney, and Runway for DST creation, which represents only one facet of GAI's potential. Future studies should explore how these GAI tools can be applied in other educational domains, investigating their roles in enhancing collaborative learning and problem-solving in subjects beyond DST. Developing more comprehensive GAI toolsets tailored to various academic disciplines and aligned with different pedagogical approaches would facilitate a deeper exploration of their functional versatility and inherent limitations.

Furthermore, this study had a limited exploration of the risks associated with over-reliance on GAI tools, which could affect students' autonomy and critical thinking skills. While GAI tools provide benefits in DST's efficiency and creativity, it is crucial for future studies to develop pedagogical strategies that balance the use of GAI with the preservation of student agency. Research should also examine how to structure GAI integration in a reasonable way that encourages cognitive engagement and avoids diminishing students' ability to think critically and independently. Clear guidelines on the ethical use of GAI tools in educational settings are also necessary to ensure responsible adoption. Additionally, students' perceptions and adoption intentions regarding GAI may have been influenced by their varying levels of familiarity with these tools. Students with limited experience with GAI tools might have relied on their initial impressions or existing beliefs, thereby shaping attitudes and intentions (Shahzad et al., 2024). Thus, future research should examine how ongoing exposure to GAI tools influence students' engagement, attitudes, and usage patterns over time.

Lastly, individual characteristics (e.g., gender), ethics, and socio-cultural (e.g., life experiences) aspects can affect students' beliefs and behaviors regarding GAI tools. Future studies could explore how these factors impact students' ability to effectively use GAI tools in collaborative learning contexts. Specifically, gender dynamics may shape students' approaches to creativity, critical thinking, and decision-making, thereby affecting their ability to leverage GAI tools effectively in team-based problem-solving tasks. Future studies could incorporate gender as a variable to explore its impact on collaborative learning and to provide a more nuanced understanding of GAI's role in diverse educational contexts. Future research should also focus on developing comprehensive frameworks to assess the effects of GAI's integration in education and measure their impact on learning outcomes. Such work would guide educators to design GAI-enhanced learning environments that promote meaningful learning while ensuring responsible use of GAI tools in the digital age.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41239-025-00526-0.

Supplementary Material 1

Author contributions

Xiaodong Wei contributed to the conceptualization and design of the study, data collection, analysis, interpretation of results, and manuscript drafting. Lei Wang assisted with the methodology, data analysis, and drafting and revising of the manuscript. Lap-Kei Lee contributed to the literature review and provided critical feedback during the drafting process. Ruixue Liu, the corresponding author, supervised the study, contributed to the study's conceptual framework, and provided guidance throughout the research process. All authors read and approved of the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

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