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PAPER

Integrating Mobile AI in Art Education: A Study on Children's Engagement and Self-Efficacy

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ABSTRACT

Existing literature has extensively explored the application of artificial intelligence (AI) in core subjects such as mathematics and language, but its use in children's painting education remains limited. Addressing this gap is crucial, particularly in examining how AI can enhance children's self-efficacy, motivation, and engagement in art. This study developed a scaffolded teaching method using a mobile AI synchronous generation drawings (MAI-SGD) tool and evaluated its effectiveness in primary school art education. A quasi-experimental design was adopted, involving 60 third-grade students divided into an experimental group (using MAI-SGD) and a control group (using traditional paper painting). Data were collected through motivation, self-efficacy, and art engagement scales. Results indicated that students using MAI-SGD demonstrated higher artistic engagement ($p < 0.05$) and significantly outperformed the control group in drawing motivation and creative self-efficacy. These findings suggest that MAI-SGD enhances creative interest and benefits technology-sensitive learners. The study offers empirical support for AI in children's art education and provides insights for its reform, emphasizing individualized teaching. Future research should explore MAI-SGD's applicability across cultural contexts and educational stages to advance its theoretical and practical contributions to art education.

KEYWORDS

mobile learning, artificial intelligence (AI), drawing education, creative self-efficacy, motivation, engagement, mobile AI synchronous generation drawing (MAI-SGD)

1 INTRODUCTION

Mobile learning is a critical and growing field, and mobile technology is gradually showing an essential role in teaching and learning [1]. The world currently needs more efficient learning models, and technological evolution is changing teaching models, all of which will be accompanied by students taking an active role in education [2]. Mobile learning has unique advantages as a teaching tool to improve student learning outcomes and change education models. It integrates appropriate

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teaching methods into the design of learning models to improve student learning outcomes [3]. In recent years, the development of mobile education has come from the rapid growth in the popularity of smart mobile devices [4, 5]. Okros [6] stated in the book "Gen Z: Digital in Their DNA" that no generation has demonstrated the same level of technological expertise or adaptability at such a young age as Generation Z. This echoes the sentiment expressed by [7] that no generation has lived in an era where technology has been so readily available at such a young age. A report from Cisco shows that mobile devices are growing faster than the world population, with the number of mobile users set to grow at 2% per year. By 2023, more than 70% of the world's population will have a mobile phone [8]. Research further indicates that by 2025, there will be an estimated 5.6 billion mobile phone users, with coverage reaching most areas and exceeding 90% [9]. Therefore, to adapt to and support increasing mobility, teaching methods should be changed and adjusted, and reasonable conditions should be created for using mobile technology in teaching based on authentic learning [10].

Integrating artificial intelligence (AI) and mobile learning has completely changed digital education and heralded a new transformation and reform of learning methods [11, 12]. In 1956, AI was defined as "the science and engineering of creating intelligent machines." In education, AI can help teachers predict students' learning status and performance, recommend learning resources, and automate assessments to improve students' learning experience [13]. The pervasive use of mobile devices enables learners to engage in learning at any time and location [14]. In addition, integrating mobile learning and AI has mutually promoted the advantages of the two technologies. [15] believes that the mobile Internet has brought more application scenarios for AI. At the same time, mobile devices provide ubiquitous access and adaptive content, and the development of AI is closely related to mobile learning [16]. Therefore, more and more mobile learning is driven by AI [17]. Studies further indicate that AI-based mobile learning significantly improves student learning outcomes and that AI-based mobile learning has been shown to provide excellent instructional delivery [18].

However, the combination of AI and mobile learning still faces challenges. On the one hand, the standardization of early childhood education AI courses and effective teaching methods are lacking, resulting in uneven teaching quality [19]. On the other hand, some studies have pointed out concerns about the negative impact of mobile AI learning. Technological stress and fatigue can decrease students' willingness to engage in mobile learning, accompanied by adverse effects such as social overload, information overload, intrusion into their lives, and invasion of privacy [20]. In addition, it is worth noting that young children grow up with these AI applications, but their AI literacy is low. Children may not know how to use AI and the basic working principles behind these tools and may have misconceptions about these technologies; children are easily misled or misuse AI tools [21]. It can threaten their safety if AI gives wrong and misleading information or advice. Furthermore, technostress may cause cognitive burden and creativity decline in students when using AI-assisted learning for a long time, which is also a direct consequence of the change [22]. [23] pointed out that when students become accustomed to relying on AI recommendations rather than exploring independently, it may reduce their ability to create independently. Research further indicates that combining AI and mobile learning technology is expected to improve flexibility and applicability [18]. Therefore, it is necessary to impart basic knowledge about AI to children through proper teaching methods.

However, children's lack of drawing ability will ultimately lead to a lack of motivation and creative self-confidence [24]. Imagining by depicting observable entities is challenging for children to represent three-dimensional objects on a two-dimensional surface, and they may even fail to complete the drawing [25]. Moreover, associations formed in children's minds are influenced by their society and culture, so the painting challenge is multiplied [26]. Research further shows that children struggle with attention and engagement when drawing [27]. Teachers lack training in implementing creativity programs, and creativity research lacks knowledge of existing programs that stimulate children's creativity and effectiveness [28]. Therefore, Rahiem [29] teachers need to be able to develop and adopt innovative and improved digital teaching methods to solve problems.

The research addresses the goal of constructing a practical MAI-SGD based on a scaffolding teaching framework to improve the effectiveness of teacher instruction while filling the gap in AI-supported technology in children's painting education and providing empirical data to support the use of AI in art education. This study will explore the impact of MAI-SGD on students' motivation to draw, creative self-efficacy, and engagement in art. In addition, the impact of this study aims to provide empirical data to support the application of AI in art education so that teachers can implement personalized teaching in different learning contexts, especially for children of different drawing levels, thereby improving their drawing motivation and creative self-efficacy. In addition, it explores the model of AI-enabled children's art education to provide a theoretical basis for future education policy and technology development. The experiment results will evaluate changes in students' art engagement, motivation, and creative self-efficacy in the drawing course. This study aims to answer the following three questions through experiments and analysis. The research questions are as follows:

1. Is there a significant difference in artistic engagement in drawing between students using a mobile AI-powered synchronous drawing tool and students drawing traditionally on paper?
2. Is there a significant difference in creative self-efficacy between students using a mobile AI-powered synchronous drawing tool and students drawing traditionally on paper?
3. Is there a significant difference in motivation in drawing between students using a mobile AI-powered synchronous drawing tool and students drawing traditionally on paper?

2 LITERATURE REVIEW

2.1 Mobile AI technologies in education

[16] pointed out that the development of AI is closely related to mobile learning because mobile devices provide ubiquitous access and adaptive content. Hwang et al. [30] showed in their literature review that the main topics of AI-supported mobile learning research in recent years have focused on "mobile learning," "artificial intelligence," and "intelligent tutoring systems," and the number of studies is on the rise. The research shows that mobile AI technology has positive potential and challenging limitations in teaching. On the one hand, previous research has repeatedly demonstrated mobile AI technology's effectiveness and positive impact on learning.

Moya and Camacho [11] developed an instructional framework for AI-driven mobile learning information. Integrating AI and mobile learning can expand and enhance the principles of mobile learning accessibility, universality, and connectedness interactivity, thereby improving learning experiences and outcomes. In addition, [18] pointed out that AI-driven mobile English learning improves students' English proficiency. For example, mobile AI's timely feedback improves students' English pronunciation problems. Not only that, but mobile AI also enhances students' positive learning attitudes and increases learning opportunities for students.

[31] developed an AI-based mobile learning media, and research showed that professionals tested the app as belonging to the excellent category and having a high degree of practicality. The results of the Android-based mobile learning app for students were positive, with a response rate of 79.5%, showing that students have a high degree of engagement with mobile AI technology tools. The combination of intelligent adaptive learning platforms and well-designed mobile learning has improved student engagement and learning outcomes in STEM subjects [32]. In addition, [33] claims that mobile learning extends mobile access programs and introduces AI as the most advanced mobile learning teaching framework. In addition, from a technical perspective, mobile AI technology brings significant advantages to users and developers by running deep learning models locally on devices, which enables low latency, high privacy, cost savings, and more efficient computing. These characteristics have led to mobile AI's increasing application and development in smart device education [34].

Several studies have explored the effectiveness of mobile learning AI technology on student teaching and its positive impact. [35] The point is that AI technology is developing rapidly in the context of smartphone computing and can be used to design and develop intelligent mobile applications to improve teaching methods. [36] developed a teaching method based on AI machine learning through football teaching videos on the mobile Internet. The research shows that students can intuitively analyze actions and improve teaching quality. Reconstruction of the football teaching environment is conducive to promoting the integration of football teaching with innovative learning. [37] The design of a mobile online education resource-sharing system from the perspective of human-computer collaboration improves resource-sharing efficiency. It enhances users' enthusiasm for contributing online education resources. Clearly, research shows that mobile learning AI technology has become an important teaching tool in the field of education.

However, mobile AI education technology still has many problems and challenges. In a mobile learning environment, the stability of the network connection is crucial. An unstable signal or network congestion may cause delays in the response of AI applications, affecting students' learning experience [38]. Student feedback on mobile apps based on AI is faulty, and the instructions are too complicated to understand and use [18]. The teaching of mobile AI learning lacks teacher supervision, so students with weak self-regulated learning skills find it difficult to organize and plan their studies. They must limit the learning time and complete the learning materials each week [18]. Additionally, [39] pointed out that the Android-based learning media currently being developed has not been integrated with AI. It is worth noting that although AI makes personalized recommendations, in actual application, it is worth exploring whether AI systems can genuinely understand students' deep-level needs, emotional states, and cognitive abilities [40].

In addition, mobile learning AI technology has also made initial explorations in teaching painting. Mobile learning methods based on AI improve students' painting results and ability to appreciate art [41]. Progressive peer feedback based on mobile terminals combined with AI in flipped classrooms and education positively impacts elementary school students' creative art thinking, and metacognitive awareness has also been significantly improved. It is conducive to helping them reflect critically on their paintings and understand how to improve the integrity of their paintings [42]. Moreover, [27] developed a co-creation system called Story Drawer. The system supports visual storytelling by children aged 6–10 years through collaborative drawing between children and AI. The system translates children's narratives into drawings in real time, generating abstract sketches with semantic similarities to existing story content.

However, there are still significant gender differences in the use of AI in painting education. For example, research has found that AI image-processing tools may reduce girls' learning attitudes and willingness to continue learning while stimulating boys' interest in learning [43]. This phenomenon reveals the limitations of current study in terms of gender differences. In addition, [44] points out children's use of AI-enhanced technology. However, the complexity and inaccessibility of AI educational technology make AI children's paintings less inclusive. Research suggests there are still limitations in developing child-friendly AI tools that are easy to use for children's drawing. Research further suggests that current drawing education may have limitations in mobilizing students' initiative and interest [45]. There are gaps in research on the effectiveness of AI technology in motivating children to learn [46]. In addition, there is currently a lack of in-depth research on the potential application of mobile AI technology in drawing education, especially in early childhood drawing education. As such, existing research has not fully explored how AI-based mobile learning can impact children's artistic engagement, creative expression, and self-efficacy.

This study proposes an improved method for addressing the current limitations of AI in children's painting education, especially regarding feedback mechanisms, gender differences, and ease of use. First, existing research has not fully explored how AI-based mobile learning affects children's art engagement, creative expression, and self-efficacy. This study fills this gap by introducing mobile AI-supported simultaneous generation (MAI-SGD) based on the scaffolding teaching method. MAI-SGD aims to enhance students' initiative and autonomy through intelligent adaptive feedback, supervised feedback from social platforms, personalized task guidance, and dynamic support adjustment while avoiding overreliance on AI recommendations and enhancing creative expression space. In addition, it addresses gender differences. On the one hand, MAI-SGD adopts a personalized generation mechanism to adjust the feedback method and generation style according to students' interaction preferences and drawing preferences, ensuring that students of different genders can receive adaptive support. On the other hand, the social platform allows students of different genders to freely exchange and comment on works, thereby improving the fairness and inclusiveness of the AI drawing tool. Through these improvements, this study not only deepens the application of AI in drawing education but also provides a more practically valuable theoretical framework for future AI-based autonomous learning systems.

2.2 The relationship between dependent variables

Artistic engagement refers to the degree of involvement of students in artistic learning or activities [47]. Students with high artistic engagement are likelier to immerse themselves in learning, gain a deeper understanding and experience, and thrive in school and life [48]. [49] points out the importance of engagement in online learning. Student engagement can increase student satisfaction, enhance motivation, reduce feelings of isolation, and improve student performance in online courses. [50] emphasizes the importance of active participation in the educational process to achieve the best learning outcomes. In addition, [51] believes that from a participation perspective, student success depends on the degree of participation.

Motivation to learn is the internal strength or external factor that drives students to participate in learning [52]. Internal motivation leads to more active participation in learning tasks [53]. Internal and external motivation can promote long-term learning plans [54]. Motivation influences the learning process, which can improve the factors that affect the quality of education and learning [55]. Furthermore, Rostan's [56] study explored how motivation to participate in formal visual arts training promotes competence and creativity in young art students. In arts learning, extrinsic motivation is external and more straightforward to develop than intrinsic motivation. Intrinsic motivation in the form of interest in the arts and a desire to create tends to promote longer-term engagement in learning than extrinsic motivation in the form of grades or rewards [57]. Notably, intrinsic motivation is more elevated than extrinsic motivation, as demonstrated by the fact that those with lower intrinsic motivation may be elevated more significantly in specific contexts due to external stimuli or other factors [58]. Thus, innovative and effective teaching methods need to be developed for teaching drawing to enhance student motivation.

Learning self-efficacy is a student's belief in his or her ability to accomplish goals in a given learning task [59]. Research has shown that the more students believe in their knowledge and skills, the more engaged and persistent they will be in completing tasks [60]. Additionally, students with high self-efficacy have greater intrinsic motivation, resilience, and positive attitudes toward learning, qualities that make up for their initial achievement disadvantages and allow them to eventually outperform academically those students who lack self-confidence despite higher grades [61]. Research has further shown that fostering students' self-efficacy promotes cognitive and emotional self-regulation, gradually leading to self-reliance [62–64]. Notably, children are more likely to overestimate their self-efficacy, and children tend to have a more optimistic or overconfident view of their ability to, for example, learn, solve a problem, or complete an activity [65]. Therefore, the need to help children understand and be truthful about their abilities is critical, as reasonably guiding children to a proper understanding of self-efficacy can better motivate them to learn and grow.

The dependent variables in this study include engagement, motivation, and self-efficacy, which influence each other to reflect the integrity of the learning process and provide a multi-perspective analysis. The higher the motivation, the higher the learning engagement, and motivation is positively correlated with engagement, i.e., higher motivation tends to lead to higher engagement [66, 67]. Similarly, engagement can directly enhance learning motivation [68]. In addition, when students develop a high level of engagement in arts activities, it enhances their intrinsic motivation to learn and promotes a lasting interest in arts learning [68]. Further, motivation and learning self-efficacy complement each other. Highly motivated students attempt tasks more vigorously and increase their self-efficacy through successful experiences. Students with high self-efficacy are more likely to remain motivated to learn, creating a positive cycle. Meanwhile, self-efficacy is an important but neglected component of motivation regulation for compelling motivation [69]. Self-efficacy strongly affects learning engagement. Highly engaged students are more likely to feel a sense of accomplishment in arts learning, which increases confidence in their abilities.

Overall, arts engagement promotes motivation to learn, and motivation to learn further enhances learning self-efficacy. Thus, all three factors work together to promote higher learning experiences and growth in arts education.

2.3 Theoretical framework

This study is built on a multi-theoretical framework, mainly based on social constructivist learning theory and Zone of Proximal Development (ZPD) theory. Social constructivism argues that learning is realized through social interactions and cultural tools, and individuals construct knowledge during dynamic interactions with the environment [70]. As illustrated in Figure 1. ZPD theory further emphasizes that learners supported by appropriate scaffolding can perform tasks beyond their current independent abilities, thus promoting cognitive development and skill enhancement [71]. The mobile AI synchronous generation drawing (MAI-SGD) tool in this study can be considered an interactive learning tool that provides real-time feedback and challenges children moderately within their ZPD, allowing them to continuously improve their drawing skills and artistic understanding during the interactive process.

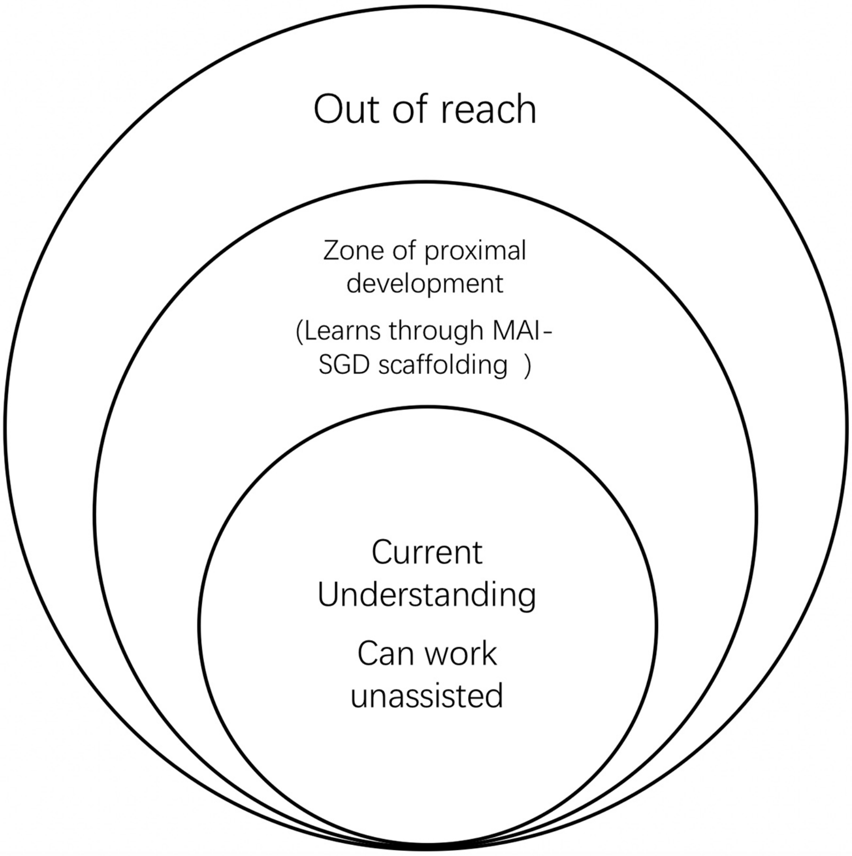

Fig. 1. Zone of proximal development model adapted from [72]

In addition, studies have shown that children's drawing processes are a reproduction of the objective world and a key pathway for their cognitive development and creative expression [25, 73]. As children's imagination and visual expression are still in the developmental stage, the subject matter of their drawings often originates from their perceptions and impressions of the real world. Drawing activities help children explore and understand reality and promote the development of abstract thinking, problem-solving skills, and emotional expression through the construction of visual symbols. Particularly in children aged 4–10, drawing is considered a form of implicit learning, enabling them to unconsciously acquire new skills such as spatial awareness, shape recognition, and compositional skills [74].

Research has further shown that ZPD strategies can help students learn effectively, and scaffolding can be an effective strategy for teaching skills [75]. [76] claimed that teachers would be more effective if they taught with ZPD and used instructional strategies targeting the class's "average" ZPD. [77] states that ZPD designers may match strategies to specific learning, allowing the ZPD approach to enhance the effectiveness of course instruction.

[78] study noted that the combination of collaborative learning and Vygotsky's ZPD can increase the effectiveness of simulation-based instruction. Notably, [79] states that teachers must ensure that students are within their ZPD when designing learning activities and support materials, which allows learning tasks to be both appropriate to the student's level of ability and appropriately challenging so that cognitive skills can be enhanced with guidance and support. However, the ZPD strategy is also subject to some skepticism. A ZPD strategy in which teachers or technological tools provide too much guidance may inhibit students' ability to learn independently, causing them to become reliant on external support and undermining the development of independent problem-solving skills. [75] In addition, the ZPD practice approach emphasizes teacher control rather than allowing students to explore and construct knowledge freely [80]. ZPD ignores students' differences and opportunities for active exploration [81]. Notably, ZPD requires teachers to provide individualized support and adjust instructional strategies, and teachers are overburdened, making it difficult for them to take care of each student's task setting [82].

Therefore, combining social constructivism and ZPD theory, this study hypothesizes that the MAI-SGD tool can effectively promote children's cognitive development and skill enhancement in the process of drawing by providing dynamic and personalized guidance, reducing the burden on teachers. The AI tool not only responds to children's operations in real-time but also provides children of different ability levels with a data-driven intelligent feedback mechanism that personalizes and effectively supports children with varying levels of ability through a data-driven intelligent feedback mechanism, which allows children to get rid of their dependence on the teacher and explore independently. This intelligent interaction enhances children's learning initiative. It provides appropriate challenges within their ZPD, enabling them to improve their drawing ability through continuous exploration and experimentation and to gain a stronger sense of self-efficacy for artistic creativity and motivation for drawing.

2.4 Development process of mobile AI synchronized generative drawing tool

Based on the above theoretical background and previous experimental evidence, the MAI-SGD main interface used in this study includes five modules: a drawing training module, an AI interactive feedback module, a personalized style generation module, an online classroom and community module, and a task recording log. AI is a tool developed on the Yee Heart platform. The Drawing Training module allows students to draw with basic controls such as straight lines, curves, circles, and perspective lines. Light and dark relationships and volume can be shaped. It also allows students to practice color matching and adjusting warm and cool tones using different brush strokes. The AI Interactive Feedback Module allows students to use the AI tools to automatically identify the sketches they have drawn and generate beautiful images, as shown in the figure. The Personalized Style Generation module allows students to choose their drawing style according to their preferences. The task log allows students to view their previous work at any time and facilitates the teacher to check and evaluate the students' progress. Of note is the Online Classroom and Community module. Research has shown that while AI tools provide a personalized and independent learning path, students lack social connections. Therefore, an online social module could allow students to upload their work on the software platform. Peers and teachers can comment, like, or follow each other's work, as shown in Figure 2. It also facilitates teachers in managing students' progress, monitoring, commenting on feedback, and regulating task progress.

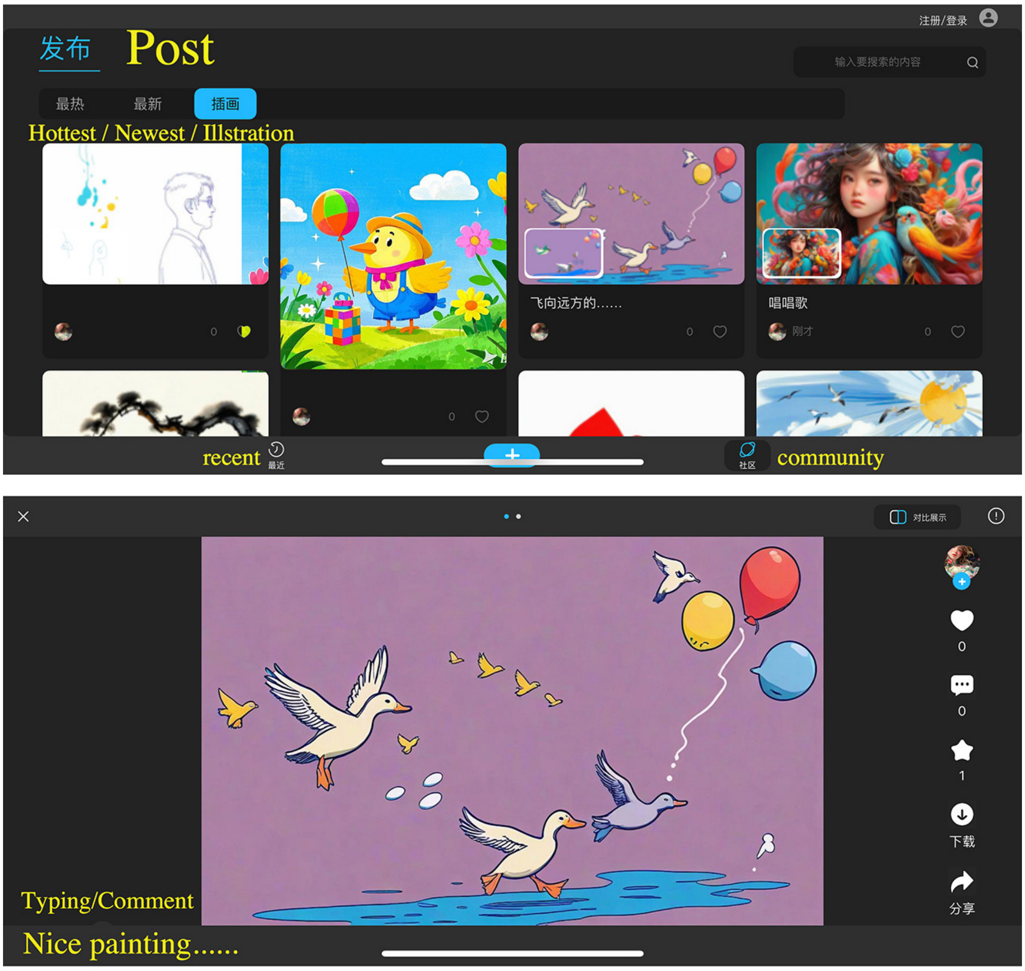

Fig. 2. MAI-SGD socialization platform

Artificial intelligence interactive learning benefits can give students personalized technical support and timely feedback to support efficient task completion [83]. It is consistent with the theoretical framework of ZPD, which suggests that supporting students beyond their capabilities, where appropriate, can enhance students' academic achievement success, goal attainment, and self-efficacy [84]. Additionally, consistent with social constructivist theory, which supports that students interact socially and learn new knowledge and that the social process takes an important place. Social interaction in this study refers to students interacting with the MAI-SGD; in addition to the tool's social platform, communication, including commenting, liking, sharing, and bookmarking, is also important in enhancing students' social learning. Notably, Scratch, a tool for remote collaboration and sharing of creative work developed by [85], points out that a system that supports social creativity must promote sharing and entertainment. Scratch allows an online community to create and share animated stories and video games. It is used mainly by children between the ages of 8 and 17. The study results show that the most popular subcategory of the application module in the tool is social, with 28%. Children participate by commenting, tagging, bookmarking, joining galleries, and participating in forums. Therefore, in this study, the social points platform of MAI-SGD was developed to enhance students' social skills in online communication. The focus is on the availability of feedback from teachers and peers' comments on the social platform, which fulfills the core requirement of social constructivism. The social constructivist perspective recognizes that children learn through each other and that more capable peers and adults learn by providing support or mediation [86]. Please refer to the illustration in Figure 3 for a visual representation of the MAI-SGD structural framework.

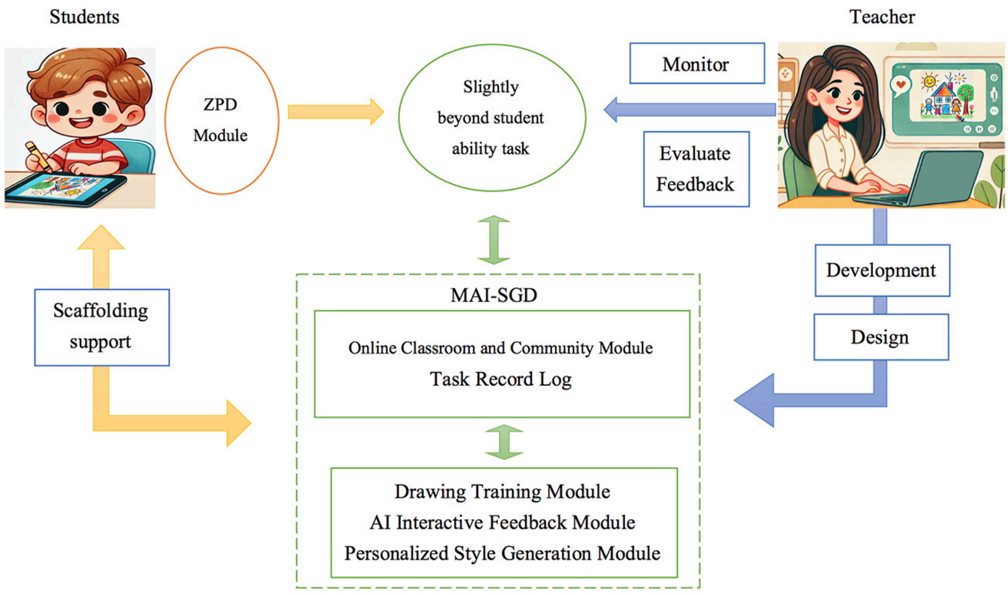

Fig. 3. MAI-SGD structure framework

3 METHODOLOGY

3.1 Participants

In this study, we used cluster sampling to select two existing classes from the second grade of an elementary school in a city in southwestern China, with a total of 60 students. One class was randomly assigned to the experimental group (n = 30), and the other to the control group (n = 30). Since the classes already existed, individual random assignment was not possible, so a quasi-experimental design was used. The sample in this study consisted of 32 boys and 28 girls. Previous studies have shown that a quasi-experiment with 60 participants per group is sufficient to detect medium to large effect sizes with sufficient statistical power in a similar educational research context [87].

Students were exposed to two equally supervised methods in the experimental and control group treatments. Teachers were asked to maintain a neutral role during the experiment and avoid providing extra guidance or feedback to any group of students. The drawing lessons were taught by the same teacher and followed a unified syllabus and teaching plan to reduce the impact of the teacher factor on the experimental results. All lessons were conducted in the same classroom and simultaneously to reduce interference from environmental factors. Before the experiment began, the research team assessed the students' AI literacy and digital painting experience through questionnaires and interviews. The results showed that all students had a comparable basic level of AI literacy and had not received relevant training or digital painting experience, ensuring that the baseline levels of the experimental group and the control group were the same. In addition, a pre-test of painting ability was conducted before the experiment, and the results showed no statistically significant difference in painting ability between the two groups ($p > 0.05$), ensuring that the initial state of the two groups of students was comparable.

During the experiment, all participants used the same model of tablet computer to ensure consistency in the experimental conditions. Students in the experimental group (Experimental group A) used the mobile AI synchronization drawing tool for classroom drawing exercises, while students in the control group (Control Group B) used the traditional paper drawing (TPD) tool for the same drawing tasks to assess the effects of different drawing tools on students' artistic learning. As a quasi-experimental study, the lack of random assignment may introduce confounding variables, affecting the results' external validity. However, through pre-test assessment, statistical control, and surveys of students' prior experience, we found that students had not tried AI-assisted drawing before. It ensured that the experimental and control groups were comparable regarding baseline characteristics.

All student information was kept strictly confidential, and anonymous numbering (A1–A30) for the experimental group and B1–B30 for the control group) was used during the study to ensure no personally identifiable information was involved in the data collection and analysis process. In addition, the research team made it clear to parents and students that the experiment was based entirely on the principle of voluntariness and that students could withdraw at any time without affecting their normal studies. This study's design, data collection, and analysis process complied with international ethical standards, and ethical approvals were obtained from relevant organizations to ensure the compliance of the experiment and the credibility of the findings.

Before the experiment began, the research team obtained ethics approval from the author's university. All potential ethical concerns were carefully reviewed and addressed to ensure the study adhered to ethical standards. To ensure transparency and consent, the team provided detailed written information to both the students' parents or guardians and the students themselves. This included the purpose of the study, the procedures involved, any potential risks or benefits, and how the data would be handled and used.

3.2 Data collection instruments

The engagement scale used in this study was adapted from the learning engagement inventory [88]. The questionnaire items for measuring engagement were randomly distributed. In addition, the order of the questionnaire items was changed to reduce the primacy and recency effects [89]. The questionnaire items were divided into three dimensions: behavioral, affective, and cognitive. The answers were rated on a 5-point scale ranging from 1 (never) to 5 (always). The questionnaire has demonstrated good internal consistency, with a coefficient of $\alpha = 0.93$. The coefficients of its subscales are as follows: behavioral involvement ($\alpha = 0.82$), emotional involvement ($\alpha = 0.91$), and cognitive involvement ($\alpha = 0.88$).

Our motivation survey was adapted from the instructional materials motivation survey (IMMS), an 18-item scale that assesses motivation based on a 5-point Likert scale. This study measured learner motivation based on the ARCS model [90]. The scale contains four dimensions: attention, relevance, confidence, and satisfaction. The instrument has been validated in several studies [91, 92]. In addition, the motivation questionnaire was derived from papers that empirical studies have validated, and the overall reliability of the ARCS has a Cronbach's alpha value of 0.93.

Creativity self-efficacy was adapted from the creativity self-efficacy scale (CSE) developed by [93]. The scale assesses creativity self-efficacy based on a 5-point Likert scale. The sub-dimensions 1–4 are creative examining strategies; 5–8 are creative finished product beliefs; and 9–12 are resisting negative evaluations. CSE is an overall belief in one's ability to think creatively or solve problems creatively, i.e., it may be a domain-generalized trait. The scale has received several experimental validations of its good reliability for use [94, 95], with an overall Cronbach's alpha of CSE at 0.87, making the scale suitable as a reliable instrument for use in studies related to assessing self-efficacy.

This study conducted a statistical descriptive analysis to examine the elemental distribution of the data and assess whether it conformed to the assumption of normal distribution. In addition, each scale's internal consistency reliability (Cronbach's alpha) was calculated to ensure the reliability of the measurement tool. Subsequently, an independent sample t-test was used to compare the differences between the experimental and control groups in terms of variables such as learning engagement, motivation and creative self-efficacy after the experiment. Furthermore, this study used SPSS to test whether there were significant differences in motivation, engagement, and creative self-efficacy between the experimental group using MAI-SDG and the control group using paper and pencil drawing.

3.3 Experimental procedure

This study used quantitative methods and a quasi-experimental design to collect data through a pre-test and post-test control group experiment. The entire experimental activity lasted two sessions of 40 minutes each. Before the start of the experiment, the instructor spends 10 minutes informing the class of the objectives of the lesson, as well as outlining the task. Then, a 15-minute pre-test was administered to test students' motivation, arts engagement, and creative self-efficacy. After the pre-test, a 40-minute session of drawing was conducted. A 15-minute posttest of the experiment was administered at the end of the lesson (see Figure 4).

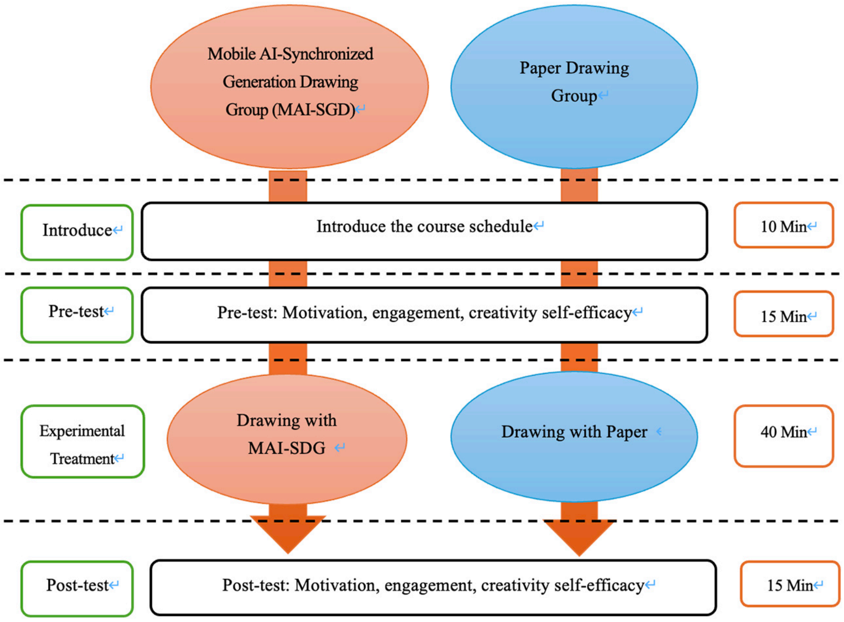

Fig. 4. Experimental procedure for data collection

We have considered the duration of children's attention spans and their learning characteristics. Research shows that children's attention spans shift quickly [96]. Students' concentration spans are suitable for 30–40 minutes of structured, novel tasks [97]. Research further indicates that integrating machine learning in online education can improve students' long-term retention of visual attention during AI demonstrations [98]. It is worth noting that digital screens and digital content can stimulate children's interest [99]. Moreover, studies have shown that short periods can impact students' motivation and self-efficacy. For example, [100] designed an experiment in which students learned in hypermedia twice for 30 minutes each time, and the results showed a significant difference in performance and self-efficacy between the experimental and control groups. Therefore, this experiment was set up with an experimental treatment of 40 minutes. This study limited each phase to 40 minutes, which not only conformed to the limits of their attention span but also stimulated engagement and motivation through the novelty of the technology.

Both the experimental and control groups used the same drawing themes. However, the tools were different; the control group used the TPD tool, and the experimental group used the MAI-SGD tool, as shown in Figure 5. Both groups performed the same drawing theme. The drawing themes were drawings of animals of interest to children, in line with the cognitive range of children [101, 102]. The researchers prepared pictures of animals familiar to children as comprehension materials and asked children to draw the animals. The researchers first conducted a pilot study with second graders and found that the difficulty of drawing on this topic was appropriate for this age group. Also, children in this age group reported that the animals were highly cognizant. This satisfies Harris's [25] research that young children tend to imagine based on familiarity and that children's drawings are non-abstract or fully fantasized representations, imagining on top of reality. This avoids biasing the test results by some children not knowing what the object of the drawing is. It should be clarified that the formal experiment did not include students from the pilot study. Students in the experimental group drew using a tablet with a mobile AI synchronized generation drawing tool, while students in the second control group used a TPD tool. The effects were derived from the software provided by the developer. As shown in Figure 1, the participants in the experimental group could create their drawings with the MAI-SGD Tool, which predicts and generates the final effect in time based on each step of the student's drawing; the AI predicts the final effect and prompts the student's drawing. Results This study used SPSS to examine whether there were significant differences in art engagement, motivation, and creative self-efficacy between the experimental group using the MAI-SGD tool and the control group using the traditional paper-based drawing tool.

Fig. 5. MAI-SGD painting interface and features

4 RESULTS

This study administered a pre-test and post-test questionnaire to students' drawings and quantitatively analyzed them for engagement, motivation, and self-efficacy scales. This study used a multiple paired samples t-test to assess the effect of the MAI-SGD tool on students' motivation, engagement, and self-efficacy in drawing. All hypotheses formulated in this study were tested at a 0.05 significance level. In the analysis, $p \leq 0.05$ indicates that the results are statistically significant, $p < 0.01$ is considered statistically significant, and $p < 0.001$ is considered highly statistically significant. If $p > 0.05$, the results were considered not statistically significant [103].

4.1 Motivation

Table 1. Comparison of the t-test for motivation between the experimental group and the control group

Results of Motivation t-test Analysis							
Scale	Group(M ± SD)		*t*	*df*	*d*	95% CI	
	TPD (*n* = 30)	MAI-SGD (*n* = 30)				Lower	Upper
Motivation	3.14 ± 0.94	3.97 ± 0.90	–3.482**	58	0.899	–1.305	–0.352

Note: ***p* < 0.01.

This study compared the motivation levels of students in the experimental and control groups using an independent samples t-test to examine the effect of the MAI-SGD tool on students' motivation to learn. The experimental group used MAI-SGD for drawing training, while the control group used the TPD tool for the same learning tasks. Table 1 shows the comparative results and statistical analysis of the motivation scores of the two groups of students.

The results of the statistical analysis showed that the motivation scores of the students in the experimental group ($M = 3.97$, $SD = 0.90$) were significantly higher than those of the control group ($M = 3.14$, $SD = 0.94$), with $t = -3.48$, $p < 0.01$, and $d = 0.899$, indicating a more significant effect size. According to Cohen's (1988) criterion, the d-value was close to 0.9, suggesting that the MAI-SGD strongly influenced the enhancement of learning motivation.

This result suggests that AI-based drawing tools can enhance students' learning motivation. MAI-SGD may keep students more engaged and interested in learning by providing higher interactivity, instant feedback, and personalized learning experiences than traditional paper-based drawing methods. The study also suggests that the intervention of AI technology reduced the frustration caused by technical difficulties or delayed feedback in traditional drawing learning, thus enhancing students' motivation. Future research could further explore how MAI-SGD affects the motivational mechanisms of students at different levels and verify its impact on learning persistence in conjunction with longitudinal studies.

The results of this study support the hypothesis regarding the motivation to draw, indicating that students using MAI-SGD have significantly higher motivation to draw than students who draw on traditional paper. One of the research objectives was to explore the differences in the impact of the two drawing methods on students' drawing motivation. The results showed that the mobile AI tool significantly enhanced students' interest in drawing and intrinsic motivation through interactivity, instant feedback, fun, and social platform interaction. This finding is consistent with self-determination theory, which states that technology-supported interactivity and autonomy can enhance learning motivation. Therefore, the research results verified the hypothesis and provided theoretical support for the future integration of AI tools in art education.

4.2 Engagement

Table 2. T-test comparing the participation of the experimental group with the control group

Results of Engagement t-test Analysis							
Scale	Group (M ± SD)		*t*	*df*	*d*	95% CI	
	TPD (*n* = 30)	MAI-SGD (*n* = 30)				Lower	Upper
Engagement	3.16 ± 0.99	4.01 ± 0.87	–3.532**	58	0.912	–1.334	–0.369

Note: ***p* < 0.01.

This study compared the learning engagement of students in the experimental and control groups using an independent samples t-test to examine the effect of the Mobile AI Synchronized Generative Drawing tool on students' learning engagement. Students in the experimental group used the MAI-SGD for drawing training, while the control group used the TPD tool for the same task. Table 2 shows the results of the comparison and statistical analysis of the engagement scores of the two groups.

The results of the statistical analysis showed that students in the experimental group had significantly higher engagement scores (M = 4.01, SD = 0.87) than those in the control group (M = 3.16, SD = 0.99), with t = –3.532, p < 0.01, and d = 0.912, indicating a more significant effect size. According to Sawilowsky's [104] criterion, d > 0.8 indicates that MAI-SGD has a substantial impact on increasing learning engagement.

This result suggests that the AI-based drawing tool MAI-SGD is more effective in enhancing students' learning engagement than the traditional paper-based drawing method. It may be attributed to the interactivity, instant feedback, and personalized learning experience provided by AI technology, which enables students to maintain a higher concentration level and immersion in the drawing learning process. In addition, MAI-SGD may have reduced learning frustration due to technical bottlenecks or lack of feedback, thus increasing students' willingness to continue learning. Future research could further explore how MAI-SGD affects changes in engagement across different levels of students and validate its long-term effects on learning persistence in conjunction with longitudinal studies.

The study's results confirmed the hypothesis regarding engagement, i.e., students using the mobile AI synchronous drawing tool had significantly higher engagement in art than students drawing traditionally on paper. One of the research objectives was to compare the impact of the two drawing methods on students' artistic engagement, and the results showed that the mobile AI tool significantly increased students' engagement and involvement through its synchronous collaboration function and diverse drawing options. This finding is consistent with related research, which shows that technology-enabled interactive environments can promote active student participation. Therefore, the research results support the hypothesis and show that mobile AI tools significantly enhance students' artistic engagement.

4.3 Creative self-efficacy

Table 3. T-test for creativity self-efficacy between the experimental group and the control group

Results of Creative Self-Efficacy t-test Analysis							
Scale	Group (M ± SD)		*t*	*df*	*d*	95% CI	
	TPD (*n* = 30)	MAI-SGD (*n* = 30)				Lower	Upper
Self-efficacy	3.21 ± 1.05	3.97 ± 0.93	–2.961**	58	0.765	–1.268	–0.245

Note: **$p < 0.01$.

Independent sample *t-tests* were used to compare the creative self-efficacy (CSE) scores of students in the experimental group with those in the control group to explore the impact of the MAI-SGD tool on students' creative beliefs and self-efficacy. Students in the experimental group used the MAI-SGD for drawing exercises. In contrast, students in the control group used a traditional paper-based drawing tool to complete the same learning tasks. Table 3 shows the comparative results and statistical analysis of the CSE scores of the two groups of students.

The results of the statistical analyses showed that students in the experimental group had significantly higher CSE scores (M = 3.97, SD = 0.93) than those in the control group (M = 3.21, SD = 1.05), with a $t = –2.961$, $p < 0.01$, and *a* $d = 0.765$, suggesting that the effect sizes were at a moderate to high level (Cohen, 1988). This result suggests that drawing learning using the MAI-SGD effectively enhances students' creative self-efficacy.

This finding may stem from the diverse creative support provided by the AI tool, such as the automatic generation of drawing styles, intelligent optimization of sketches, and personalized drawing suggestions that allow students to receive immediate feedback and reduce creative anxiety as they explore ideas. In addition, MAI-SGD increased students' confidence in their creative abilities, allowing them to be more proactive in experimenting with novel designs and complex compositions. In contrast, traditional paper-based drawing may require higher technical mastery, resulting in lower creative self-efficacy for some students due to skill limits.

The results of this study support the hypothesis regarding creative self-efficacy, indicating that students who use MAI-SGD have significantly higher creative self-efficacy than students who traditionally draw on paper. One of the research objectives was to explore the difference in the impact of the two drawing methods on students' CSE. The results show that mobile AI tools significantly enhance students' creative confidence through real-time assistance and creative inspiration. Therefore, the results verify the hypothesis and provide a practical basis for the future use of AI tools to enhance students' creative self-efficacy.

5 DISCUSSION

The main objective of this study was to explore the effects of a MAI-SGD tool and a traditional paper-based drawing tool on students' learning engagement, creativity, self-efficacy, and motivation. The study results showed that using an AI synchronous generation drawing tool enhances students' learning engagement, creativity, self-efficacy, and motivation. The MAI-SGD tool provides timely feedback to students. When students use MAI-SGD to draw, the tool can analyze their input sketches in real time and generate high-quality results based on deep learning algorithms. For children who are not proficient in drawing skills, the MAI-SGD tool can promptly identify the content of the children's drawing sketches and generate the result based on the sketches. This timely feedback mechanism enhances students' CSE. The unique experience of human-computer interaction also enhances children's engagement and motivation.

5.1 Research question 1

The results of this study show that drawing learning using MAI-SGD can significantly enhance students' motivation. The motivation scores of students in the experimental group were significantly higher than those of the traditional paper-based drawing group, indicating that the AI-assisted interactive experience positively motivated the learning process. Instant feedback and interaction enhanced students' interest in learning. The AI-generated drawing provided by MAI-SGD enabled students to see sketches created to generate new results quickly, and the successful experience enhanced students' sense of achievement and self-efficacy [105]. In contrast, traditional drawing is time-consuming and lacks dynamic feedback, which may cause some students, especially those with poor drawing skills, to lose patience or interest.

The results of this study are consistent with some of the results of similar previous research projects. [41] developed a deep learning-based art learning system using AI models to help students recognize and classify artworks. The results showed that AI learning can improve students' motivation. [106] pointed out that AI painting can enhance the user experience and stimulate the user's willingness and motivation to create continuously by participating in the creation process. [107] developed a method for children to co-create art with AI, working to improve empirical research on attention deficit hyperactivity disorder in children. The study further supported the findings that co-creation with machines effectively enriched children's emotional expression with attention deficit disorder and mobilized their motivation.

However, the instability and variability of AI drawing styles may decrease children's interest over time [107]. Additionally, previous studies have not compared traditional paper-based drawing or explored the importance of social platform use in AI-assisted children's drawing in their research development.

The study's results emphasize the advantages of MAI-SGD in enhancing motivation, suggesting the potential of MAI-SGD to stimulate more profound interest in children's drawing learning. In the opinion of educational technology researchers, the MAI-SGD can be a valuable tool to assist students' motivation towards drawing. However, the sustained enhancement of students' long-lasting interest and motivation in drawing may come from the traditional paper-based drawing, in which the realistic presentation of the paper-based drawing may contribute to the child's sense of accomplishment. Only that, as electronic devices can affect a child's attention span [108]. Long-term paper drawing may also better affect students' attention enhancement. It suggests that instructional design needs to be improved in the development of students' overall development, i.e., balancing the use of AI tools and TPD time in the classroom may be necessary.

5.2 Research question 2

The study found that MAI-SGD is a better tool for student engagement and motivation than traditional paper-based drawing and that MAI-SGD brings human-computer interaction, multi-sensory learning such as visual and tactile senses, social platform interaction, and timely feedback generation to help students realize their ideas and sketching goals into beautiful patterns. Moreover, in drawing, they gain a deeper understanding and knowledge of real-world drawing objects. These findings are similar to the study [45] that increased creativity and engagement in drawing education through digital drawing with AI. Similarly, [109] developed scaffolded instruction with AI-driven communication modeling in children's aesthetic education to improve students' engagement and understanding of traditional cultural concepts. Like the conclusions reached in this study, AI drawing tools can promote children's motivation towards drawing objects and assist their perception of the world.

However, concerns about the potentially detrimental effects of children's digital learning based on gadgets are growing in several current studies. Studies have shown that children show a strong interest in digital education with electronic devices [110], and the application of MAI-SGD in electronic devices may be an important factor in stimulating children's interest. Children may be interested in social interactions, cartoon images with timely feedback, and graphic artwork on social platforms. It suggests that MAI-SGD software supported by electronic devices can benefit children's knowledge and understanding of the world. MAI-SGD software has a positive effect on children's educational engagement enhancement. However, many studies have concerns about teaching with digital devices. Interactive drawings and cartoon animations in electronic products may affect children's concentration. Visual fatigue [111]. Over-reliance on digital technology [112, 113]. Risk of digital addiction in children [114]. Therefore, a drawing software development for children can provide time frames for task completion, with short goals set to end the task and avoid prolonged eye use. In addition, teachers can give digital paper combining learning, such as generating sketches on a pad and then guiding children to copy them on actual drawing paper, to minimize the reliance on electronic screens.

The study results showed that MAI-SGD positively promoted students' drawing engagement, which was closely related to students' classroom performance. It is important for students to actively participate in the classroom and deepen their understanding of the drawing object. Children play an important role in imagination and cognitive development through drawing and doodling [115]. Teachers can use the MAI-SGD tool in the classroom in conjunction with scaffolding teaching methods to increase student initiative, enhance love of the classroom, and promote cognitive understanding. However, children must use electronic devices in moderation to avoid over-reliance, which would affect their long-term learning outcomes and development.

5.3 Research question 3

The results of this study suggest that the use of the MAI-SGD tool improves students' creativity self-efficacy. MAI-SGD's iterative generation of beautiful patterns from students' sketches enhances students' satisfaction with their creativity, successful performance, and creativity self-efficacy. When students are faced with a drawing task that is moderately beyond their ability given by the teacher under the scaffolding approach, students can try to solve the problem using MAI-SGD's new tool, and MAI-SGD generates feedback from the student's sketches to give the student unexpected feedback, which is refreshing to the student. MAI-SGD made students sketch ideas more creatively by migrating the generation in different styles. Previous studies similar to this one coincide with the findings of this study. An [116] developed an AI painter using AI algorithms to create an intelligent painting system that can improve college students' self-efficacy and creativity, thus improving their self-efficacy. Washington [117] indicated that AI-driven writing improves writers' self-efficacy and creativity. Le [118] stated that online AI education enhances students' creative thinking ability in digital arts. However, the attention to self-efficacy of AI-assisted instruction in children's drawing remains lacking.

However, research scholars believe that the adverse effects of AI on children deserve attention. First, students' over-reliance on AI-generated content affects students' cognitive abilities by weakening key features of complex human cognition, with students favoring quick fixes and losing the ability to find slow solutions with utility constraints [119, 120]. There is an increase in laziness, the dissemination of misinformation, and a decrease in creativity [121]. On the other hand, some researchers give consistently opposite views. They argue that AI creativity tools support children's creativity-related tasks, which can increase creative engagement and lower the barrier to entry [122]. AI assistance can prevent humans from losing their creative intelligence, transcending habitual digital dependence through a state of creative flow. On top of utilizing AI to enhance students' creative self-efficacy, solutions must be developed to mitigate the adverse effects of AI dependency.

In addition, uploading one's work on MAI-SGD's unique social platform and communicating with learning peers and positive feedback from peers promotes students' free imagination even more. Teacher feedback also promotes the growth of students' creativity and self-efficacy. It is important to note that teachers on online platforms should never criticize children, even if their creativity is less than ideal [123].

Those being criticized may exacerbate the social exclusion to which people with attention deficit hyperactivity disorder are vulnerable [124]. Additionally, studies have shown that children negatively evaluate their abilities following teacher criticism, and surprisingly, peer criticism does not significantly affect children's responses when peers criticize students' creativity [125]. On the contrary, some studies point out that direct negative comments from peers may exacerbate their social anxiety. Children rejected in peer evaluations are more likely to experience negative evaluations and be ostracized in social interactions. Children whose lower social initiative is ignored may receive less attention in peer evaluations [126]. Research has further shown that teacher praise or criticism has a moderating role in the relationship between different individual/peer factors and bullying behaviors in boys and girls [127]. Therefore, MAI understands the characteristics of different groups of children and provides appropriate social support and interventions essential for promoting children's social development.

The results of the study showed that MAI-SGD had a positive effect on students' creativity and self-efficacy in drawing. Students with high creative self-efficacy will have a greater sense of belief in their creativity. They are more focused on thinking about strategies for their creative endeavors to create more distinctive work. In addition, higher creative self-efficacy can help students counteract negative evaluations and allow them to focus more on their learning. However, it is important to note that utilizing the MAI-SGD social platform allows children to share their work to enhance their social skills and creative self-efficacy. It is also necessary to pay attention to the students' psychological state, correctly guide popular children to care for and support their peers, and especially positively evaluate rejected and neglected children. Teachers' positive evaluations help disadvantaged children to improve their self-confidence.

5.4 Revelation and advice

The results of this study not only have important implications for educational practice but also provide a practical direction for the industrial environment and policy formulation. In an industrial setting, MAI-SGD can train children's digital literacy, helping them improve their drawing and design skills while combining the advantages of traditional drawing to promote creativity and concentration. In the creative industries, it can assist with games, animation design, advertising, and marketing, quickly generating visual content to improve efficiency. MAI-SDG can help designers quickly generate product prototypes or architectural sketches and optimize teamwork in industrial design and engineering. In addition, in the fields of medical care and rehabilitation, it can also support art therapy and child development. To verify its effectiveness in different scenarios and expand its potential for innovative applications in multiple industries. In addition, the research results also provide a basis for the formulation of children's education policies, suggesting that the time allocated to AI tools and traditional drawing in the curriculum design should be reasonably distributed, and the possibility of interdisciplinary integration should be explored. Moreover, this tool can be used for multidisciplinary applications, such as teaching children about digital literacy, mathematical visualization, picture books with literary images, and the development of curriculum tools. In short, by balancing the use of AI tools and traditional methods, this study provides a practical path for the comprehensive development of students and staff, with broad practical application value.

There are significant differences between MAI-SGD and other mobile AI-based learning apps in terms of functionality and technical implementation. First, MAI-SGD focuses primarily on real-time drawing and design tasks, which can capture the user's drawing actions in real time and generate high-quality images or designs. In addition, MAI-SGD also integrates online social platform functions, allowing students and teachers to interact socially on the system and facilitating teachers to monitor students' learning progress. Studies have shown that MAI-SGD positively impacts children's motivation, engagement, and creative self-efficacy. In contrast, other learning applications based on mobile AI focus more on personalizing the learning experience by providing users with customized learning content and feedback through natural language processing (NLP) and recommendation algorithms [128]. In addition, there are also significant differences between MAI-SGD and other mobile painting AI applications in terms of application scenarios. Other AI painting applications are usually designed for specific painting fields and around specific painting goals. For example, [129] developed an oil painting classification model and a personalized oil painting education system that can assist in adjusting the learning plan and avoid the repetition of learning content, thereby improving students' learning efficiency. [130] developed an AI-based traditional Chinese painting system to enhance the audience's understanding of integrated painting images. In addition, some studies [131] have developed AI-driven interactive painting synthesis systems for children, aiming to enhance children's learning motivation in painting exploration, and have similar conclusions to this study, that is, significantly improving children's interest in painting. Overall, AI-powered synchronous drawing tools (e.g., MAI-SGD) and mobile AI-based learning apps have different focuses regarding their technical core and application goals. MAI-SGD provides a new approach to teaching children to draw through real-time drawing and social interaction functions and has been shown to positively impact student learning. In contrast, other mobile AI-based learning apps focus more on personalized learning and domain-specific knowledge transfer. The MAI-SGD study provides an important addition to the current field, especially in teaching children's painting, and demonstrates its unique educational value.

It is worth noting that MAI-SGD can be used as an effective tool to stimulate students' participation, motivation, and self-efficacy in drawing education. However, research shows that long-term use of electronic products can affect children's attention. Therefore, this study suggests combining traditional paper and pen drawing to balance cultivating students' interest and the development of attention. In the development of educational technology, MAI-SGD's personalized learning function and instant feedback mechanism provide developers with an optimization direction. At the same time, attention should be paid to integrating attention management functions to improve students' learning experience. Additionally, educators should be clear about the specific goals of using AI tools to ensure that they complement, rather than replace, traditional methods. Traditional methods should be emphasized in the early stages of learning to build foundational skills, and AI tools should be introduced later to enhance creativity and efficiency.

Based on its findings, this study provides educators with several suggestions on how to implement MAI-SGD tools effectively. First, clarify the teaching objectives and introduce AI tools in stages, prioritizing traditional methods to lay a foundation and gradually combining AI functions to enhance creative expression. Second, the personalized style generation function can design learning tasks that suit students' abilities and promote interaction and cooperation through multi-user collaboration functions. In addition, it provides instant feedback and guides students to reflect on their work to cultivate creative thinking. Additionally, MAI-SGD is suitable for classroom settings and supports remote and asynchronous learning scenarios, providing flexible learning opportunities for students. However, educators should be mindful of controlling how much time young students spend using electronic screens to avoid potential health risks. Future research could further explore optimizing the tool's design to better suit the needs of different learning environments.

Future research can explore the application and optimization of MAI-SGD in depth from multiple directions, including conducting long-term effect studies to evaluate its continued impact on interest, attention, and drawing skills; in addition, conducting in-depth research on the differences in attention allocation and cognitive load between MAI-SGD and traditional drawing methods; optimizing the combination of MAI-SGD blended learning and other new models to design a teaching framework that alternates between "digital and paper" to enhance students' interest and concentration; At the same time, educators can develop a curriculum framework that allocates specific time to traditional basic drawing practices and AI-assisted activities, creating more accurate personalized learning paths based on individual differences to meet the learning needs of different students. These research directions will provide a scientific basis for further exploring the potential of MAI-SGD, promote the organic integration of AI tools and traditional methods, and promote the all-around development of learners.

6 CONCLUSION

This study verified the significant effect of MAI-SGD as an educational aid for children's painting in improving learning motivation, engagement, and creative self-efficacy, providing necessary theoretical and practical support for applying AI in education. The research results show that MAI-SGD can effectively stimulate children's interest in learning and support their creative expression through real-time feedback, personalized style generation, and multi-sensory interaction functions, which is highly consistent with Piaget's cognitive development theory, social constructivism theory, and Vygotsky's ZPD theory.

However, future research should further optimize the MAI-SGD personalized learning system, combine it with deep learning technology to provide more accurate drawing suggestions for children, and introduce multidimensional assessment indicators (such as creativity, problem-solving ability, and artistic thinking development) to measure its educational value comprehensively. Not only that, but MAI-AGD is not only suitable for children's art education but can also be used in a wider range of educational contexts in the future. For example, MAI-SDG can generate diagrams of the experimental process or 3D models of geographical landscapes in science experiments to help students better understand abstract concepts. In special education, MAI-AGD can help autistic children express emotions and understand social situations better by generating visual content. In medical education, generating anatomical images or surgical simulation scenarios helps medical students learn more intuitively about human body structure and medical operations. Design and architecture students can use AI tools to quickly generate design sketches or architectural models to improve design efficiency and creativity.

In addition, this study has certain limitations. The study was conducted only with 60 students of a specific age group and educational background, which may limit the applicability of the research results to other groups, such as different age groups, cultural backgrounds, or educational environments. The results of this study focus on the short-term impact on children's creativity. On the one hand, these tools can stimulate children's creative expression and enhance their self-confidence and creative self-efficacy through features such as personalized style generation, instant feedback, and multiple social interactions. On the other hand, the long-term impact of mobile AI tools on children is also worth considering. Long-term use may lead to children's over-reliance on AI-generated content, creating a risk of homogenization of creativity, and may undermine the development of traditional drawing skills. At the same time, long-term use of electronic products can also damage students' attention and eyesight. Adopting the flipped classroom teaching model, with a set time for using AI tools in class and traditional drawing methods after class, is recommended to maximize its positive impact. Combining AI tools with traditional drawing methods while guiding children to use technology critically encourages original thinking and personalized expression.

In addition, the potential of MAI-SGD in long-term creativity development and interdisciplinary applications should be explored while also focusing on its future applicability in different cultural contexts and age groups. Such as cross-cultural studies or long-term analyses of AI's impact on creative development. At the practical level, educators need to balance AI tools with traditional drawing methods so that children do not become overly reliant on technology and neglect basic skills training. They also need to mitigate the potential negative impact of electronic devices on children's attention and psychological state by improving peer evaluation strategies and teacher support mechanisms. This study provides new research directions and practical paths for the deep integration of AI and children's education, laying an essential foundation for the future design of more scientific and humane AI-assisted learning tools.

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