Research Article

Research on the Design Logic and Implementation Pathways of the Triangular Classroom Teaching Model in Chinese Universities under the Digital Intelligent Context

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ABSTRACT

The digitalization of teaching model is a key pathway to enhance university students' learning quality and efficiency. However, current problems exist in Chinese universities including insufficient application of digital technologies, a predominant one-way knowledge transmission model, and inadequate teacher-student interaction. Based on the PAD Class Model and integrated with Bandura's Reciprocal Determinism, this study incorporates generative AI/AI agent into teaching process to construct a "Triangular Classroom Teaching Model". This model establishes three stages during the teaching process: "self-preparation (human-machine interaction), teacher-student interaction, and peer discussion (student-student interaction)" to address the limitations of the PAD (Presentation-Assimilation-Discussion) Class Model, such as the lack of preparation and real-time feedback, through the interplay of environment (digital technology), individuals (students), and behavior (learning). During the self-preparation stage, generative AI/AI agent facilitate student-led inquiry. In the teacher-student interaction stage, they enable data-driven analytics and tailored instruction. Finally, during peer discussions stage, they serve as cognitive tools to expand students' cognitive horizons. The "Triangular Classroom Teaching Model" implements the "student-centered" philosophy through multi-dimensional collaboration, improving teaching quality and learning efficiency, and providing an operable innovative paradigm for the digitalization of teaching model in Chinese universities.

Keywords: artificial intelligence generated content (AIGC); generative artificial intelligence (GAI); human-computer collaboration; human-computer interaction (HCI); intelligent agent; smart teaching; teaching digitalization; triangular classroom teaching (TCT) Model

1. Introduction

Report to the 20th National Congress of the Communist Party of China explicitly proposes to "promote the digitalization of education and build a society and country of learning where lifelong learning is pursued by all." Digitalization of teaching provides students with access to high-quality education. The digitization of teaching models is one of the key aspects for higher education institutions to achieve educational

digitalization [2]. In the past, it has been proven that information technology can enhance students' concentration, effectively promote their active learning, and improve their learning outcomes [1]. Accordingly, with the accelerated development of digital technologies, artificial intelligence, as a crucial means of enabling digitalization, has seen significant progress in both development and application, driving the evolution of education from "informationization" to "digitization" and then to "digital intelligence". The *Outline of the Plan for the Construction of China into an Education Powerhouse (2024-2035)* further emphasizes "implementing a national strategy for educational digitalization and promoting AI-driven educational transformation," highlighting the pivotal role of AI in digital transformation strategies. The Department of Higher Education of the Ministry of Education advocates for universities to leverage AI to innovate talent cultivation and teaching models, providing actionable recommendations for integrating AI into educational digitalization. The application of artificial intelligence in teaching is an effective way to enhance teaching quality [3]. In 2025, China's Ministry of Education and eight other departments jointly issued the *Guidelines on Accelerating Educational Digitalization*, focusing on digital transformation in education. The document calls for "comprehensively advancing intellectualization and promoting AI-empowered educational innovation," stressing the need to "integrate AI technologies into all elements and processes of teaching and learning." The issuing of the above-mentioned documents aims to explore innovative human-AI collaborative teaching models, empower students with personalized learning pathways, and enhance the quality and efficiency of education. Additionally, UNESCO [4] has pointed out the potential of generative AI in curriculum design, teaching, and learning. Therefore, conducting research to investigate human-AI collaborative teaching models, effectively applying AI in higher education, and further leveraging its role in instruction are critical for improving learning efficiency and quality, advancing teaching digitalization, and progressing toward "intelligent digitalization."

Intelligent digitalization differs from traditional digitalization by emphasizing AI-enabled intelligent empowerment. As a teaching enhancement tool, when teachers apply artificial intelligence to their teaching practices, it can enrich the options of teaching strategies and improve the quality and effectiveness of teaching [5]. However, Chinese universities still face challenges in implementing AI-driven teaching digitalization. Currently, the application of AI in education remains underexplored and underutilized [6]. Further research is needed to examine the effective integration of AI into teaching and to innovate human-AI collaborative teaching models. Many Chinese universities still adhere to traditional teaching methods, where digitalization merely involves incorporating information technology into conventional classrooms without deeply integrating digital technologies, thus teachers continue to dominate the teaching process while students remain passive learners [7]. As a key concept in AI, generative AI/AI agent has become a promising direction for the application of artificial intelligence. Generative artificial intelligence is a new technology that can generate original content such as audio, video, text, and images, and can also provide feedback to its users [8]. Intelligent agents (also known as learning partner) are anthropomorphic virtual characters applied in digital learning environments, aiming to facilitate the learning process through instructional guidance and emotional support [9]. Currently, such agents have begun to be applied in different educational stages such as kindergartens, primary schools, secondary schools, and universities as an integral part of intelligence literacy education to cultivate students' digital literacy, which has a positive impact on students' emotions and behaviors [10-12]. The adoption of intelligent agents is an effective way for learners to build higher self-efficacy during the learning process [13]. In terms of combining traditional learning methods with artificial intelligence, intelligent agents play an active role because learners conduct learning through human-computer interaction in such learning model [14]. The immediate feedback provided by the agents helps to enhance learners' learning enthusiasm [15]. Agents can effectively promote collaborative learning among

college students, help them create personalized learning environments, provide different assistance to students with different learning efficiencies, and improve their academic performance [11]. AI technology has transformed students' learning paradigm for it can effectively facilitates students' active and deep learning through human-computer interaction, thereby better supporting students in obtaining knowledge and developing competencies. However, the application of generative AI/AI agent in Chinese universities is still in the exploratory stage and has not been fully popularized. Therefore, a key focus of this study is to explore how to fully leverage the strengths of generative AI/AI agent in the teaching process, construct a student-centered pedagogical model, and facilitate personalized learning for students.

Furthermore, the existing teaching models have incorporated a large number of digital elements, but no corresponding teaching models have been developed for students who are accustomed to traditional teaching models and have weak self-study abilities. In some cases, there is even a situation where "digital technology is prioritized over teaching activities", which is a case of putting the cart before the horse [16]. While the digitalization of education represents the current trend, improving teaching models through digital means does not simply entail the incorporation of digital technology or the reckless abandonment of traditional methods. Instead, it requires careful consideration of students' learning conditions and a thoughtful integration of digital tools into teaching activities to genuinely facilitate a shift from a teacher-centered to a student-centered paradigm, ultimately enhancing the learning efficiency of university students in a substantive manner. Therefore, this research build upon the currently effective teaching model (the Presentation-Assimilation-Discussion "PAD" Class Model) and fully integrate generative AI/AI agent into triangular Classroom Teaching Model. It will deeply integrate Reciprocal Determinism with generative AI/AI agent to form a "human-machine, teacher-student, and student-student." This approach fills the research gap in multidimensional interaction models within China's intelligent digitalization landscape and resolves key issues in current teaching digitalization practices.

2. Exploration and design of the triangular classroom teaching model

The PAD Class Model, proposed by Zhang [17] based on brain science, is a localized Chinese teaching model designed to address the issues of insufficient interaction between teachers and students as well as students' passive learning. In this model, during the class, half of the time is spent on teacher-led instruction, while the other half is devoted to students' independent exploration through discussions. The process is specifically consisted of three teaching stages: Presentation, Assimilation, and Discussion. Since its introduction, numerous studies have explored the effectiveness of the PAD Class Model across different learning stages and various disciplines from both theoretical and empirical perspectives. Grounded in constructivist learning theory and social learning theory, the PAD Class Model not only effectively enhances students' engagement and learning enthusiasm, but also improves students' learning attitudes and habits, thereby boosting their academic achievement [18-19]. With the increasing prevalence of the "student-centered" teaching philosophy, many scholars have begun to develop new teaching models on the basis of the PAD Class Model, expanding its scope of application. For instance, Shi et al. [20] thoroughly analyzed the strengths and weaknesses of the PAD Class and the BOPPPS model, organically integrating the three stages of PAD (Presentation, Assimilation, Discussion) with the six stages of BOPPPS (Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, Summary) to form a new teaching model. This integrated model was applied in university classrooms to enhance students' engagement in learning activities and promote active learning. Similarly, Lyu et al. [21] merged the PAD Class Model with the 5E Instructional Model (Engagement, Exploration, Explanation, Elaboration, and Evaluation) to form a six-stage teaching model comprising platform construction, cooperative inquiry, targeted instruction with intentional gaps,

assimilation, application, and diverse assessment. Experimental validation confirmed its effectiveness, demonstrating positive impacts on students' practical skills, metacognitive abilities, and critical thinking abilities, while effectively increasing the level of teacher-student interaction within the class. Therefore, innovating teaching models based on the PAD Class Model can effectively enhance students' learning motivation and improve their learning outcomes.

However, the PAD Class Model also shows certain limitations. First, its design lacks a preparation stage before the class, which is not conducive to student self-directed learning before class and affects their understanding and digestion of course content, particularly regarding key and difficult concepts. The absence of a preparation stage hinders deep comprehension, impacting learning efficiency and effectiveness. Second, the PAD Class Model employs a discussion format that occurs in a subsequent session, making it difficult for teachers to gauge student understanding in real-time and provide immediate feedback to address students' in-class confusion. In the context of higher education digitalization, the PAD Class Model also presents certain constraints. The original teaching stages of the PAD Class fail to effectively integrate with digital technology, negatively impacting the implementation of teaching digitalization and reform [22]. Consequently, this study designs the Triangular Classroom Teaching Model, aiming to improve and innovate upon the PAD Class Model, address its limitations, and integrate generative AI/AI agent into the PAD Class framework to enhance students' learning outcomes.

In the era of artificial intelligence, with the full development of digital technology, teaching models should evolve from the traditional teacher-student dyadic structure to an AI-empowered teacher-machine-student triadic structure, thereby driving innovation in teaching methods and fully implementing the "student-centered" educational philosophy [23]. This aligns with the Reciprocal Determinism proposed by the American psychologist Bandura [24], which posits that environment, individual, and behavior interact and influence each other, forming an organic whole. The formation of individual behavior is the result of the interaction among these three factors. Reciprocal Determinism can effectively explain students' learning behaviors and knowledge acquisition process, positing that learning behavior results from the combined effects of environmental and individual factors. Based on Bandura's Reciprocal Determinism Theory, the Triangular Classroom Teaching Model constructed in this study consists of three stages: "Self-Preparation, Teacher-Student Interaction, and Peer Discussion," as illustrated below:
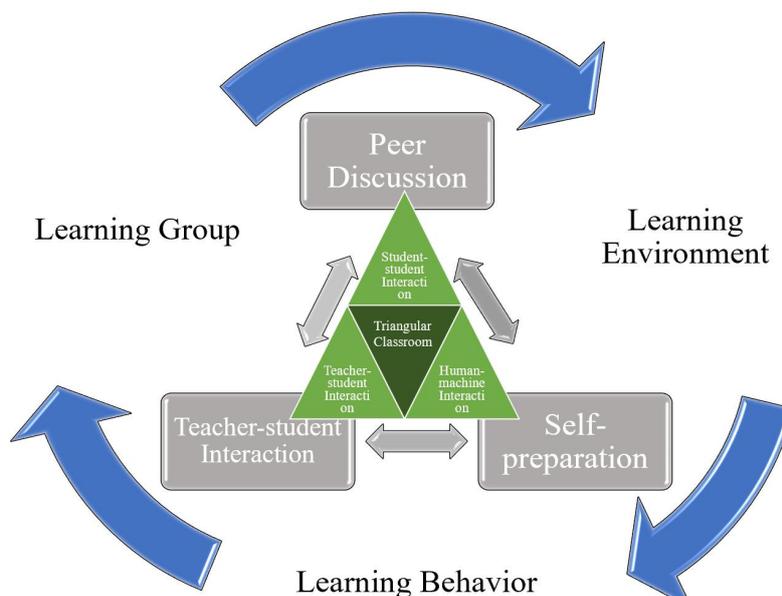

Figure 1. Framework of the Triangular Classroom Teaching Model

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In the Triangular Classroom Teaching Model, the "environment" refers to the AI-supported learning ecosystem (e.g., intelligent agents and online platforms), the "individual" corresponds to students' self-directed and collaborative behaviors, and "behavior" encompasses learning activities such as preparation and discussion. For example: During the self-preparation stage, AI, as an environmental factor, provides personalized learning resources. Students, as individuals, engage in human-AI interaction to initiate preparation behaviors, which in turn feedback into the environment to optimize resource recommendations. In peer discussion stage, student-student interaction occurs within the environment formed by the learning group facilitated by generative AI/AI agent, influencing individual collaborative behaviors, with generative AI/AI agent acting to reinforce the interaction effect. Altogether, these three factors form a dynamically interacting organic whole.

In the Triangular Classroom Teaching Model, students are the constructors of knowledge, the teacher acts as the guide for learning methods, and generative AI/AI agent serves as the learning assistant. In the era of AI, while artificial intelligence—including generative AI and intelligent agent—demonstrates advantages in convenience and efficiency and has already, to some degree, replaced certain teaching functions, human teachers remain irreplaceable due to their capacity for empathy and ability to provide emotional support to students. This is because artificial intelligence struggles to match the level of emotional support offered by human teachers [25]. In the process of student learning, with the assistance of AI, teachers can employ innovative pedagogical models, create a positive classroom atmosphere, design instructional activities, and modify assessment methods to provide scaffold support that fosters students' skills, such as guiding them toward independent thinking and cultivating critical thinking and collaborative abilities. Meanwhile, AI technology enables teachers to optimize or select the most suitable learning activities based on its feedback [26]. Therefore, Triangular Classroom Teaching Model will enhance students' sense of central position and much attention is given to the individual factor, namely the student's central role and primary function in teaching activities. Through multi-dimensional collaboration involving teacher-student, student-student, and human-machine interaction during the teaching process, it aims to enhance students' motivation throughout the learning process and their participation in the classroom, promoting active learning and deep learning, thereby achieving more effective teaching outcomes [27]. Simultaneously, it addresses the limitations of the PAD Class Model, such as the lack of a preparation stage, the inability of teachers to provide timely feedback, and the lack of digital integration, to make targeted improvements to optimize the teaching model.

Specifically, in the "self-preparation" stage, before class, the teacher assigns tasks via an online learning platform, requiring students to review material from the previous session and preview the content of the upcoming lesson. When students encounter unfamiliar concepts during this stage, they can interact with generative AI/AI agent, using them as digital tutors, thereby enhancing their ability to utilize digital technology for learning assistance. Generative AI/AI agent can also recommend relevant learning resources based on the course content and students' learning needs, thereby fostering students' digital literacy while cultivating their capacities for self-directed inquiry learning and active learning. This stage addresses the limitation of the lack of preparation in the PAD Class Model.

In the "teacher-student interaction" stage, teaching activities are organized around four parts: review, lead-in, preparation check, and teacher-student interaction. When students arrive in class, the teacher first poses open-ended questions about the content of previous lesson to assess learning outcomes, while generative AI/AI agent then recommend relevant cases based on students' response outcomes to reinforce their understanding. Subsequently, the teacher conducts an in-class quiz on the new material via the online learning platform to gauge students' grasp of the knowledge, laying the groundwork for subsequent in-class activities. Generative AI/AI agent analyze assessment results and provide teachers with diagnostic feedback

on students' learning difficulties, enabling teachers to dynamically adjust teaching content and pacing. The teacher then explains and addresses questions based on the preparation results and the doubts students encountered during preparation stage, leveraging the strengths of traditional direct instruction to deepen students' understanding, while also supporting students with weaker independent learning skills. This stage facilitates collaborative interaction between teacher and student, boosts student learning motivation, and addresses the limitations of PAD Class Model that teachers fail to provide immediate feedback.

In the "peer discussion" stage, aligning with the "student-centered" principle advocated by constructivist learning theory, teaching activities are designed around two parts: group discussion and summary. This stage focuses on the transfer and application of knowledge. Specifically, teachers pose contextually-grounded questions based on the course content, facilitating structured peer discussions. By adopting the learning method of peer learning and peer assessment, the students' active participation can be enhanced, the formation of a learning community can be promoted, interaction among students can be realized, and students' collaborative exploration abilities can be cultivated. During discussions part, students can utilize generative AI/AI agent for human-machine interaction to verify ideas or broaden their perspectives, fully integrating digital technology into the discussion process. generative AI/AI agent record the discussion content and participation level of each group, further deepening human-machine interaction. Finally, in the summary part, based on feedback from generative AI/AI agent, the teacher summarizes the students' discussion outcomes and the key knowledge points of the lesson. This aims to achieve students' basic-level (knowledge-based) learning objectives while promoting the attainment of advanced-level (competency-based) learning objectives. However, it should be noted that throughout the implementation of Triangular Classroom Teaching Model, while teachers actively advocate for and utilize digital and intelligent technologies, they must also carefully consider the potential concerns associated with technology-enhanced teaching, particularly regarding the security of student information and data.

3. Case Study: Design and application of the triangular classroom teaching model in the course "research methods in preschool education"

This study takes the second chapter "Ethical Issues in Preschool Education Research" of the "Research Methods in Preschool Education" course for the preschool education major as the study object of this case study to explore the specific application of the Triangular Classroom Teaching Model in practical classroom teaching. In this case study, the course content is designed to enhance students' learning enthusiasm and promote their autonomous and active learning. In order to implement the *Guidelines for Ideological and Political Education in Higher Education Curriculum* issued by the Ministry of Education, the teaching design incorporates ideological and political elements to fully leverage the main channel role of classroom teaching. Through the integration of ideological and political education, we aim to achieve an organic combination of educational goals, knowledge goals, skill goals and emotional goals to promote the all-round development of students.

The Triangular Classroom Teaching Model structures in-class teaching process into six steps: review, lesson introduction, preparation, teacher-student interaction, group discussion, and summary. The detailed design is as follows:

3.1. Review

Before class, the teacher assigns review tasks to students via the Rain Classroom platform, employing an AI-empowered task-driven approach, to help students focus on key review points, enhance review efficiency, and deepen their understanding of the "Overview of Preschool Education Research." During class,

the teacher uses a digital human to pose questions, capturing students' attention and increasing interactivity. The questions include open-ended ones such as the role of mixed-methods research, the difference between cross-sectional and longitudinal studies, and why the observational method is suitable for research on young children. These aim to assess students' grasp of the material, consolidate knowledge obtained from the previous lesson, and set the stage for new content. Based on students' responses, generative AI/AI agent (e.g., KIMI, DeepSeek, Doubao) automatically releases relevant literature excerpts or cases to aid their comprehension, while teachers provide supplementary guidance and explanation.

3.2. Lesson introduction

In this lesson introduction part, the teacher employs the case-based teaching method, using the video of the classic case "Zhai Tianlin CNKI Incident" and the recent academic misconduct case involving the vice president of South China Normal University plagiarizing an English translation of a paper as the lesson introduction. These highly representative and socially relevant cases capture students' attention. Through teacher-student interaction, the class explores the academic issues reflected in these two incidents and potential preventive measures, stimulating students' reflection on academic integrity and guiding them to examine norms of academic conduct from different perspectives. This sparks students' interest in learning, enhances classroom engagement level, and lays the foundation for the subsequent learning of the course content.

3.3. Preparation

Before class, the teacher also uses the Rain Classroom platform to assign preparation tasks, adopting an AI-empowered task-driven approach to familiarize students with the upcoming course content in advance. Students, with the assistance of generative AI/AI agent, input keywords like "preschool education research ethical guidelines" to automatically generate knowledge graphs and analyses of frequently asked questions. Simultaneously, based on data such as the number of times students review specific knowledge points and the questions they raise, relevant cases will be recommended by the intelligent agent. Through this human-computer interaction through generative AI/AI agent, students gain a preliminary understanding of "ethical issues in preschool education research," identify their knowledge gaps, develop self-directed learning skills, and improve preparation efficiency. In class, the teacher conducts an online quiz via Rain Classroom to assess students' preparation outcomes. The quiz consists mainly of objective questions covering topics like the ethical principles of educational research, the main components of informed consent forms, and the contents of academic integrity, thereby checking the effectiveness of student preparation and laying the groundwork for in-depth learning and activities in class.

3.4. Teacher-student interaction

This step integrates traditional lecturing with an interactive model of student questioning. Based on the real-time quiz results compiled by generative AI/AI agent, the teacher selects content where students made frequent errors and combines this with key and difficult teaching points, such as educational research ethical principles, to provide detailed explanations, helping students understand the knowledge more deeply. Subsequently, the teacher provides targeted explanations for the problems and feedback displayed by generative AI/AI agent regarding students' pre-class preparation, thereby enhancing two-way interaction between teachers and students. By encouraging students to actively ask questions, it promotes deeper thinking and helps them better grasp the knowledge, achieving their basic-level learning objectives (knowledge-based objectives).

3.5. Group discussion

This step aims to promote the transfer of obtained knowledge to practical scenarios in the field of preschool education, deepen students' understanding of academic ethics, and guide them to consistently uphold ethical bottom lines in the application of digital technology, thereby helping students to shape correct academic values. The teacher designs discussion topics such as "ethical guidelines for research involving preschool children" to guide students to discuss in groups and facilitate student-student interaction. Simultaneously, generative AI/AI agent are introduced for assistance, allowing students to engage in human-machine discussion with the platform or agent, thereby broadening their thinking, exploring more diverse perspectives, and deepening human-machine interaction. In this part, generative AI/AI agent can assess students' participation level in the discussion (e.g., frequency of contributions), identify students with lower interaction frequencies, and send prompts to the teacher. Based on that, the teacher can then proactively invite these students to share their opinions to enhance their participation.

3.6. Summary

In the summary part, the teacher uses the comprehensive discussion outcomes summarized by generative AI/AI agent to review the key knowledge points of the lesson. During the summary part, the teacher re-emphasizes the importance of academic integrity and ethical principles, guides students to reflect on their learning process, helps them consolidate knowledge, and promotes the autonomous construction of their knowledge system, thereby achieving advanced-level competency objectives. Furthermore, in the aspect of ideological and political education, the cultivation of digital technology ethics awareness has also been integrated. Students interact with generative AI/AI agent before and during the class, understanding its positive impact on learning. At the same time, they must also deeply recognize the ethical issues that may arise during the use of artificial intelligence, prompting them to think dialectically and enhancing their digital literacy.

4. Conclusion and implications

Teaching digitalization serves as an effective pathway to enhance university students' learning quality and efficiency. However, the current advancement of teaching digitalization in higher education faces challenges such as "teacher-dominated instruction with passive student engagement," "prioritizing digital technology over teaching activities," and "the underutilization and ineffective implementation of artificial intelligence in teaching practices." To address these issues, this study draws upon the PAD Class Model, refines its limitations, and integrates Bandura's Reciprocal Determinism. The original PAD Class framework is enhanced by incorporating generative AI/AI agent into teaching procedures, thereby advancing the PAD Class Model into the Triangular Classroom Teaching Model and providing academic reference for university educators from the perspective of pursuing digital innovation in their teaching practice.

The Triangular Classroom Teaching Model can effectively enhance college students' learning initiative and enthusiasm in the current digital intelligent era, cultivate their abilities in self-directed learning, inquiry-based learning, and collaborative learning, and foster habits of active learning. Simultaneously, as the teaching stages of the Triangular Classroom Teaching Model are improved based on the PAD Class Model, it can accommodate students with weaker self-directed learning skills, compensating for the shortcomings of previous digital teaching designs. Triangular Classroom Teaching Model genuinely implements the "student-centered" philosophy, promotes the improvement of classroom teaching quality in universities, enhances the learning experience of university students, increases their learning efficiency, and strengthens learning outcomes, thereby vigorously advancing the process of teaching digitalization in higher education. Furthermore, innovating teaching models by integrating digital technology and incorporating generative

AI/AI agent into the stages of Triangular Classroom Model makes the teaching model of each institution more personalized and diversified, which can promote the practical application of AI technology in higher education teaching and advance the implementation of the "AI+" initiative. Additionally, it helps cultivate university students' digital awareness, develop their digital literacy, improve their ability to utilize digital technology, and foster the habit of lifelong digital learning.

Although this study has elaborated and discussed the design logic and implementation path of the Triangular Classroom Teaching Model, in the future, more teaching experiments are still needed to apply the Triangular Classroom Teaching Model to undergraduate teaching to verify the effectiveness of the model through empirical research. Specifically, the study will first establish experimental and control groups and implement rigorous teaching experiments using a pretest-posttest design to verify the effectiveness of the Triangular Classroom Teaching Model. Second, during the posttest phase, questionnaires will be distributed to assess students' learning confidence, as well as their satisfaction with and engagement in the Triangular Classroom Teaching Model. Finally, follow-up tests will be administered to students after a certain period following the posttest to examine their knowledge retention. Additionally, beyond the Triangular Classroom, future research could further explore other AI-assisted teaching models to refine the research framework on AI-supported instruction.

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Conflict of interest

The authors declare no conflict of interest

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