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Research on Generative AI-enabled Mathematics Experiment Teaching and Teacher Empowerment

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Abstract: College mathematics experiment teaching in situation simulation is difficult; student participation is not high, and teacher guidance effectiveness is also limited. This paper explores generative AI in mathematics experiment situation simulation applications and its role in teacher professional development empowerment mechanisms. This paper relies on constructivism and situation cognition theory, builds a prompt-driven AI teaching aid, and then develops a teacher-student interaction model for mathematics experimental situation simulation teaching. A total of 320 science-and-engineering undergraduates from a university were recruited and randomly assigned to an experimental group (160 students) and a control group (160 students). The experimental group is introduced to generative AI to assist with dynamic situation simulation, while the control group uses MATLAB and Maple, traditional mathematics software, to carry out teaching. The study relies on questionnaire surveys, experiment operation scores, and classroom observation records to collect quantitative and qualitative data. Statistical analysis of the experimental data revealed that the experimental group demonstrated significant advantages over the control group in both the efficiency of constructing experimental situations and student engagement, while teachers who used AI scored significantly higher than those who did not on all dimensions and on overall efficacy ($P < 0.01$). The research shows that generative AI can effectively assist with complex mathematics experimental situations, dynamic simulation, and instant feedback. By putting teachers in the experiment teaching design process, monitoring, and personally evaluating these aspects, professional ability is significantly strengthened, providing a feasible path for reform in college mathematics experiment teaching.

Keywords: Generative artificial intelligence; Mathematics experiment teaching; Situational simulation; Teacher empowerment; Higher education

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1. Introduction

Mathematical experiments constitute an important component of college mathematics education, aiming

to visualize and dynamize abstract mathematical theories through computer software or programming environments, thereby cultivating students' ability to solve practical problems using mathematical tools [1]. However, traditional mathematical experiment teaching tends to emphasize training in software operation skills and the verification of predetermined models, lacking the creation of authentic, complex, and open situational contexts. As a result, students struggle to establish efficient connections between mathematical knowledge and real-world application scenarios [2]. Meanwhile, teachers commonly face challenges in experiment-based teaching, including scarce lesson preparation resources and difficulty responding in real time to students' diverse inquiry needs, which constrains further improvement in the quality of experimental teaching [3].

In recent years, generative artificial intelligence (Generative AI) has achieved breakthrough developments, with generative AI tools represented by large language models (such as ChatGPT) demonstrating powerful capabilities in natural language understanding, code generation, and multimodal interaction [4]. In the field of education, multiple studies have confirmed that generative AI can reshape instructional design, optimize resource provision, and empower teacher professional development [5–7]. In mathematics education, existing research has shown that AI can assist mathematical problem-solving and adaptation of learning content [8]; however, empirical studies targeting situational simulation in college mathematical experiments and systematic teacher empowerment remain relatively scarce.

In light of this, the present study focuses on introducing generative AI into college mathematical experiment teaching to support the dynamic simulation of experimental situations. It aims to clarify two core questions: whether generative AI can effectively support the creation of experimental situations and students' inquiry activities, and how this teaching model affects teachers' experimental teaching service capacity and professional development. The study employs a quasi-experimental design and multidimensional data for the investigation, hoping to provide a theoretical basis and practical reference for the digital-intelligent transformation of college mathematical experiment teaching.

2. Theoretical framework and experimental design

2.1. The situational-cognitive connotation of mathematical experiment teaching

Mathematical experiment teaching is not merely operational training with software tools; more importantly, it serves as a crucial vehicle for mathematical knowledge construction and problem-solving skill development. Situated cognition theory holds that learning is a socialized practical process occurring within specific situations, and that the meaning of knowledge depends entirely on the situation in which it arises [9]. In mathematical experiments, a well-designed situation can transform abstract formulas and theorems into operable, perceptible dynamic objects, thereby stimulating students' motivation for inquiry. Leveraging its vast knowledge base and powerful semantic generation capabilities, generative AI can rapidly construct interdisciplinary, multi-level mathematical application contexts—such as economic applications, physical simulation, and data analysis—thus compensating, to a certain extent, for the static and monolithic nature of traditional textbook situations.

2.2. Generative AI situational simulation and a teacher-empowerment model

Building on the above analysis, this paper constructs a teaching model that progresses from Prompt-driven instruction to AI-assisted teaching, and then to teacher–student interaction. The model comprises three

core components: (1) Prompt-driven instruction: teachers define experimental objectives, constraints, and contextual backgrounds through carefully designed prompts; (2) AI generation and simulation: generative AI dynamically produces mathematical model hypotheses, derivation steps, code implementation schemes, and visualization contexts based on the prompts, adjusting simulation parameters in real time according to student feedback during the interaction; (3) teacher–student interaction: teachers guide students to critically evaluate the generated results on the basis of AI simulation, conducting in-depth analysis and correction of the relevant mathematical principles.

By automatically completing repetitive instructional tasks such as basic code generation and contextual background description, the model reduces teachers' cognitive load, enabling them to devote their efforts to higher-order teaching activities such as heuristic questioning and metacognitive guidance, while achieving comprehensive enhancement across instructional design, process guidance, and evaluation feedback [10–12].

3. Experimental system and implementation process

3.1. Platform construction and prompt design

The experiment builds a mathematical experiment simulation system based on mainstream large language model platforms, combined with Python/MATLAB/syslab code execution environments, drawing on the construction experience of virtual–real integration inquiry-based experiments and virtual simulation experiments [13–15]. To regulate AI output, the research team developed a modular prompt framework comprising three main components: role setting, which configures the AI as a mathematical experiment teaching assistant that participates in instruction through guided approaches rather than providing direct answers; task decomposition, which breaks complex experiments into five stages—situation description, variable definition, model construction, algorithm construction, and conclusion examination—progressively guiding AI output; and error tolerance and correction, which requires students to identify hallucinations or logical flaws in AI-generated content during the experimental process and correct them using mathematical theory, making this a key component of cultivating critical thinking.

3.2. Experimental subjects and procedure

A total of 320 science-and-engineering undergraduates from a university were recruited and randomly assigned to an experimental group (160 students) and a control group (160 students). The control group received traditional mathematical experiment instruction: teachers provided fixed experiment guidebooks, and students used Python/MATLAB/syslab to complete designated verification experiments such as numerical integration and differential equation solving. Under the same experimental topics, the experimental group incorporated generative AI assistance: students designed their own prompts and interacted with the AI, explored changes in mathematical models under different parameters, and used AI-generated code for visualization; teachers primarily supervised the accuracy of AI-generated content and guided students in deeper mathematical thinking. The experiment lasted one semester (16 weeks) at 2 credit-hours per week. Pre- and post-experiment questionnaire surveys were administered to both teachers and students, and experimental reports and classroom video data were collected; the data were analyzed through triangulation.

4. Experimental results and discussion

4.1. Analysis of situational simulation effects and student engagement

Statistical analysis of the experimental data revealed that the experimental group demonstrated significant advantages over the control group in both the efficiency of constructing experimental situations and student engagement (**Table 1**).

Table 1. Comparison of the experimental and control groups on key experimental indicators

Experimental indicator	Control group	Experimental group	Increase	Levene F	Levene *P*	t	*P*
Situational comprehension accuracy	71.52±7.15	84.37±6.28	12.85	1.892	0.170	17.033	<0.01
Situational task completion	78.60±6.83	89.14±5.76	10.54	2.104	0.148	14.826	<0.01
Experimental operation standardization score	7.35±1.18	8.41±1.02	1.06	3.267	0.071	8.623	<0.01

Note: Levene's test indicated homogeneity of variance between the two groups ($P > 0.05$), so independent-samples t-tests were used; $P < 0.01$ denotes a significant difference.

As shown in **Table 1**, after the introduction of generative AI, the time students needed from raising a problem to constructing a situational model shortened noticeably, enabling them to devote more energy to parameter exploration and model optimization. The experimental group explored far more model parameters than the control group, and the AI situational-simulation approach broadened the scope of students' inquiry. Classroom-interaction frequency also rose further, and AI-assisted inquiry learning stimulated students' willingness to express themselves and their collaborative behavior.

4.2. Analysis of teacher empowerment

Teacher empowerment is another core dimension examined in this study. Using a self-developed "College Mathematics Teachers' Experimental Teaching Efficacy Scale," which covers four dimensions—instructional design, process guidance, technology integration, and evaluation and feedback—the study compared pre- and post-experiment self-rated data between teachers who used AI and those who did not (**Table 2**).

Table 2. Comparison of experimental teaching efficacy between teachers who used AI and those who did not

Dimension	Teachers not using AI (M±SD)	Teachers using AI (M±SD)	Increase	t	*P*
Instructional design capability	7.00±2.45	11.75±3.29	4.75	4.614	0.0012
Process guidance and elicitation	8.71±2.50	15.66±3.22	6.95	6.662	<0.001
Technology integration application	10.14±3.24	15.49±3.50	5.35	4.068	0.0025
Evaluation and feedback efficiency	9.57±2.30	15.34±3.76	5.77	5.708	<0.001
Overall efficacy	35.43±9.61	58.25±12.10	22.82	5.714	<0.001

Note: $P < 0.01$; $P < 0.001$ indicates an extremely significant difference.

The results show that teachers who used AI scored significantly higher than those who did not on all dimensions and on overall efficacy (all $P < 0.01$), with the largest increases in process guidance and elicitation ($t = 6.662$), overall efficacy ($t = 5.714$), and evaluation and feedback efficiency ($t = 5.708$).

4.3. Discussion: The intrinsic mechanism of teacher empowerment

The empowering effect of generative AI on university mathematics teachers does not operate through the simple replacement of skills; rather, it arises from a mechanism that progresses from load reduction to enablement and ultimately to restructuring. In terms of cognitive load reduction, AI automatically handles tedious tasks such as situational description and code debugging, thereby alleviating teachers' cognitive load during experiment preparation and classroom response, and freeing greater attention for optimizing teaching strategies. Regarding capability restructuring, with AI assistance, teachers' roles shift from knowledge transmitters to learning architects and thinking guides, requiring them to master new digital literacies such as prompt engineering and critical evaluation of AI output; the very process of acquiring these competencies iteratively upgrades their professional capabilities. In emotional empowerment, student engagement is further enhanced, and teaching outcomes improve, providing teachers with positive feedback in terms of achievement and professional identity, which in turn stimulates intrinsic motivation to continue exploring new teaching models [16–18].

The investigation also revealed that some teachers tend to over-rely on AI or experience anxiety about the mathematical rigor of AI-generated output. This suggests that universities, while promoting AI-assisted experimental teaching, must simultaneously provide training in the practical ethics of AI use and in assessing mathematical rigor, so as to ensure that technology-assisted instruction does not undermine the core value of the mathematics discipline.

5. Conclusion

This study developed a generative-AI-based situational simulation model for university mathematical experiment teaching and validated its effectiveness through a controlled experiment in enhancing students' inquiry efficiency and realizing teacher empowerment. The results demonstrate that generative AI markedly shortens situation-construction time and increases student engagement, while also strengthening teachers' sense of professional efficacy in lesson planning, process guidance, technology integration, and evaluation and feedback. Through cognitive load reduction and role restructuring, it opens a new pathway for the professional development of university mathematics teachers.

Future research may expand the experimental sample size and disciplinary coverage, explore the differentiated effects of different types of generative AI tools—such as multimodal large models—in mathematical experiment teaching, and establish a long-term support system for developing teachers' AI-based teaching-service capabilities.

Disclosure statement

The author declares no conflict of interest.

References

[1] Cao YM, Wu JF, 2024, Exploring and Research on Generative AI Empowering the Selection and Matching of Mathematics Classroom Teaching Content. Journal of Mathematics Education, 33(5): 60–66.

[2] Zhu YX, Yang F, 2023, ChatGPT/Generative Artificial Intelligence and Educational Innovation: Opportunities,

Challenges, and the Future. Journal of East China Normal University (Educational Sciences), 41(7): 1–14.

[3] Gu XQ, Wang CL, Wang PJ, et al., 2025, Mechanism, Demand and Path of Generative Artificial Intelligence Empowering Teaching. Journal of the Chinese Society of Education, 2025(4): 15–22.

[4] Feng XY, Xu X, Zhang HK, 2025, A New Paradigm of Teaching Design Empowered by Artificial Intelligence. Open Education Research, 31(3): 63–73.

[5] Liu M, Guo S, Wu ZM, et al., 2024, Generative Artificial Intelligence Reshaping the Form of Higher Education: Content, Cases and Pathways. e-Education Research, 45(6): 57–65.

[6] Li XW, Xu YY, Zhai XS, et al., 2024, Generative Artificial Intelligence Empowering the Development of University Students: International Experience and China's Path. Distance Education in China, 44(12): 36–49.

[7] Song Y, Xu CL, Mu XX, 2024, Research on the Evaluation and Optimization of New Classroom Teaching Empowered by Generative Artificial Intelligence. Modern Educational Technology, 34(12): 27–36.

[8] Peng J, Wu NZ, 2024, Artificial Intelligence Empowering the Integrated Development of Teachers: Logical Framework and Generation Path. Modern Educational Technology, 34(10): 23–31.

[9] Tang CH, Wang MZ, Liu YQ, et al., 2025, Research on the Impact of Generative Artificial Intelligence on the Competence of University Teachers. Advances in Education, 15(5): 106–116.

[10] Huang T, Huang WJ, Zhang ZM, 2025, How Artificial Intelligence Empowers Teachers' Professional Development: Theoretical Model and Practical Direction. Modern Distance Education Research, 2025(1): 35–44.

[11] Mu S, Chen XR, Zhou DQ, 2025, Analysis of Generative Artificial Intelligence Empowering Instructional Design: Needs, Methods and Development. Open Education Research, 31(1): 61–72.

[12] Li Y, Sun LY, Jiang QY, et al., 2025, AI Literacy of University Teachers and Strategies for Improvement. Open Education Research, 31(1): 23–33.

[13] Zhu YN, Lou ZR, Wu TX, et al., 2023, Research on the Inquiry-Based Experimental System Integrating Virtual and Real. Journal of System Simulation, 35(1): 82–94.

[14] Chen SJ, Ye B, 2026, Construction Practice of Virtual Simulation Experiment for Enterprise Management Diagnosis. Experiment Science and Technology, 24(3): 49–54.

[15] Yu NP, Zhang YR, 2023, The Impact of ChatGPT/Generative Artificial Intelligence on Education: A New Frontier of Great-Power Game. Journal of East China Normal University (Educational Sciences), 41(7): 15–25.

[16] Song H, Lin M, 2023, Teachers' Work Changes in the Era of ChatGPT/Generative Artificial Intelligence: Opportunities, Challenges and Responses. Journal of East China Normal University (Educational Sciences), 41(7): 78–90.

[17] Miao FC, 2023, On the Technical Principles of Generative Artificial Intelligence and Its Educational Suitability. Modern Educational Technology, 33(11): 5–18.

[18] Liu BQ, Nie XL, Wang SJ, et al., 2024, Generative Artificial Intelligence and the Reshaping of Future Education Form: Technical Framework, Capability Characteristics and Application Trends. e-Education Research, 45(1): 13–20.

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