

AI-Powered Socratic Learning for Psychological Statistics: Enhancing Flipped Classroom Practices with Generative Intelligent Tutoring Systems

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Abstract: This study integrates the Socratic Playground Intelligent Tutoring System (ITS) into a flipped classroom model for a psychological statistics course. The system, based on an AI-supported Learning Management System (LMS) with a Socratic-style large language model, is combined with flipped classroom teaching to explore the impact of adaptive pre-class tasks, personalized grouping, continuous post-class reflection, and various teaching methods on instruction effectiveness. It investigates the optimal timing, methods, and strategies to improve teaching and learning outcomes, with the goal of enhancing classroom interaction, learning atmosphere, student interest, and learning effectiveness, while fostering problem-solving, critical thinking, and autonomous learning skills. The study also provides data-driven insights to refine the system. The process includes pre-class task assignments, in-class personalized grouping, post-class reflection, and evaluation of classroom configuration to assess effectiveness and inform improvements. The results aim to optimize teaching and system design, supporting future implementation and refinement.

Keywords: Socratic Playground; Intelligent Tutoring System (ITS); Flipped Classroom; Personalized Learning

1. Introduction

In the context of advancing psychological research and the big data era, psychological statistics is a foundational course for psychology majors, offering essential skills for research and critical thinking. However, traditional teaching often struggles to meet students' diverse needs for personalized learning and feedback. To address this, the study explores the integration of generative AI and flipped classrooms under Socratic Playground, utilizing AI-enabled learning management systems and intelligent tutoring systems. These technologies adapt to learners' preferences, reduce cognitive load, and enhance application skills. The research investigates the optimization of teaching strategies through Socratic questioning, adaptive grouping, and real-time feedback, aiming to achieve optimal learning outcomes by matching learner characteristics, knowledge complexity, and pedagogies. Supported by AI algorithms that assess learning behaviors and provide personalized recommendations, the study seeks to enhance the theory-practice connection and improve teaching quality and student outcomes, informed by the works of Hu et al. (2025) and Zhang et al. (2024). In summary, the research questions of this paper are:

Question 1: How can we optimize teaching links to enhance learning effectiveness?

Question 2: Which teaching methods are most effective for adaptive learning at what time and place?

Question 3: How can the support of adaptive technology enhance interaction and students' core competencies?

2. Research Methods

A quasi-experimental study uses an AI-enabled flipped classroom LMS (AI-FC-LMS) to explore teaching mode optimization in psychological statistics. Participants are 78 psychology undergraduates. The 2×3×4 design compares AI-FC-LMS to traditional flipped classrooms across learning stages (before, during, after) and learning modes (tutoring, vicarious, gamification, teachable agents). Table 1 shows the experimental process.

Table 1. The Specific Experimental Process of AI-FC-LMS

Stage	Research Objectives	Time	Specific Research Content	Research Indicators	Research Methods
Stage 1	Learner Characteristics	1 - 2 weeks	Group by cognitive styles		
	Assessment and Experimental Grouping		(AI - FC - LMS vs. Traditional Flipped Classroom)	Cognitive patterns, learning motivation, statistical anxiety, etc.	Questionnaire survey, theoretical analysis
Stage 2	Implementing Socratic - style Flipped AI Classroom	3 - 15 weeks	Before class: Recommend personalized learning materials	Basic knowledge learning, question generation	Theoretical analysis, AI recommendation,
			During class: Allocate intelligent interaction modes	Interaction mode adaptability	AI - adaptive task allocation
			After class: Arrange personalized review	Review effectiveness	AI - adaptive task allocation
Stage 3	Integration of Optimal Teaching Strategies	16 - 18 weeks	Multi - dimensional learning effect assessment	Knowledge acquisition, learning motivation, cognitive ability etc.	Structured modeling, learning trajectory analysis

3. Expected research findings

This study predicts that AI-FC-LMS will improve the teaching of psychological statistics by personalizing learning through dynamic task adjustment based on student motivation and affective factors. AI will optimize pre-class preparation with intelligent recommendations, enhance classroom interaction via smart grouping and Socratic guidance, and provide personalized post-class feedback to reduce statistical anxiety. Students using AI-FC-LMS are expected to show better knowledge mastery, higher test scores, and increased motivation compared to traditional flipped classrooms. Theoretically, this study advances AI-flipped classroom pedagogy, offering empirical support for educational theories. Practically, it aids teachers in personalized instruction, improves teaching quality, and supports broader educational reforms using AI and flipped classroom models in higher education.

4. Innovative Points, Limitations, Conclusion, and Outlook

This study presents an AI-FC-LMS model that integrates artificial intelligence into flipped classrooms to enhance the teaching of psychological statistics. By leveraging the LCC theory and the ICAP framework, the model optimizes three-stage learning processes through personalized tasks, intelligent grouping mechanisms, and instantaneous feedback systems. The AI-driven platform dynamically tailors its teaching strategies based on learners' motivations, cognitive abilities, and preferences, thereby enhancing knowledge acquisition, fostering active participation, and promoting critical thinking skills. Theoretically, this research enriches the pedagogical framework of AI-infused flipped classrooms while providing robust empirical evidence for the efficacy of AI in educational settings. From a practical perspective, it offers actionable teaching strategies to facilitate personalized instruction, improve educational quality, and advance the integration of AI technologies in academic environments. However, the study acknowledges several limitations, including data variability, concerns regarding the generalizability of AI applications, challenges associated with mode switching, the use of small sample sizes, and potential external validity issues. These limitations underscore the need for further validation and refinement to ensure broader applicability of the AI-FC-LMS model across diverse

academic disciplines and cultural contexts. Future research should focus on addressing these challenges to maximize the model's potential for transformative impact in education.

References

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