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Generative AI Teaching Assistants Reshaping Teacher Knowledge Workflows: Modeling and Causal Analysis Based on Multimodal Logs

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ABSTRACT

This study explores the impact of generative artificial intelligence (AI) teaching assistants on teachers' knowledge workflows through a multimodal interaction log analysis framework, combining petri net modeling and causal inference methods. The research reveals that generative AI significantly enhances task efficiency by reducing node compression rates (up to 28.9%) and optimizing process links (up to 35.1%), particularly in structured tasks like resource pushing. It also alleviates teachers' cognitive load, which is evidenced by a drop in subjective scores from 5.9 to 4.8 during interactive feedback stages. Key findings highlight a positive correlation between interaction frequency and structural optimization, with higher AI usage intensifying task compression effects. The study provides actionable insights for integrating generative AI into educational systems while addressing limitations in complex task modeling and behavioral data granularity.

KEYWORD

Generative AI, Teaching Assistant, Teacher Knowledge Workflow, Structural Modeling

INTRODUCTION

With the rapid development of generative artificial intelligence (AI) technology, generative AI based on large-scale language models is gradually infiltrating into various tasks of educational scenes. As one of its main application forms, classroom teaching assistants have become an important part of the current intelligent education system. In the teaching process, generative AI teaching assistants can assist teachers to complete tasks such as course material generation, classroom interactive guidance, and student feedback analysis, thus reshaping teachers' knowledge production and organization mode to some extent (Hargreaves, 2025). The traditional teacher knowledge workflow is mainly based on manual decision-making, which relies on teachers' experience accumulation and structured cognition in pre-class preparation, classroom implementation, and after-class feedback. The process is relatively stable, but its efficiency is limited. Generative AI improves the efficiency of task execution, which leads to the deep transformation of teachers' role boundaries, task cognitive structures, and knowledge processing mechanisms (Ahn et al., 2024; George, 2023). At present, there is not enough research on

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the changes of teachers' knowledge workflows after generative AI participation in teaching. Most of the existing studies remain at the superficial level of teaching effect evaluation and teacher-student interaction enhancement; they lack a systematic analysis of the internal structure evolution and task mechanism reconstruction of knowledge workflows (Bower et al., 2024; Yoo, 2024). Some existing works use questionnaire surveys or observations to analyze the attribution of teachers' behaviors, but they fail to combine the generative AI with the dynamic interactive data between teachers, and it is difficult to truly understand the reconstruction path of teachers' knowledge workflows in the actual teaching scene (Borchers et al., 2024; Cukurova, 2025). The workflow modeling method based on static flow charts or manual coding experiences the problems of strong subjectivity and coarse expression granularity, and it is difficult to describe the dynamic evolution of tasks under the condition of multimodal information. In causal reasoning (Spanos, 2022; Weidlich et al., 2024), lack of effective means to identify the influence of key variable processing before and after generating AI intervention, leading to vague understanding of its reconstruction mechanism. These problems make it difficult to reveal the structural influence of generative AI on teachers' knowledge workflows and its mechanism, thus limiting its effective integration and scientific application in the education system (Moundridou et al., 2024; Yeh, 2025).

In this study, the generative AI teaching assistant is not only defined as a productivity tool; it is also regarded as an intermediary agent embedded in the online learning environment, reshaping the generation, organization, and transmission of teaching knowledge in the online teaching environment.

In the field of education, generative AI technology has gradually penetrated teaching support and learning activities, which has triggered a wide discussion on its role and boundary. Rudolph et al. (2023) reviewed the application status of generative AI in higher education, discussed its various influences on the teaching profession, and analyzed the historical and current trends, pointing out that although generative AI brought challenges, it was more a teacher's assistant to improve productivity than a complete replacement for the teaching profession. In this context, it is of great significance to understand the multidimensional role of generative AI in the educational ecosystem for promoting its effective integration and promoting the positive response of all parties (Aithal & Aithal, 2023; Baidoo-Anu & Ansah, 2023). Kanont et al. (2024) studied the influencing factors of Thai higher education students' acceptance of generative AI technology through questionnaire surveys and structural equation model analysis. They found that expected benefits, perceived usefulness, technical attitude, and behavioral intention significantly affected students' adoption of generative AI. This discovery has further led to an in-depth discussion on the role boundary and applicable scenarios of generative AI in specific teaching tasks (Cooper, 2023; Nikolopoulou, 2024). Ahmed et al. (2024) evaluated the feasibility of ChatGPT as a teaching assistant for introductory programming courses. They found that it performed well in explaining basic programming concepts, but it was insufficient in solving complicated students' puzzles and providing personalized support. Although all the above studies were conducted from the perspective of the feasibility of teachers, students, and tools, most of them focus on the preliminary functional evaluation, lacking a systematic discussion on the reconstruction of the overall teaching mechanism after the deep integration of generative AI into the education process (Chan & Tsi, 2024; Kaplan-Rakowski et al., 2023).

With the generative AI gradually entering the educational practice as a classroom teaching assistant, academic circles have created a multi-dimensional discussion on its influence on teachers' knowledge flows and educational equity. Zhai (2025) analyzed the change of teachers' roles and the influencing factors in the era of generative AI by constructing four role frameworks: observer, user, collaborator, and innovator. The author pointed out that teachers' cognition, acceptance, knowledge, and practice are the key factors to promoting the effective integration of generative AI into educational practice and emphasized the importance of continuous professional development and institutional support. This role transformation not only reflects the deep integration of technology and education, but also echoes the dynamic synergy between teachers' identity cognition and professional behavior in the digital transformation (Luo et al., 2025). Verma et al. (2023) discussed the application potential,