Beyond Replacement: The Instructor-AI Synergistic Ecosystem in Science Education

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Abstract

This author-synthesized perspective connects three peer-reviewed, Scopus-indexed studies conducted by the same research team to present a coherent research narrative on integrating Generative Artificial Intelligence (GenAI) into science education. Across these studies, GenAI was examined in three complementary roles: as a scaffold for developing scientific explanation competency, as a real-time formative assessment tool that triggers self-regulated learning (SRL) in chemistry, and as a subject of qualitative analysis that revealed how the human instructor and AI can function together in the classroom. The resulting framework—the Achievement-Based Instructor-AI Synergistic Learning Ecosystem—proposes that AI does not replace the human teacher but functions as a personalized SRL facilitator, while the teacher serves as an Adaptive Expert who shifts between simplifying and elaborating content based on learner achievement. This synthesis illustrates the continuity across the studies and how each builds upon the findings of the previous one. This perspective has not undergone independent peer review; readers are encouraged to consult the original publications listed below.

Keywords: AI in education, formative assessment, chemistry education, self-regulated learning, phenomenon-based learning, pre-service teacher education, AI-human collaboration, scientific explanation

The integration of Generative AI (GenAI) into science instruction has demonstrated considerable efficacy in enhancing learner competencies when embedded within a well-designed learning ecosystem under the pedagogical guidance of the instructor (Almasri, 2024). Notably, the deployment of AI within a phenomenon-based learning framework (Ratniyom et al., 2025) was found to significantly improve learners' competency in constructing scientific explanations—one of the core scientific literacy competencies defined by PISA (OECD, 2023). By coupling GenAI with authentic phenomenon inquiry and collaborative group work, the instructional design effectively reduced cognitive load while providing learners with well-structured exemplars of scientific explanation, thereby facilitating more effective learning (Ratniyom et al., 2025).

Ratniyom et al. (2026a) examined the use of GenAI as a formative assessment tool in a first-year chemistry course for pre-service science teachers. The AI system evaluated learners' understanding in real time, generating quantitative scores (percentage-based) alongside qualitative feedback aimed at improving learning. A critical finding was that the immediacy and individualized nature of AI-generated feedback—tailored to each learner's proficiency level—served as a key mechanism for activating self-regulated learning (SRL) processes (Ng et al., 2024). Beyond the technological affordance, the participants' emerging professional identity as future teachers constituted an additional motivational driver that reinforced their learning engagement. This was captured in the qualitative data, in which one pre-service teacher reflected upon receiving immediate AI feedback:

> *"...if I can't solve these problems, but I'm going to become a teacher, what on earth will I teach my students in the future? So, because of that, I just have to try harder; I have to practice more."*

Having established the efficacy of AI in enhancing learning outcomes, a fundamental question arises:

Does AI serve as a replacement for the human instructor, or can it function collaboratively within the instructional process?

Ratniyom et al. (2026b) addressed this question through secondary qualitative analysis, synthesizing qualitative data to propose a model of a *Synergistic Learning Ecosystem*. The findings indicated that AI integration in the classroom does not supplant the human instructor; rather, it establishes an Achievement-Based Instructor–AI Synergistic Learning Ecosystem in which learners leverage AI as a personalized SRL facilitator, while the human instructor retains the most critical role as an Adaptive Expert—dynamically shifting between the functions of Simplifier and Elaborator in response to the achievement levels of different learner groups.

Disclaimer: This is an author-synthesized perspective connecting the author's own peer-reviewed publications. It has not undergone independent peer review. Readers are encouraged to consult the original studies cited below.

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