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Generative AI-Supported Learning in Pre-Service Science Teacher Education: A Systematic Review of Experiential Learning and Reflective Thinking for SDG 4

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ABSTRACT

Objective: *The review synthesises how generative artificial intelligence (GenAI) is used in pre-service teacher education, with particular attention to science and STEM contexts, experiential learning alignment, reflective thinking, and the implications for Sustainable Development Goal 4 (SDG 4).* ***Method:*** *The review screened 411 unique records exported from Scopus and identified a priority subset of 45 records. In the updated working assessment, 35 records had received detailed assessment: 30 full texts and five abstract/metadata-only records. Twenty-two full-text records were retained for supporting or contextual synthesis, eight were excluded, three remained unclear, and two were provisionally retained on abstract evidence. Ten priority records remained pending assessment.* ***Results:*** *GenAI was used as a dialogic reflection partner, lesson-design assistant, cognitive or metacognitive scaffold, research-learning support, and interactive tutor or simulation agent. However, the studies varied in population, disciplinary context, theoretical framework, and outcome measurement. Experiential and reflective activities were reported, but explicit implementation of all four stages of Kolb's cycle was not established in the studies assessed. Direct reflective-thinking measures were limited and were mainly reported in studies outside science/STEM teacher education. No assessed study simultaneously combined a clearly implemented four-stage Kolb cycle, direct reflective-thinking measurement, and a pre-service science/STEM teacher population.* ***Novelty:*** *The review distinguishes GenAI functions, experiential-learning alignment, and different forms of reflection-related evidence. It identifies the need for theoretically structured, human-centred GenAI-supported learning designs that can strengthen reflective thinking in science teacher education and contribute to SDG 4.*

INTRODUCTION

Science teacher education requires prospective teachers to integrate disciplinary understanding with inquiry-oriented pedagogy, evidence-based reasoning, classroom decision-making, and the capacity to respond to diverse learners (Breslyn & McGinnis, 2019). These demands are not met through content acquisition alone. Pre-service teachers also need opportunities to examine their instructional decisions, interpret evidence from teaching and learning, identify assumptions, and revise pedagogical approaches (Hordvik et al., 2024). Reflective thinking is therefore relevant not merely as a retrospective activity, but as a professional reasoning process through which experience can be evaluated and transformed into informed action (Sherwood, 2024).

The rapid development of generative artificial intelligence (GenAI) has introduced new possibilities for supporting such processes. Conversational large language models can respond to prompts, offer alternative explanations, generate questions, critique lesson plans, and provide iterative feedback (Beale, 2025). In teacher education, these affordances may position GenAI as a dialogic scaffold or a cognitive partner rather than only as a content-production tool (Spasopoulos et al., 2025). Recent studies have

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