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Digital Learning Aid Systems for Enhancing Students' Problem-Solving Skills in Physics Education: A Systematic Literature Review

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ABSTRACT

Objective: *This study aims to examine how digital learning aid systems support the development of students' problem-solving skills in physics education. The study focuses on identifying how digital tools facilitate conceptual understanding, visualization of abstract physics concepts, inquiry-based learning processes, and student engagement in solving physics problems.* ***Method:*** *This research employed a systematic literature review following PRISMA guidelines. Articles were collected from Scopus-indexed journals and Google Scholar using predefined keywords related to digital learning, physics education, and problem solving. A total of 312 articles were identified, 276 remained after duplicate removal, and 20 articles published between 2021 and 2025 met the inclusion criteria, consisting of Scopus Q1–Q3 empirical studies available in full text. Data were analyzed using a structured extraction sheet and thematic synthesis to identify instructional mechanisms and patterns of technology integration.* ***Results:*** *A synthesis of 20 studies shows that digital learning aid systems enhance problem-solving through interactive simulations, virtual laboratories, artificial intelligence tools, and immersive visualization technologies. Research trends indicate a shift from simulation-based learning toward AI-supported and adaptive digital environments that provide scaffolding, feedback, and inquiry-based experimentation. These features support conceptual reasoning, analytical thinking, and structured solution strategies..* ***Novelty:*** *This review reveals that digital learning aid systems function as integrated problem-solving ecosystems that combine visualization, inquiry scaffolding, and adaptive feedback, extending beyond the single-technology approaches reported in previous studies.*

INTRODUCTION

Digital technology has become an integral component of modern physics education, particularly in the context of the 21st-century digital transformation, which emphasizes critical thinking, problem-solving, collaboration, and technological literacy as essential learning competencies. Educational institutions increasingly integrate digital platforms, interactive applications, and online learning environments to support student-centered learning and flexible instructional practices. These technologies allow educators to design learning environments that combine visualization, interaction, and immediate feedback, often difficult to achieve in traditional classroom instruction. Research shows that digital technologies can improve accessibility of learning materials and promote active participation in physics learning activities (Jugembayeva & Murzagaliyeva, 2022). Technology integration also supports innovative instructional strategies that encourage inquiry and exploration of physical phenomena (Kamarudin et al., 2024). Furthermore, digital learning environments enable collaborative learning and facilitate knowledge construction through interactive engagement among students (Leow & Neo, 2023; Qureshi et al., 2023).

The integration of digital technology is particularly important in physics education because many physics concepts are abstract and mathematically complex. Students often struggle when they try to apply conceptual knowledge to solve physics problems in unfamiliar situations. Several studies report that students tend to rely on memorizing formulas rather than understanding the underlying physical principles needed for problem solving (Gjerde et al., 2022). This tendency often leads to fragmented conceptual understanding and ineffective reasoning strategies during problem-solving (Braun & Graulich, 2024). Research also indicates that limited conceptual understanding can hinder students' ability to analyze and interpret physics problems systematically (Bouchée et al., 2022; Guerra-Reyes et al., 2024). Recent studies also indicate that technology-rich learning environments in 21st-century learning require students to engage in higher-order thinking. However, many learners still demonstrate low performance in analyzing, evaluating, and applying physics concepts during technology-supported learning, highlighting a gap between technology integration and students' problem-solving competence.

Digital learning technologies offer opportunities to address these challenges by providing interactive learning environments that support conceptual exploration and reasoning in physics learning. Simulation-based platforms enable students to visualize abstract physical phenomena and dynamically manipulate variables. For example, interactive simulations enable students to observe processes such as wave motion, electric fields, or particle interactions that are difficult to represent in conventional classrooms (Ogegbo & Ramnarain, 2022). Studies show that simulation-based environments and virtual laboratories can improve conceptual reasoning and inquiry skills in physics learning (Papalazarou et al., 2024). In addition, technology-supported learning environments encourage students to test hypotheses and evaluate outcomes through experimentation, thereby strengthening conceptual understanding (Kranz et al., 2023).

Besides simulations, gamified digital learning platforms have also attracted significant attention in physics education research. Gamification integrates elements such as challenges, rewards, and immediate feedback into learning activities to increase student engagement. Platforms such as Quizizz and Kahoot allow teachers to conduct formative assessments while encouraging students to actively participate in solving physics problems (Zhang & Crawford, 2024; Maraza-Quispe et al., 2024). Research indicates that gamified learning environments can enhance student motivation and classroom participation during physics instruction (Gaurina et al., 2025). In addition, digital assessment platforms provide immediate feedback that helps students identify misconceptions and refine their reasoning strategies during problem-solving activities (Stanja et al., 2023; Gross et al., 2025).