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The Potential of E-Learning in Understanding Concepts in Science and Physics Education: A Bibliometric Analysis

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ABSTRACT

Objective: *The objective of this study is to describe trends, contributions, developments, and research opportunities in e-learning for conceptual understanding in physics and science education.* ***Method:*** *The research method employed was bibliometric analysis using the Scopus database. Data were obtained from the Scopus database using the search terms "E-Learning" AND "Physics Education" OR "Science Education" AND "Conceptual Understanding," yielding 2,735 documents. The Scopus database was filtered by year, document type, and language, resulting in 2,363 documents for analysis.* ***Results:*** *The results indicate that research on e-learning's impact on conceptual understanding in physics or science education has been a trend over the past ten years. The top contributing authors are H, Gwo-Jen; S, Niwat; K, Heru; and S, Andi, while the top affiliations are Indonesia University of Education, Padang State University, and Malang State University. Current developments in e-learning have been categorized as artificial intelligence, so the opportunity for data-driven research lies in developing artificial intelligence for learning.* ***Novelty:*** *Technological transformation has impacted the world of education, particularly in strategies to improve students' conceptual understanding. This study presents a bibliometric mapping of e-learning research related to conceptual understanding in physics and science education. This study differs from previous research, which has not presented a thematic evolution to guide future research.*

INTRODUCTION

In the transition from Industry 4.0 to Society 5.0, significant advances in digital technology have been made. These technological advancements have a significant impact on human well-being, particularly in education. The use of technology is expected to create an educational system that is more adaptive, innovative, and responsive to 21st-century learning needs. Integrating technology into the learning process can enhance the quality of interaction between educators and students through various interactive digital media (Alenezi et al., 2023; Sari et al., 2025). With the support of technology, the learning process not only takes place conventionally but also utilizes various digital platforms that support learning activities (Josué et al., 2023). This indicates that integrating technology is expected to help students hone their skills, particularly their conceptual understanding. Therefore, the use of technology in education is a strategic step in improving the quality of learning in the digital age, particularly in enhancing conceptual understanding (Bond et al., 2021).

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Achievements through digital technology are expected to provide quality education that fosters students' ability to understand concepts in depth (Rahmah & Lubis, 2024). Conceptual understanding is expected to help students connect the knowledge they have learned to various phenomena in their surrounding environment. With a solid conceptual understanding, students do not merely memorize learning materials but can also explain, interpret, and apply these concepts in various situations (Arsyad & Syakhrani, 2024). This ability serves as a primary indicator of meaningful learning. Furthermore, conceptual understanding is also expected to support the development of critical thinking, analytical, and problem-solving skills. Therefore, the learning process must be designed to encourage students to actively and deeply build conceptual understanding. Consequently, enhancing students' conceptual understanding is a primary goal in the pursuit of quality education (Hansen, 2023), particularly in understanding scientific concepts related to the natural world.

One area of learning that requires a deep conceptual understanding is science, particularly physics. Physics examines various natural phenomena, explaining them through scientific concepts that are often abstract and complex. In school settings, many students still struggle to fully grasp physics concepts (Aksit & Wiebe, 2020). This situation leads students to tend to memorize formulas without understanding the underlying concepts (Nilimaa, 2023). Consequently, students often struggle when faced with problems that require applying these concepts in specific contexts. Several studies indicate that a lack of understanding of physics concepts remains one of the primary challenges in science education at all educational levels. This suggests that physics instruction still needs improvement to help students understand these concepts more deeply. Therefore, a teaching approach is needed to support students' understanding of physics concepts (Herlina et al., 2023). In this context, digital technology is particularly needed in physics learning to enhance conceptual understanding.

With the advancement of digital technology, modern education has begun to utilize various e-learning platforms to support the learning process. E-learning allows students to access learning materials flexibly through digital devices and the internet (Santiago et al., 2021; Laili & Nisa, 2025). Additionally, e-learning offers interactive features such as instructional videos, virtual simulations, discussion forums, and online quizzes that help students gain a deeper understanding of the material. In science and physics education, e-learning can also help visualize abstract concepts, making them easier for students to understand. Various studies indicate that e-learning can enhance student engagement in the learning process (Panigrahi et al., 2021). Nevertheless, the implementation of e-learning in education still requires further development to be optimally utilized in supporting students' conceptual understanding. Therefore, e-learning has become an important alternative in modern education (Dhawan, 2022).

Although research on e-learning in education continues to grow, studies that specifically map the development of this research remain limited (Djeki et al., 2022). Most previous studies have focused more on the development of instructional media or