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Bibliometric Study: Trends of Development Digital Media to Improve 21st Century Students' Skills in Physics Learning

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ABSTRACT

Objective: *This bibliometric study aims to analyze trends in the development of digital media to enhance 21st-century skills among students in physics learning. It seeks to map research patterns, identify key contributions, collaborations, and emerging themes, while highlighting gaps in the application of interactive digital tools like animations, virtual reality (VR), and augmented reality (AR) to foster critical thinking, creativity, collaboration, and communication in physics education.* ***Method:*** *This study used method with a bibliometric literature review was conducted using data from the Scopus database and analyzed using VOSviewer and Microsoft Excel.* ***Results:*** *The study's results, which show a significant increase in publication trends post-2020, peaked at 47-79 articles annually, driven by COVID-19-induced shifts to online learning. Key co-occurrence networks revealed dominant keywords like "digital media," "critical thinking," "visualization," "teaching," "students," "collaborative learning," "e-learning," "three-dimensional," and "technology," clustered into interconnected themes.* ***Novelty:*** *This study provides the first comprehensive bibliometric mapping of digital media trends specifically tailored to physics education in enhancing 21st-century skills. It offers actionable recommendations for integrating interactive visualizations in physics curricula, bridging gaps in Indonesian education amid technological advancements.*

INTRODUCTION

21st-century skills include critical thinking, creativity, collaboration, and communication, which are important elements in modern education to prepare students to face global challenges in the digital age (Trisnawati & Sari, 2019). In the context of education, these skills enable students to not only master academic material but also analyze information in depth, produce innovative solutions, and adapt to technological changes (Ngongo et al., 2019). Therefore, the current educational framework emphasizes the importance of developing 21st-century skills to create a competitive generation capable of contributing to a knowledge-based society (Hidayatullah et al., 2021). In physics education, these skills are particularly relevant to help students understand complex concepts and apply them in real-world situations.

However, the reality in the field shows that 21st-century skills are still underdeveloped (Juliandarini, 2022) among students. International assessment results, such as the Programme for International Student Assessment (PISA), indicate that students in Indonesia often face difficulties in applying critical thinking, problem-solving, and creativity, especially in materials that require an understanding of abstract concepts (Budiarti, 2023; Lestari, 2022; Mita, 2019). Even in current learning, teachers and students tend to focus on memorization without honing their ability to connect concepts with