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Mapping Research on Interactive Digital Learning Media in Science Education: A Systematic Literature Review

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Abstract
This study aims to systematically map, classify, and analyze research trends, characteristics, and gaps related to interactive digital learning media in science education using a systematic literature review (SLR) approach. Data were collected from Google Scholar using the Publish or Perish software, yielding 17,400 initial articles, which were filtered down to 34 relevant studies based on predefined inclusion criteria. The analysis followed PRISMA guidelines to ensure transparency and methodological rigor and was supported by bibliometric analysis using VOSviewer and qualitative content analysis. The results indicate that existing studies are still dominated by general discussions of digital learning, without focusing on specific types of interactive media. The use of emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) remains limited. Furthermore, most studies emphasize learning effectiveness rather than the development of innovative media designs. These findings reveal a significant research gap and highlight the need for more specific, contextual, and innovative interactive digital learning media in science education.

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Keywords: Interactive Digital Learning Media, Science Education, Systematic Literature Review, Bibliometric Analysis, PRISMA

1. Introduction

The integration of digital technology in education has significantly transformed learning paradigms from teacher-centered to learner-centered approaches. Technologies such as learning management systems (LMS), online platforms, and immersive tools like augmented reality (AR) and virtual reality (VR) enhance interactivity and facilitate deeper conceptual understanding (Djibran *et al*., 2024; Laila *et al*., 2025) [4, 16]. In addition, digital technology expands access to education beyond geographical boundaries and supports personalized learning tailored to individual needs and learning styles (Bahani & Kholid, 2024; Zahra & Fitri, 2025) [3, 32]. It also contributes to the development of essential 21st-century skills, including digital literacy, collaboration, and problem-solving (Hasnida *et al*., 2024; Tanjung *et al*., 2024) [11, 24]. Despite these advantages, several challenges persist, including the digital divide, limited infrastructure, and concerns regarding data privacy and security (Simanjuntak *et al*., 2026; Siringoringo & Alfaridzi, 2024) [29, 9]. These challenges highlight the need for strategic solutions involving policy support, educator competency development, and cross-sector collaboration to ensure equitable and sustainable digital transformation in education (Rukman, Susetyarini, Purwanti, *et al*., 2025) [28].

Science education presents additional challenges due to the abstract and complex nature of its concepts, which are often difficult to visualize using traditional teaching methods such as lectures and textbooks (Osborne, 2023) [21]. To address this issue, interactive digital learning media—such as simulations, virtual laboratories, AR, and VR—have been widely adopted to enhance

conceptual understanding, student motivation, and engagement (Kanvaria & Monika, 2023; Pramasela & Sefriyanti, 2025; Rukman, Susetyarini, & Purwanti, 2025; Yunita & Irawan, 2025) [15, 22, 27, 31]. Various forms of interactive media, including audiovisual tools and pop-up books, also contribute to improving visualization and comprehension of complex scientific phenomena (Lestari *et al*., 2025; Mauidah *et al*., 2025) [17, 18]. However, challenges remain in aligning technological integration with pedagogical objectives and adapting it to diverse student needs and learning styles (Juwita *et al*., 2023; Hasanah & Ansyah, 2022).

Interactive digital learning media—such as simulations, animations, AR, and VR—have demonstrated effectiveness in enhancing engagement, motivation, and conceptual understanding by providing concrete representations of abstract concepts (Fadhilah *et al*., 2026; Purnomo *et al*., 2025) [6, 23]. Tools like PhET simulations enable independent exploration in controlled environments (Resti *et al*., 2024) [25], while AR supports inquiry-based and collaborative learning through three-dimensional visualization (Hidayati & Hafidz, 2025; Hildayanti *et al*., 2025) [12, 13]. VR, on the other hand, offers immersive experiences that improve knowledge retention and engagement (Freire & Díaz, 2024; Pramasela & Sefriyanti, 2025) [8, 22].

Despite the increasing adoption of these technologies, their implementation is still constrained by infrastructure limitations, cost, and educator readiness (Elkoumitti *et al*., 2025; Suhenda *et al*., 2024) [5, 30]. Moreover, existing studies tend to be fragmented and focus on specific technologies without providing a comprehensive understanding of research trends, characteristics, and gaps (Akhlida *et al*., 2026; Alfahani *et al*., 2025) [1, 2].

Therefore, this study aims to systematically map and analyze research trends, characteristics, and gaps in interactive digital learning media in science education. The findings are expected to provide a comprehensive overview and serve as a foundation for developing more innovative and effective learning media.

2. Method

This study employed a systematic literature review (SLR) approach combined with bibliometric analysis to examine the development of research on interactive digital learning media in science education. The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, reproducibility, and methodological rigor (Haddaway *et al*., 2022) [10].

2.1. Data Sources and Search Strategy

Data collection was conducted on March 12, 2026, using the Google Scholar database accessed through the Publish or Perish software. The search utilized the following keywords:

"interactive multimedia" OR "virtual laboratory" OR "augmented reality" OR "mobile learning" AND "science education".

The initial search yielded 17,400 articles. After removing duplicates and limiting the publication period to 2015–2025, 16,900 articles remained for screening.

2.2. Selection Process and Eligibility Criteria

The selection process followed PRISMA stages, including identification, screening, and eligibility (Haddaway *et al*., 2022) [10]. Title screening resulted in 223 articles, which were further evaluated for relevance, yielding 34 articles for final analysis. Inclusion criteria: (1) Studies on interactive digital learning media in science education, (2) Published between 2015-2025, (3) Empirical research or media development studies, dan (4) Written in English or Indonesian. Exclusion criteria: (1) Irrelevant to science education, (2) Conceptual papers without empirical data, dan (3) Duplicate or incomplete articles.

2.3. Data Analysis Techniques

Data analysis in this study was carried out using two approaches, namely bibliometric analysis and content analysis.

2.3.1. Bibliometric Analysis

Bibliometric analysis was conducted using Publish or Perish to extract article metadata and VOSviewer software to visualize research maps. This analysis aims to identify: (1) Research clusters, (2) Keyword co-occurrence, (3) Research trends and development patterns.

2.3.2. Content Analysis

Content analysis was used to examine: (1) Types of interactive media, (2) Research focus and context, (3) Expert validation results, (4) Student responses, dan (5) Identified research gaps.

The results of both analyses were synthesized to provide a comprehensive understanding of research trends and opportunities.

3. Results and Discussion

3.1. Results

Based on the literature selection process using the PRISMA approach (Haddaway *et al*., 2022) [10], 34 articles relevant to the topic of interactive digital learning media in science education were obtained. These articles were the result of screening from a total of 17,400 articles identified through the Google Scholar database using Publish or Perish, which were then selected through a process of removing duplications, limiting publication years (2015–2025), and title screening. This selection process showed that most of the initial articles did not specifically discuss digital learning media in the context of science education.

3.2. Literature Selection Process

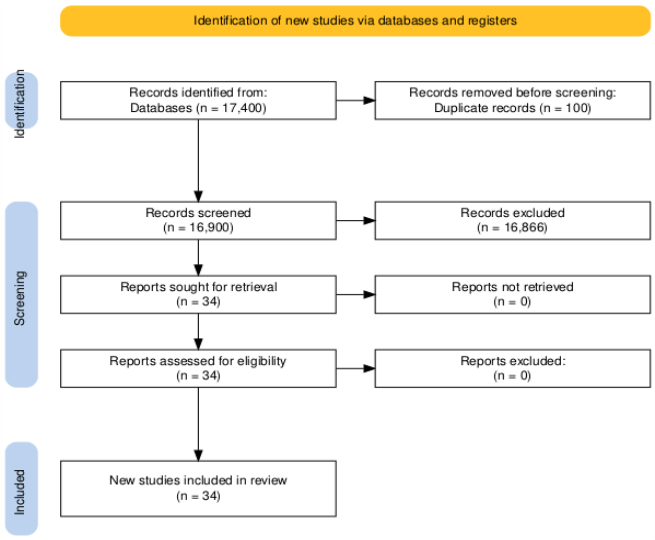

Fig 1: PRISMA Flow Diagram of Literature Selection (Haddaway *et al*., 2022)

Figure 1 shows the systematic literature selection process. Of the 17,400 identified articles, 100 were removed from duplicates and the year of publication was restricted, resulting in 16,900 articles for the screening stage. Furthermore, through title screening, 16,866 articles were eliminated for irrelevance, leaving 34 articles for further analysis.

3.3. Distribution of Interactive Digital Learning Media

Table 1: Distribution of Interactive Digital Learning Media

No	Type	Total	Percentage (%)
1.	General digital learning	29	85,3
2.	Interactive Multimedia	2	5,9
3.	Virtual Reality (VR)	1	2,9
4.	Augmented Reality (AR)	1	2,9
5.	Mobile Learning	1	2,9
	Total	34	100

The analysis shows that the majority of research (85.3%) falls into the general category of discussing digital learning in a scientific context without focusing on specific media types. Research specifically examining interactive learning media such as multimedia, VR, AR, and mobile learning remains very limited. These findings indicate that research in this area is still at a general exploration stage and has not yet led to the development of specific and innovative interactive learning media.

3.4. Tren Penelitian

Table 2: Distribusi Tahun Publikasi

No	Year	Number of Articles
1.	2018	3
2.	2019	4
3.	2020	8
4.	2021	6
5.	2022	5
6	2023	5
7	2024	2
8	2025	1
	Total	34

Publication distribution showed a significant increase in 2020–2021, closely related to the increased demand for digital learning during the COVID-19 pandemic. After that period, research trends stabilized but did not show a significant increase in the exploration of interactive learning media specifically.

3.5. Bibliometric Analysis

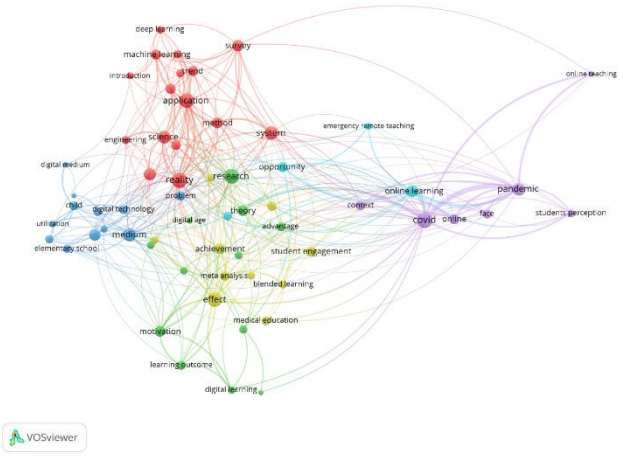

Fig 2: Visualization of Research Trends Using VOSviewer

Figure 2 shows that the VOSviewer visualization results are dominated by keywords such as digital learning, e-learning, and student engagement. Meanwhile, terms such as virtual reality, augmented reality, and interactive media appear in smaller clusters. This indicates that research is still focused on general aspects of digital learning, while exploration of technology-based interactive learning media is still limited.

3.6. Synthesis of Research Characteristics

Table 3: General Characteristics of Research

No	Rated Aspect	Category	Find
1.	Research Focus	Learning Effectiveness	Dominant
		Motivation & engagement	Much studied
		Media development	Still limited
2.	Media Types	General (digital learning)	Dominant
		Interactive multimedia	Limited
		VR/AR	Very Limited
3.	Approach	Inquiry-based learning	Start using
		Project-based learning	Limited
		STEAM	Starting to grow

The synthesis results show that research still focuses on learning effectiveness rather than media development. This indicates that research has not yet fully focused on innovation in learning media design.

3.7. Research Gaps

Table 4: Research Gaps

No	Aspect	GAP
1.	Media Specifications	Research is still general
2.	Technology	VR and AR are very minimal
3.	Focus	Dominant on effectiveness
4.	Depth	Minimal media exploration
5.	Science Context	Not specific yet

The analysis reveals a significant gap in research on interactive digital learning media in science education. Research is still dominated by general approaches, while the development of innovative technology-based media remains very limited.

4. Discussion

The research results show that studies on interactive digital learning media in science education are still dominated by general approaches that do not specifically address any particular media type. This is evident in the dominance of the general digital learning category at 85.3%, indicating that most research still focuses on broad technology integration without exploring specific media characteristics.

These findings indicate that research in this area is still in its early exploration stages, with technology being used as a learning support tool but not yet widely developed as a specifically designed learning medium. This aligns with the results of bibliometric analysis, which shows that keywords such as digital learning, e-learning, and student engagement are more dominant than specific technologies

like virtual reality and augmented reality.

The lack of research on innovative technologies like VR and AR indicates a significant gap between technological development and its implementation in science learning. However, the abstract and complex nature of science learning greatly requires visualization media capable of concretely representing concepts. Therefore, technologies like VR, AR, and digital simulation have significant potential for further development in the context of science learning.

Furthermore, the research findings also indicate that the focus of research is still dominated by measuring learning effectiveness, such as improving student learning outcomes and motivation, rather than developing the learning media design itself. This indicates that research has not yet fully focused on media design innovation based on science learning needs.

The increasing publication trend in 2020–2021 indicates an accelerated use of digital technology in learning due to the COVID-19 pandemic. However, this increase has not been accompanied by in-depth exploration of interactive learning media specifically. This indicates that research remains oriented toward technology adaptation, rather than developing media innovations.

Based on these findings, this study implies that the development of interactive digital learning media in science education needs to be directed toward more specific, contextual, and student-centered designs. The integration of innovative technologies such as VR, AR, and virtual laboratories needs to be enhanced to support the visualization of complex science concepts and encourage deeper engagement and understanding.

5. Conclusion

This research shows that the study of interactive digital learning media in science education is still dominated by a general approach with limited use of innovative technology, so that the development of more specific, contextual, and innovative media is needed to increase the effectiveness of learning.

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