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Trends And Innovations in the Use of Digital Science Encyclopedias

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Abstract

Digital science encyclopedias are increasingly used as alternative learning media to support students' understanding of scientific concepts. However, evidence regarding their research trends and development challenges remains limited. This study aims to analyze research trends, implementation focus, and gaps in the use of digital encyclopedias in science education. A Systematic Literature Review combined with bibliometric analysis was conducted on 36 journal articles published between 2020 and 2025 and indexed in Google Scholar. Keyword co-occurrence and thematic relationships were analyzed using VOSviewer. The results identify three main research clusters: digital encyclopedia development and validation, student-centered implementation, and learning effectiveness with local wisdom integration. Overlay and density visualizations indicate that studies on digital encyclopedias increased between 2022 and 2023 but remain limited compared to other digital learning media. Research involving collaboration with material experts, media experts, and contextual content is still underexplored. These findings suggest that digital encyclopedias positively support science learning but require further development to enhance contextual relevance and sustainability.

Keywords: digital encyclopedia, science learning, learning media, bibliometric analysis.

1. Introduction

Science education relevant to local resources as contextually based teaching materials is crucial for increasing students' awareness and understanding of their environment. Given Indonesia's high biodiversity (Kusmana & Hikmat, 2015), research on the variety of living things there is essential. Diversity issues, such as taxonomy, utilization, and issues pertaining to local culture (ethnoscience), can also be used as a resource for science education.

The rapid advancement of digital technology has significantly transformed science education, particularly through the development of digital learning resources that support flexible and learner-centered instruction (OECD, 2023). One such resource is the digital science encyclopedia, which integrates structured scientific knowledge with multimedia elements, hyperlinks, and web-based navigation to facilitate access to verified and up-to-date information (Roncaglia, 2021). Unlike printed textbooks, digital encyclopedias enable interactive exploration of scientific concepts and support independent learning in digital environments.

Recent studies indicate that digital science encyclopedias contribute positively to student engagement, conceptual understanding, and scientific literacy across educational levels (Pinchuk & Luparenko, 2023; Putra, 2021). Innovations such as mobile platforms, augmented reality, and web-oriented encyclopedic systems further demonstrate the shift of digital encyclopedias from static information repositories toward interactive learning media (Felt, 2024). Despite these developments, research on digital science encyclopedias remains fragmented and less visible compared to other digital learning tools, such as learning management systems or virtual laboratories.

Most existing studies focus on media development, feasibility, or learning effectiveness, while systematic analyses of research trends, innovation patterns, and thematic gaps are still limited. Consequently, a comprehensive synthesis is needed to map how research on digital science encyclopedias has evolved and to identify underexplored areas. A Systematic Literature Review combined with bibliometric analysis offers a transparent and objective approach to examining publication trends, thematic structures, and research gaps (Donthu et al., 2021). Therefore, this study aims to analyze trends, innovations, and research gaps in the use of digital science encyclopedias in science education.

Encyclopedias can make use of pertinent information technologies as technology and knowledge advance. In addition to traditional textbooks, electronic or digital encyclopedias provide a more creative and interactive alternative that has the potential to significantly increase student engagement and comprehension (Komaria & Ningsih, 2023). Digital encyclopedias enable students to delve deeper into local potential and connect scientific ideas with real-world practices (Hudson, 2014). This encourages students to develop and preserve regional potential while enhancing the educational process. By providing comprehensive and up-to-date information, digital encyclopedias can be a supportive platform for promoting local potential within the context of a community's natural and cultural resources (Bennett & Holman, 2002).
Thus, the community and academics can work together to develop sustainable local potential that is relevant to what the community needs through the use of digital encyclopedias in science education (Krajcik & Blumenfeld, 2006). All of this aims to determine the level of adoption and challenges associated with the development of learning materials for science education using digital encyclopedias. And we hope this research will be very helpful in creating more contextual

and relevant teaching strategies in science education, because local potential as a learning resource is often not in line with the formal education curriculum.

However, existing studies on digital science encyclopedias remain fragmented and focus mainly on development or effectiveness, with limited analysis of research trends and challenges. Therefore, this study aims to map trends, thematic structures, and research gaps through a Systematic Literature Review and bibliometric analysis, contributing a synthesized theoretical framework to guide future research.

2. Methods

Research Design

This study employed a Systematic Literature Review (SLR) combined with bibliometric analysis to investigate research trends, thematic structures, and research gaps related to the development and use of digital encyclopedias in science learning. The SLR design was chosen to ensure a structured, transparent, and replicable review process, while bibliometric analysis was applied to objectively map relationships among research themes and visualize the evolution of studies over time.

Research Framework and Procedures

The research framework followed a systematic multi-stage procedure adapted from bibliometric research guidelines, consisting of identification, screening, eligibility, and bibliometric analysis (Mukhlisa & Hasan, 2024; Sidiq, 2019).

Identification Stage

Literature searches were conducted on June 4, 2025, using search engine Publish or Perish softwere connected to the Google Scholar database. The search strategy employed the following keywords: “digital encyclopedia” OR “e-encyclopedia” OR “web-encyclopedia” AND “science learning”. This initial search yielded 146 publications.

Screening Stage

The retrieved publications were screened using inclusion criteria:

a. Publication year between 2020–2025
b. Focus on digital encyclopedias or electronic encyclopedic media in science or science-related education
c. Written in English or Indonesian, and
d. Published as journal articles.

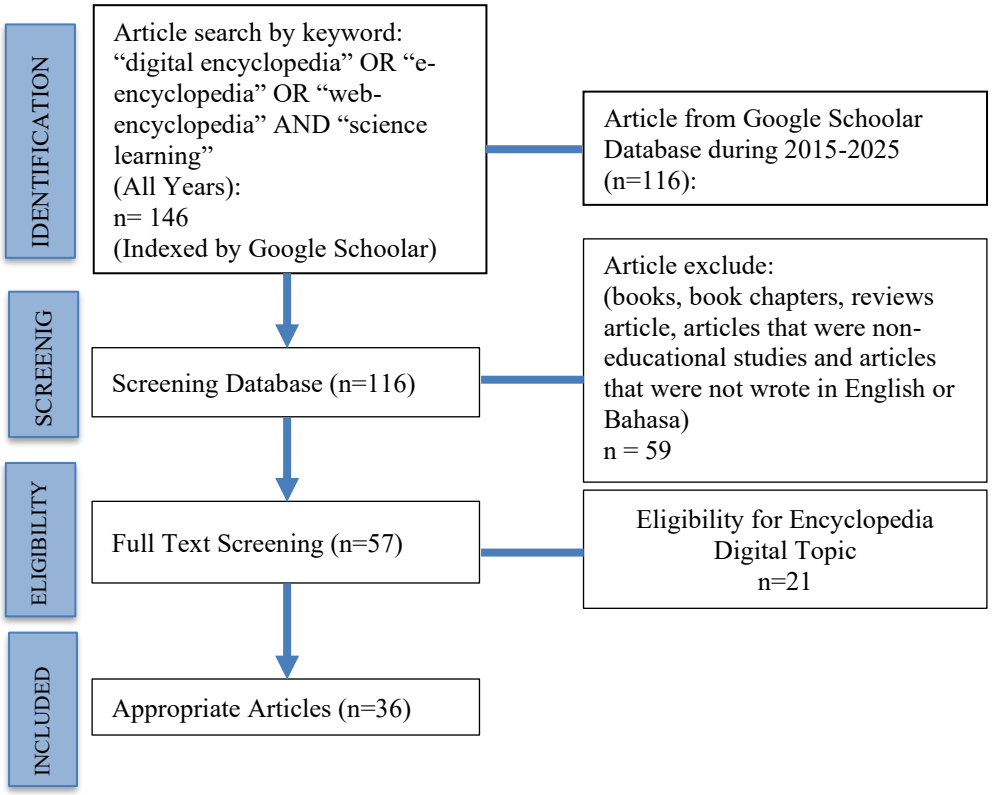
Publications in the form of books, book chapters, review articles, and non-educational studies were excluded. After this stage, 116 articles remained.

Eligibility Stage

Full-text screening was conducted to assess relevance to the research objectives. Articles that explicitly discussed digital encyclopedia development, implementation, effectiveness, or contextual integration in science learning were retained. This process resulted in 36 articles that contained a complete discussion of digital-based encyclopedia in science learning. The final result is synthesized the articles to answer the research questions for final analysis. The data selection was performed using the PRISMA method displayed as follows:

Figure 1.

Article Selection Process Using PRISMA



Bibliometric Analysis Stage

Bibliographic data (titles and abstracts) from the selected articles were exported in RIS format and analyzed using VOSviewer software to identify keyword co-occurrence patterns and thematic clustering.

The overall research procedure is illustrated through sequential stages of database searching, data filtering, full-text screening, and bibliometric visualization.

Research Instruments

Research quality was controlled through a multi-stage screening and eligibility process rather than database indexing alone. Although the initial retrieval was conducted using Publish or Perish connected to Google Scholar, article quality was ensured through strict inclusion criteria. Only peer-reviewed journal articles published between 2020 and 2025 were included, while books, proceedings, review articles, and non-educational studies were excluded. Furthermore, each article was subjected to full-text screening to assess methodological clarity, relevance to digital science encyclopedias, and the presence of explicit research objectives, methods, and findings.

To strengthen quality assurance, priority was given to articles published in reputable national and international journals, including journals indexed in SINTA, Scopus, or other recognized academic databases when available. Articles that lacked methodological rigor or provided insufficient empirical or conceptual contribution were excluded during the eligibility stage. This approach aligns with established SLR practices, which emphasize relevance and methodological transparency over database exclusivity. The combination of systematic screening and bibliometric visualization using VOSviewer enabled a reliable and objective mapping of research trends and thematic structures.

Data Analysis Techniques

Data analysis employed bibliometric co-occurrence analysis focusing on keywords extracted from article titles and abstracts. Using VOSviewer, the analysis produced three types of visualizations: Network Visualization, to identify thematic clusters and relationships among research topics; Overlay Visualization, to examine the temporal development of research themes from 2020 to 2025; and Density Visualization, to determine dominant and less-explored research areas based on keyword frequency and intensity. Interpretation of the visualizations was based on node size, link strength, and color intensity, which reflect the frequency of keyword occurrence and the strength of thematic relationships.

Relevant Methodological Modifications

Unlike conventional SLR studies that rely solely on descriptive synthesis, this study integrated bibliometric visualization analysis to enhance analytical depth and objectivity. Additionally, the inclusion period was extended to 2025 to capture recent developments in digital learning media. This methodological modification allows the study to not only summarize previous findings but also identify research gaps and future directions, particularly regarding the integration of local wisdom and contextual content in digital science encyclopedias.

3. Result and Discussion

A total of 36 peer-reviewed journal articles published between 2020 and 2025 were included in this Systematic Literature Review. Most studies were conducted in the context of science education at the elementary and secondary school levels, with a smaller number focusing on higher education. Methodologically, research and development (R&D) designs dominated the literature, followed by quasi-experimental and descriptive studies. The majority of articles examined digital science encyclopedias as instructional media, focusing on feasibility, effectiveness, or learning outcomes rather than long-term implementation or curricular integration. These characteristics indicate that research in this field is still largely exploratory and product-oriented.

Based on content analysis of the selected studies, four major themes emerged:

Theme 1: Development and Validation of Digital Science Encyclopedias
Most studies focus on the design and validation of digital science encyclopedias as learning media. These studies typically involve expert judgment, usability testing, and small-scale trials to assess feasibility and content accuracy. While results consistently indicate that digital encyclopedias are valid and feasible for classroom use, the emphasis remains on technical quality rather than pedagogical integration or instructional strategy.

Theme 2: Learning Effectiveness and Student Outcomes
A second dominant theme examines the impact of digital encyclopedias on student learning outcomes, including conceptual understanding, scientific literacy, motivation, and problem-solving skills. Findings generally report positive effects; however, most studies rely on short-term interventions and limited sample sizes. This raises questions about the sustainability and transferability of learning gains across contexts and time.

Theme 3: Technological Innovations in Digital Encyclopedias
Several studies highlight innovations such as mobile-based platforms, augmented reality, and web-oriented encyclopedic systems. These innovations reflect a shift from static digital references to interactive and multimedia-rich learning environments. Nevertheless, comparative analyses between different technological approaches are rare, and innovation is often technology-driven rather than grounded in pedagogical theory.

Theme 4: Contextual and Local Wisdom Integration
The least represented theme involves integrating local wisdom, environmental contexts, or regional potential into digital science encyclopedias. Although studies in this category report positive effects on contextual understanding and environmental awareness, their limited number indicates that contextualization remains underexplored. This gap suggests an opportunity for future research to align digital encyclopedias more closely with contextual and culturally responsive learning approaches.

Trends and Innovations in Digital Science Encyclopedias

The synthesis reveals that research trends over the past five years emphasize media development and technological enhancement rather than instructional innovation. While there is growing interest in interactive features and digital platforms, fewer studies investigate how digital encyclopedias function within broader pedagogical frameworks or curricula. Innovation in this field is therefore predominantly technological, with limited attention to pedagogical transformation, teacher practices, or long-term classroom adoption.

Research Gaps and Future Directions

Several research gaps are evident from the synthesis. First, there is a lack of longitudinal studies examining sustained use and learning impact. Second, pedagogical integration and teacher roles in using digital encyclopedias remain underexplored. Third, contextual and local content integration is limited despite its potential relevance to science learning. Addressing these gaps requires future studies that move beyond development and effectiveness testing toward theory-driven, context-sensitive, and curriculum-aligned research.

Bibliometric Visualization as Supporting Analysis

Bibliometric analysis using VOSviewer was conducted to complement the content-based synthesis. Keyword co-occurrence mapping supports the thematic findings by showing high density in development- and student-centered terms, while keywords related to contextual integration and expert collaboration appear less frequently. These visualizations reinforce, rather than replace, the SLR findings and serve as supporting evidence for identifying research gaps.

4. Conclusion

This Systematic Literature Review examines 36 studies published between 2020 and 2025 to identify trends, innovations, and research gaps in digital science encyclopedias for science education. The results indicate that research is largely focused on media development, validation, and short-term learning effectiveness. Innovations primarily involve technological features such as mobile platforms and multimedia integration. However, limited attention is given to pedagogical integration, teacher roles, long-term implementation, and contextual content such as local wisdom. Bibliometric analysis supports these findings by revealing low research density in contextual and collaborative themes. Future studies should adopt theory-driven, longitudinal, and context-sensitive approaches to strengthen the educational contribution of digital science encyclopedias.

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