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MAPPING E-MODULE RESEARCH IN SCIENCE EDUCATION: A BIBLIOMETRIC AND SYSTEMATIC REVIEW

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ABSTRACT

The growing use of digital learning resources has increased scholarly interest in electronic modules (e-modules) for science education. However, the scope of this research, its principal themes, and its geographical and methodological characteristics require systematic synthesis. This study maps research on e-modules in science education by combining a systematic literature review (SLR) with bibliometric analysis. The review followed the four stages of the PRISMA framework and used a search of Scopus conducted on 27 May 2026, supplemented by backward snowballing. The final corpus comprised 35 articles: 24 Scopus-indexed articles used for bibliometric mapping and all 35 articles used for thematic synthesis. Bibliometrix in R and VOSviewer were used to examine publication patterns, contributors, and keyword relationships, while thematic synthesis was used to classify the research focus and identify gaps. The analysis identified seven themes, with critical thinking reported as the most frequent theme in the included corpus. The manuscript also indicates a strong concentration of publications associated with Indonesia; the exact percentage and denominator should be interpreted according to the verified country-level dataset. The review points to the need for broader international collaboration, larger and longitudinal studies, and further investigation of emerging technologies in science e-modules. Because the search was conducted in May 2026, publication counts for 2026 represent partial-year data. The findings provide a structured overview of the reviewed literature rather than a claim of exhaustive coverage of every relevant publication.

Keywords: *E-Module, Science Education, Bibliometrics, Systematic Literature Review, Research Trends.*

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BACKGROUND

Digital technologies have expanded the range of resources available for teaching and learning, including electronic modules designed to support structured and relatively independent study. In science education, e-modules have been developed for different subjects and learning outcomes, including critical thinking, science process skills, scientific literacy, motivation, and learning outcomes. The growth of this literature makes it important to examine not only the number of publications but also the contributors, relationships among research themes, and areas that remain insufficiently investigated.

Previous studies provide relevant but different perspectives on digital learning and science education. For example, Momani et al. (2023) reviewed digital learning in science education, while Syachruroji et al. (2024) mapped broader science-education research trends. Alshammari et al. (2024) examined e-learning research during the COVID-19 pandemic, and Nurbaiti et al. (2026) reviewed interactive e-module development in secondary schools for the 2021–2025 period. These studies provide useful context, but their stated scopes are broader than, or different from, the present study's combined focus on e-module research specifically within science education, contributor and country patterns, keyword co-occurrence, and thematic synthesis of a combined corpus.

The contribution of the present review is therefore defined narrowly: it brings together bibliometric mapping of Scopus-indexed records and a thematic synthesis of those records plus relevant studies identified through backward snowballing. This design enables the study to examine publication and collaboration patterns in the indexed dataset while also considering relevant national studies not retrieved in the Scopus search. The two datasets are not treated as interchangeable: bibliometric indicators are calculated from the 24 Scopus records, whereas thematic synthesis uses all 35 included articles.

The claim that no previous study has addressed this topic comprehensively should not be presented as an absolute statement unless it is supported by a documented search. To substantiate the gap, the authors should report a reproducible supplementary search of relevant review and bibliometric studies, including the databases or platforms searched, search date, search terms, and screening logic. The defensible gap is that the studies identified in the authors' search did not combine the same scope and analytical dimensions used here, rather than that no related study exists.

Accordingly, this study addresses four research questions: (RQ1) How have publication trends in e-module research in science education evolved over the period covered by the search? (RQ2) Which authors, institutions, and countries are most represented in the Scopus-indexed dataset? (RQ3) What themes and keyword clusters characterize the included literature? and (RQ4) What gaps and future research directions can be identified from the reviewed evidence?

RESEARCH METHOD

Research Questions

RQ 1: How have publication trends in e-module development research in science education evolved from 2019 to 2026?

RQ 2: Who are the most productive authors, institutions, and countries

in e-module development research in science education?

RQ 3: What are the dominant research themes and clusters based on keyword co-occurrence analysis?

RQ 4: What are the research gaps and emerging trends that warrant further development?

Search Strategy

This study employs a Systematic Literature Review (SLR) approach modified with bibliometric analysis, following the procedures outlined by Triandini et al. (2019), which encompass the formulation of research questions, literature searching, determination of inclusion and exclusion criteria, article quality assessment, and data collection and analysis. Article quality assessment in this study focuses on thematic relevance and the availability of full-text documents in accordance with the established inclusion and exclusion criteria.

The study selection process follows the four stages of PRISMA: 1) identification, 2) screening, 3) eligibility, and 4) inclusion, applied as a standard framework for article selection. In the identification stage, an article search was conducted on May 27, 2026, using official access to the Scopus database through an institutional account of Universitas Negeri Yogyakarta. Scopus was selected because it is a database proven to have broad coverage, including in the field of education, offering high indexing accuracy and supporting standardized search procedures across all indexed sources. These features ensure data consistency and reliability, which are of paramount importance in bibliometric analysis and scientific mapping (Baas et al., 2020; Donthu et al., 2021).

The search was conducted using the following query string: TITLE-ABS-KEY ("e-module" OR "electronic module" OR "digital module") AND TITLE-ABS-KEY ("science education" OR "science learning" OR "biology education" OR "physics education" OR "chemistry education") AND TITLE-ABS-KEY ("development" OR "design" OR "learning" OR "teaching"). This combination was intended to encompass various terms representing the central theme, namely the relationship between e-module development and science learning. The initial search yielded 85 articles. This was followed by the screening stage. After applying filters for document type (article and review) and language (English), the results were narrowed to 31 documents. Based on full-text screening using the established inclusion and exclusion criteria, 7 articles were excluded, with the following breakdown: 1 article was not a digital e-module (OER), 2 articles were literature reviews, 2 articles were SLR or bibliometric studies, 1 article addressed general e-learning, and 1 article concerned a printed module. Reliance on a single database search potentially risks overlooking relevant articles that are not indexed or that employ different terminology (Wohlin, 2014). Therefore, to supplement the database search results, backward snowballing was conducted by examining the reference lists of the included articles, as recommended by Wohlin (2014). This process yielded 11 additional articles from reputable national journals (SINTA 2) published in Indonesian that were relevant to the research topic but not indexed in the Scopus search results. Subsequently, in the eligibility stage, a comprehensive review of each article's content was conducted. Articles were evaluated against strict inclusion criteria to ensure relevance to empirical studies on e-module development in science education. The selection process resulted in 35 selected articles (24 articles from Scopus and 11 articles from snowballing), which constitute the primary

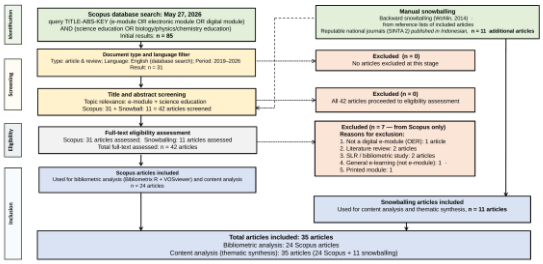
focus of analysis in this study. Although the dataset is relatively small, this reflects the nascent and emerging stage of science e-module bibliometric research. The strict application of inclusion criteria ensured that only highly relevant and rigorous studies were included, thereby maintaining analytical quality over quantity. Furthermore, the addition of snowballing ensured comprehensive coverage of reputable national publications not indexed in Scopus. The inclusion and exclusion criteria are presented in Table 1 below:

Table 1. Inclusion and Exclusion Criteria

Aspect	Inclusion Criteria	Exclusion Criteria
Document type	Peer-reviewed journal articles	Conference proceedings, book chapters, theses
Language	English (database search) and Indonesian (snowballing)	Other than English and Indonesian
Topic	Development, implementation, or effectiveness of science e-modules	Outside the scope of science e-module development
Context	Science education (general science, physics, biology, chemistry, or applied sciences)	Outside the context of science education
Period	2019–2026	Outside the specified year range
Availability	Full text available	Abstract only or inaccessible

The article selection process is presented through a PRISMA diagram, as illustrated in Figure 1.

Figure 1. PRISMA Diagram



Sources: (Baas et al., 2020; Page et al., 2021; Triandini et al., 2019; Wohlin, 2014).

Data Analysis

Data analysis was conducted quantitatively through bibliometric analysis and qualitatively through thematic synthesis. Bibliometric analysis employed the Bibliometrix package in R (Aria and Cuccurullo, 2017) to generate statistical indicators, including annual publication trends, the most productive authors and institutions, country distribution, and the most cited articles. Network visualization was performed using VOSviewer to produce keyword co-occurrence maps, inter-country co-authorship networks, and research theme clusters (van Eck and Waltman, 2010). In this study, the two data sources served distinct analytical purposes. The 24 Scopus-indexed articles were used exclusively for bibliometric analysis due to their standardized and complete bibliographic metadata, which is a prerequisite for quantitative mapping (Baas et al., 2020; Donthu et al., 2021). The 11 articles obtained through snowballing, published in reputable Indonesian national journals (SINTA 2), were incorporated into the thematic synthesis to ensure comprehensive coverage of relevant national studies not indexed in Scopus (Wohlin, 2014). All 35 articles, comprising 24 Scopus articles and 11 articles obtained through snowballing, were utilized for thematic synthesis to identify dominant themes and research gaps in e-module development within science education (Donthu et al., 2021). The entirety of this analysis was designed to address all four research questions, ranging from mapping publication trends and identifying key contributors, to mapping research themes and identifying gaps and future research directions.

RESULTS AND DISCUSSION

Publication Trends of E-Module Research in Science Education (RQ1)

To address RQ1, an analysis of annual publication trends was conducted on 24 Scopus-indexed articles meeting the inclusion criteria. The results of the publication trend analysis are presented in Figure 2.

Figure 2. Annual Scientific Production of e-module research in science education for the period 2019–2026

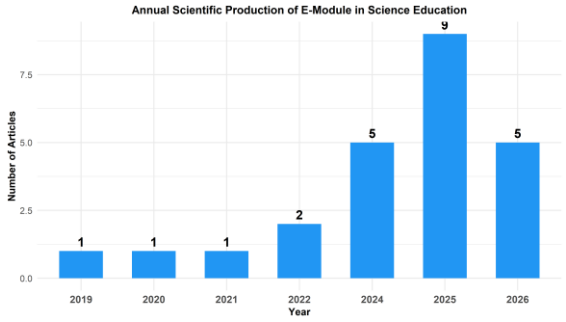


Figure 2 illustrates that research on e-module development in science education experienced growth over the period 2019–2026, with an annual growth rate of 25.85%. During the 2019–2022 period, the number of publications was relatively low and stable, ranging from 1 to 2 articles per year. No publications were identified in 2023. A significant surge occurred in 2024 with 5 articles, reaching its peak in 2025 with 9 articles, before remaining high in 2026 with 5 articles.

This growth pattern is consistent with the findings of Cahyani and Aminudin (2025), who identified the COVID-19 pandemic as a crucial turning point that compelled and accelerated digital transformation across all sectors of education globally. In the Indonesian context, Fuadiy et al. (2025) explain that the surge in post-pandemic digital education research was also driven by the Merdeka Belajar policy, which emphasizes digital integration in learning, thereby stimulating academic interest in the development of digital teaching materials such as e-modules. These findings are further consistent with the bibliometric analysis of e-learning by Owan et al. (2026), which demonstrated that e-learning research grew by 25.43% per year with a significant surge after 2020, reflecting the massive global digital education reform in the post-pandemic era. The absence of publications in 2023 likely reflects a post-pandemic adaptation gap before digitally-based development research surged significantly again in 2024–2025 (Alshammari et al., 2024).

E-module research in science education in Indonesia can be traced back to Astalini et al. (2019), who pioneered the field by integrating e-modules and e-assessment in mobile learning-based science education. The publication surge in 2025–2026 is reflected in the emergence of innovative studies, such as M. Simbolon et al. (2025), who integrated artificial intelligence into digital science modules, and T. Priyani et al. (2026), who developed inquiry-based e-modules within a local context.

Most Productive Authors, Institutions, and Countries (RQ2)

To address RQ2, an analysis was conducted on the productivity of authors, institutions, and countries, as well as the identification of source journals and the most cited articles from the 24 Scopus-indexed articles. The results of the analysis are presented in Figure 3, Figure 4, and Figure 5.

Figure 3. Most Productive Authors

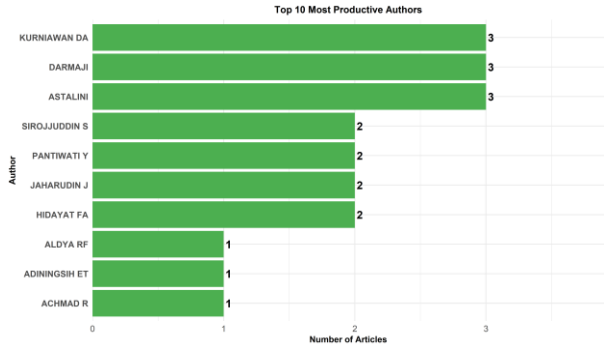
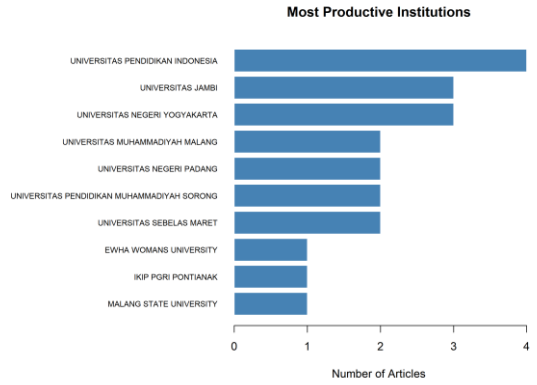


Figure 3 demonstrates that Kurniawan DA, Darmaji, and Astalini are the most productive authors, each contributing 3 articles, followed by Sirojjuddin S, Pantiwati Y, Jaharudin J, and Hidayat FA, each with 2 articles. All of the most productive authors are affiliated with institutions in Indonesia, particularly Universitas Jambi. The average number of co-authors per document is 5.33, with an international co-authorship rate of 12.5%. The dominance of Indonesian authors reflects that e-module research in science education constitutes an active research agenda among Indonesian academics, in line with the increasing demand for indexed scientific publications driven by the SINTA policy (Fry et al., 2023).

Figure 4. Most Productive Institutions



Based on the affiliation analysis per article presented in Figure 4, Universitas Pendidikan Indonesia (UPI) is the most productive institution, contributing to 4 articles, followed by Universitas Jambi and Universitas Negeri Yogyakarta (UNY), each contributing to 3 articles. Universitas Muhammadiyah Malang (UMM), Universitas Negeri Padang (UNP), Universitas Pendidikan Muhammadiyah Sorong, and Universitas Sebelas Maret (UNS) each contributed to 2 articles. The dominance of Indonesian institutions reflects that e-module development in science education constitutes an active research agenda among Indonesian higher education institutions.

The high productivity of UPI, Universitas Jambi, and UNY in e-module research is inseparable from the strategic role of these three institutions as Teacher Training and Education Institutions (Lembaga Pendidikan Tenaga Kependidikan/LPTK), which consistently promote innovation in digital teaching material development. This is consistent with the findings of Yudhoyono et al. (2025), who explain that higher education institutions in Indonesia, particularly LPTKs, serve as the primary drivers in producing practice-oriented educational research. Furthermore, the distribution of institutions spanning from Java to Papua, as exemplified by Universitas Pendidikan Muhammadiyah Sorong, indicates that interest in science e-module development is not solely concentrated on the island of Java, but is beginning to expand across various regions of Indonesia. Nevertheless, the absence of significant international cross-institutional collaboration suggests that the science e-module research network in Indonesia remains predominantly local and needs to be expanded through international research partnerships (Fuadiy et al., 2025).

Figure 5. Country Distribution and Most Cited Articles

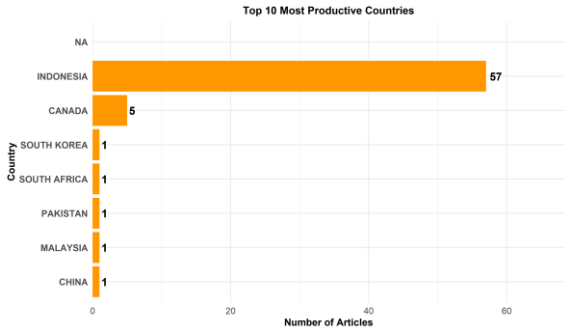


Figure 5 demonstrates that Indonesia dominates publications with 17 articles (89.5%), far surpassing Canada and South Africa, each contributing only 1 article (5.26%). Indonesia's dominance is consistent with the general trend in which Indonesia has experienced a dramatic increase in science education publications since 2017, and aligns with Indonesia's strategic Vision 2045 agenda, which places investment in educational research as a national priority (Muchson et al., 2024; Yudhoyono et al., 2025). Nevertheless, the high dominance of a single country indicates that international collaboration in science e-module research still needs to be expanded (Fuadiy et al., 2025).

The total citations from Indonesia reached 105 citations, with an average of 6.18 citations per article. The most cited article is Astalini et al. (2019) with 48 citations, followed by Dewi et al. (2022) with 29 citations, and Astalini et al. (2022) with 7 citations. The high citation counts of Astalini et al. (2019) and Dewi et al. (2022) indicate that research on mobile learning and Android-based e-modules in the context of science learning has become an important reference for subsequent researchers. Meanwhile, articles by M. I. Thobejane et al. (2026) from South Africa and M. Kates et al. (2026) from Canada suggest that science e-module research is beginning to develop beyond Indonesia, albeit with still very limited contributions.

Dominant Research Themes and Clusters (RQ3)

To address RQ3, two types of analysis were conducted. First, keyword co-occurrence analysis and thematic mapping were performed using VOSviewer and Biblioshiny on the 24 Scopus-indexed articles. Second, manual thematic synthesis was carried out on all 35 included articles to identify dominant research themes.

Figure 6. Keyword co-occurrence map of e-module research in science education



Figure 6 presents a thematic map based on keyword co-occurrence analysis, forming two main clusters. The first cluster is centered on e-module as the central node with the highest number of connections, linked to mobile learning, critical thinking, educational technology, science learning, and case-based learning. This indicates that e-module research is predominantly associated with the utilization of educational technology and the development of higher-order thinking skills. The second cluster is situated on the right side of the map, connecting science process skills with inquiry-based learning, science attitude, learning outcomes, motivation, and the node e-modules. This indicates the presence of a research group focused on measuring students' process skills and learning outcomes in the context of inquiry-based learning. Both clusters are connected through a pathway that traverses science

process skills, suggesting that science process skills serve as a bridge between e-module development and the measurement of learning outcomes. These findings are consistent with Antonio and Prudente (2024), who demonstrated through meta-analysis that inquiry-based approaches are effective in enhancing higher-order thinking skills in science learning, including science process skills, which constitute the primary focus of the second cluster.

Table 2. Summary of E-Module Research Themes in Science Education (n=35)

No	Theme	F	Sample Articles
1	*Critical Thinking*	11	Suryawati et al. (2024); (+10 others)
2	*Science Process Skills*	6	Priyani et al. (2026); (+5 others)
3	*Creative Thinking*	6	Nurita et al. (2025); (+5 others)
4	*Scientific Literacy*	5	Thobejane et al. (2026); (+4 others)
5	Motivation & Learning Outcomes	4	Astalini et al. (2019); (+3 others)
6	21st-Century Skills	4	Desnita et al. (2025); (+3 others)
7	Development & Others	7	Astalini et al. (2024); (+6 others)
Total		**35**	

The results of the manual thematic synthesis conducted on all 35 included articles, comprising 24 Scopus articles and 11 articles obtained through snowballing, reveal seven research themes as presented in Table 2. The critical thinking theme dominates with 11 articles, followed by the development and other themes with 7 articles, science process skills and creative thinking with 6 articles each, scientific literacy with 5 articles, and motivation and learning outcomes as well as 21st-century skills with 4 articles each.

The dominance of the critical thinking theme is reflected in a number of studies that consistently demonstrate the effectiveness of e-modules in enhancing students' critical thinking skills, including Cynthia et al. (2023) in physics learning and Liana et al. (2022) in junior secondary science learning. These findings are consistent with Sujatmika et al. (2024), who identified a significant increase in critical thinking research in science education over the past decade, as well as Gürbüz and Aşiksoy (2023), who affirmed critical thinking as a primary 21st-century competency. This is further consistent with Nurbaiti et al. (2026), who identified critical thinking as the most frequently measured dependent variable in interactive e-module research.

The remaining themes also demonstrate significant contributions. The science process skills theme is represented by Hamidi et al. (2024) and T. Priyani et al. (2026), who demonstrated that PBL and inquiry-based e-modules are effective in enhancing students' science process skills. The creative thinking theme is reflected in the work of Wulansari et al. (2023) and Fahru et al. (2024), who developed STEM-based and Flip-PDF-based e-modules. The scientific literacy theme is represented by Oktarina et al. (2023) and M. I. Thobejane et al. (2026), while the 21st-century skills theme is represented by Fitri and Asrizal (2023) and B. Setiaji et al. (2025).

Figure 7. Thematic map of e-module research in science education

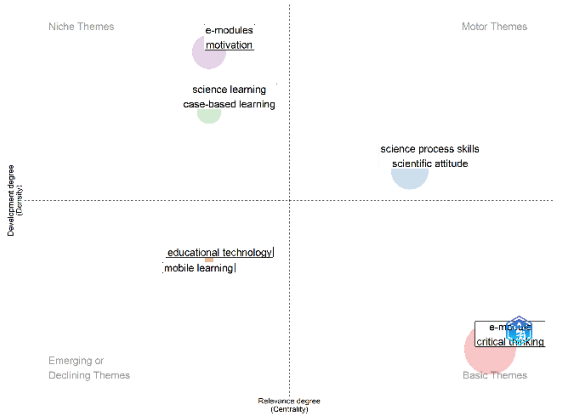


Figure 7 presents the results of the thematic map analysis using Biblioshiny from 24 Scopus articles, distributing themes across four quadrants. The motor themes quadrant is occupied by science process skills and scientific attitude, indicating that these two themes are the most central and actively developed, consistent with the findings of Hamidi et al. (2024) and T. Priyani et al. (2026). Niche themes include e-modules, motivation, science learning, and case-based learning, which tend to remain isolated. Basic themes are occupied by e-module and critical thinking, indicating that despite their dominance in frequency, their development tends to be stagnant and requires more innovative approaches (Gürbüz and Aşiksoy, 2023). Emerging or declining themes include mobile learning and educational technology, which demonstrate a declining trend. The divergence in results between manual thematic synthesis and the thematic map is expected, given the differences in approach and data sources, and thus both analyses are mutually complementary. The positioning of mobile learning in the declining quadrant indicates that the integration of cutting-edge technologies such as artificial intelligence in science e-modules remains limited and presents a promising avenue for future research (M. Simbolon et al., 2025; Zhu et al., 2025).

Research Gaps and Future Trends (RQ4)

Based on the thematic synthesis of the 35 included articles, several research gaps were identified. The first pertains to the extremely high geographical dominance, with 89.5% of articles originating from Indonesia, indicating that science e-module research has yet to develop on a global scale. International collaboration remains highly limited, as evidenced by only two articles originating from outside Indonesia, namely M. I. Thobejane et al. (2026) from South Africa and M. Kates et al. (2026) from Canada, while research from Southeast Asia, Latin America, and the Middle East is nearly absent (Muchson et al., 2024). This geographical concentration limits the generalizability of findings, as conclusions drawn predominantly from Indonesian contexts may not be directly applicable to other educational systems with different curricula, technological infrastructure, and pedagogical cultures.

Second, from a methodological standpoint, the majority of studies employ conventional development models such as ADDIE and 4D on a small scale involving a single class or school. Large-scale and longitudinal studies measuring the long-term impact of e-modules on learning outcomes remain highly limited (Winangun et al., 2024). The absence of such studies weakens the evidence base for policy recommendations regarding e-module integration in national science curricula. Third, the integration of cutting-edge technologies in science e-modules is still minimal; of the 35 articles analyzed, only M. Simbolon et al. (2025) integrated artificial intelligence in digital module development, while augmented reality-based development and adaptive learning have yet to be explored (Zhu et al., 2025).

Fourth, the thematic map results indicate that critical thinking is positioned in the basic themes quadrant, dominant in frequency yet stagnant in development, suggesting the need for more innovative and diverse approaches to integrating critical thinking into science e-modules (Gürbüz and Aşiksoy, 2023). Based on these identified gaps, future research directions in science education e-module development should be oriented toward: (1) the expansion of cross-national international collaboration, (2) large-scale and longitudinal research, (3) the integration of cutting-edge technologies such as AI and AR, and (4) the development of more innovative thematic approaches that transcend the dominance of critical thinking.

CONCLUSION

This study examined e-module research in science education by combining bibliometric analysis of 24 Scopus-indexed articles with thematic synthesis of a 35-article corpus that also included 11 studies identified through backward snowballing. In response to RQ1, the retrieved Scopus records show a rise in publication activity in the later years of the review period; however, the annual growth rate should be reported only after its calculation has been verified, and 2026 must be treated as partial-year data. In response to RQ2, the author, institutional, and country patterns indicate a strong Indonesian presence in the included literature, but the country percentage must be recalculated using a clearly stated denominator and counting method. In response to RQ3, the keyword analysis identifies connected research clusters around e-modules and science-learning outcomes, while the manual synthesis identifies critical thinking as a frequently addressed theme, subject to clarification of the coding procedure and theme-count denominator. In response to RQ4, the reviewed studies suggest opportunities to expand international collaboration, strengthen large-scale and longitudinal evaluation, and investigate emerging technologies in science learning.

These implications should be interpreted in light of the study's limitations. The bibliometric dataset was restricted to Scopus-indexed articles retrieved with the specified search string, the snowballing component was limited to studies found through reference lists, and the search was conducted before the end of 2026. The findings therefore map the literature captured by this procedure rather than all research worldwide on science e-modules. Future reviews could search additional databases, document the snowballing procedure in greater detail, and use a reproducible coding protocol to compare themes across countries, educational levels, and technologies.

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