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Research Trends in The Utilization of E-Modules in Science Learning: A Systematic Literature Review

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Abstract: This study aims to systematically map research trends in the utilization of e-modules in science learning from 2020 to 2024. This study employed a Systematic Literature Review (SLR) approach following PRISMA guidelines to ensure a transparent and systematic selection process. Data were collected from the Scopus database, resulting in 261 identified articles, of which 20 empirical studies were selected through identification, screening, eligibility, and inclusion stages. The results show that the dominant research focus is development based on learning models (75.00%), with Problem-Based Learning as the most frequently used model (35.00%). In terms of learning outcomes, higher-order thinking skills (60.00%) and critical thinking skills (40.00%) are the most widely examined variables, while affective aspects remain underexplored. Technology integration is dominated by interactive multimedia (40.00%) and Android-based platforms (20.00%). However, the findings also reveal several gaps, including limited attention to affective outcomes, lack of methodological rigor, and insufficient consideration of contextual factors such as teacher readiness and digital equity. These findings highlight the need for more comprehensive, rigorous, and context-sensitive research to support sustainable digital learning in science education.

Keywords: Digital module; E-module; Science learning, Systematic literature review

Introduction

The rapid advancement of digital technology in the 21st century has significantly transformed the paradigm of science learning, shifting it from conventional teacher-centered approaches toward more interactive, adaptive, and student-centered learning environments. This transformation not only expands access to diverse learning resources but also encourages the integration of digital tools that support meaningful and contextual learning experiences. In this context, electronic modules (e-modules) have emerged as an innovative digital learning medium that provides structured, flexible, and self-accessible learning materials, enabling students to actively construct their understanding of scientific concepts (Heliawati et al., 2022; Widodo et al., 2020).

In recent years, the integration of e-modules in science learning has increased significantly, in line with the growing demand for 21st-century competencies such as critical thinking, problem-solving, and scientific literacy. Previous studies have shown that e-modules integrated with pedagogical approaches such as Problem-Based Learning (PBL), STEM Education, and inquiry-based learning are effective in enhancing higher-order thinking skills and conceptual understanding (Dalaila et al., 2022; Kusumaningtyas et al., 2024; Priyadi & Arsyad, 2023; Uslan et al., 2024). In addition, the use of digital technologies such as interactive multimedia and mobile-based platforms has further strengthened the role of e-modules in creating engaging and accessible learning environments (Asrizal et al., 2024; Dewi et al., 2022; Okterina et al., 2025).

However, the rapid increase in the number of publications related to e-modules has created a fragmented body of knowledge, making it difficult to identify consistent research patterns, dominant themes, and future research directions. The growing volume of studies has also led to information overload, which

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challenges researchers and practitioners in synthesizing relevant findings. Although several studies have attempted to examine research trends using bibliometric analysis (Oktarina et al., 2023) and systematic literature reviews in specific contexts (Yanti et al., 2025), these studies are limited in scope and do not provide a comprehensive and integrative understanding of the overall research landscape.

More specifically, previous studies have not simultaneously analyzed multiple important dimensions, such as research focus, learning models, outcome variables, technology integration, and research gaps within a single analytical framework. As a result, there is still a lack of holistic understanding of how e-module research in science learning has evolved and what directions should be prioritized in future studies. This limitation highlights the need for a more comprehensive synthesis that goes beyond partial or descriptive analyses.

Therefore, this study aims to systematically map research trends in the utilization of e-modules in science learning from 2020 to 2024 using a Systematic Literature Review (SLR) approach based on PRISMA guidelines (Page et al., 2021). This study is among the first to provide an integrated and comprehensive thematic synthesis by combining multiple analytical dimensions, including research focus, learning models, outcome variables, technology integration, and research gaps within a single framework. By synthesizing empirical findings from selected studies, this research seeks to identify dominant patterns, analyze methodological tendencies, and uncover critical gaps that can inform future research directions. The findings of this study are expected to contribute to the development of more effective, inclusive, and sustainable digital learning practices in science education.

Method

This study employed a Systematic Literature Review (SLR) approach to systematically identify, evaluate, and synthesize relevant studies on the utilization of e-modules in science learning. The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, rigor, and reproducibility in the selection and analysis of articles (Liberati et al., 2009; Page et al., 2021). The use of PRISMA in this study provides a structured framework that enhances the credibility and methodological validity of the review process.

The literature search was conducted using the Scopus database, which was selected due to its comprehensive coverage of high-quality peer-reviewed international publications. The search process was carried out in the first week of October 2025, and this retrieval date was specified to ensure clarity and avoid potential bias related to database indexing updates. The search employed a combination of Boolean operators and keywords, including "e-module" OR "digital module" OR "online module" AND "science learning," to ensure comprehensive and relevant search results.

The article selection process followed four main stages of PRISMA: identification, screening, eligibility, and inclusion. The initial search yielded 261 records. Since the search was conducted within a single database (Scopus), no duplicate articles were identified.

In the screening stage, articles were filtered based on predefined inclusion criteria, including publication type (peer-reviewed journal articles), language (English), and publication period (2020–2024). The selection of this time range was intended to ensure the relevance and currency of the analyzed studies in accordance with recent developments in digital learning. At this stage, 129 articles were excluded because they did not meet these criteria, resulting in 132 articles for further evaluation.

At the eligibility stage, a more rigorous selection was conducted through full-text analysis. Articles were excluded if they did not explicitly focus on the implementation of e-modules in science learning, did not contain empirical data, or were categorized as conceptual papers, literature reviews, or theoretical studies. A substantial number of articles (n = 112) were excluded at this stage due to these strict inclusion criteria. Many of these articles discussed general digital learning, focused on non-science subjects, or lacked empirical validation of e-module implementation. This rigorous filtering process is essential in SLR studies to ensure that only highly relevant and methodologically appropriate studies are included in the final synthesis.

As a result, a total of 20 empirical articles were included in this study. The inclusion and exclusion criteria are summarized in Table 1. Furthermore, the overall article selection process is illustrated in the PRISMA flow diagram (Figure 1) to provide a clear and transparent representation of each stage of the review process.

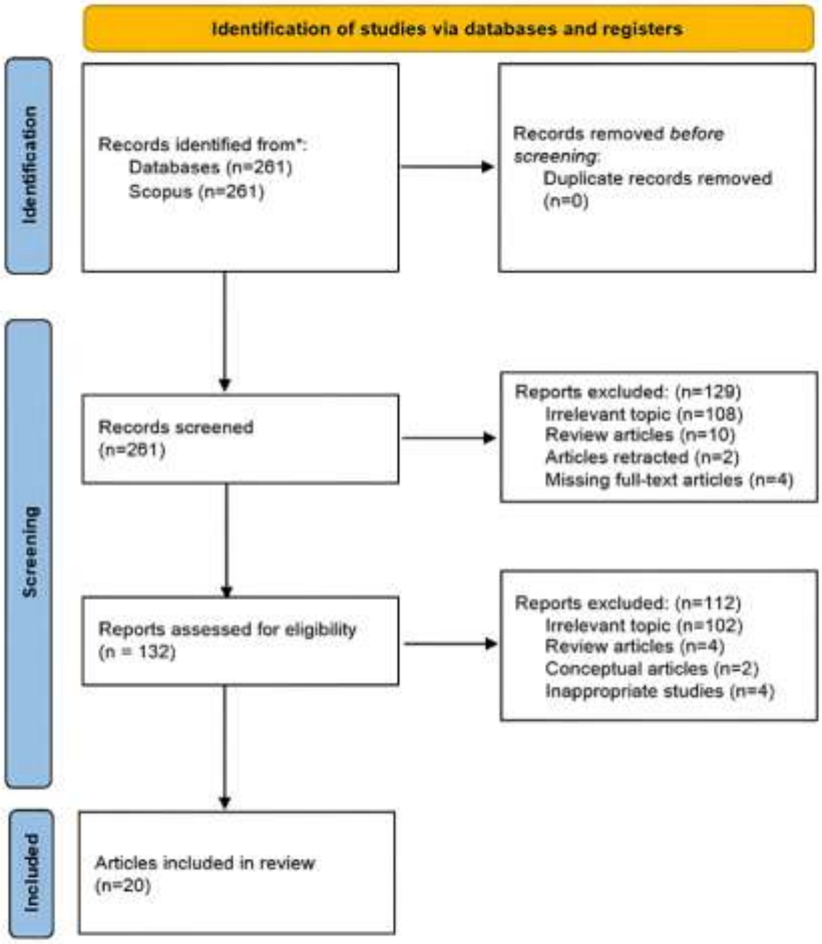

Figure 1. Systematic literature review procedure

Table 1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
Empirical research articles published in peer-reviewed indexed journals	Conceptual, literature review, or theoretical articles published in proceedings or book chapters
Articles indexed in Scopus database	Articles not indexed in Scopus
Articles published between 2020 and 2024	Articles published before 2020
Articles written in English	Articles written in languages other than English
Articles available in full-text format	Articles available only in abstract form or incomplete
Articles explicitly discussing e-module research trends in science learning	Articles only discussing e-modules or not focusing on science learning

The inclusion and exclusion criteria in Table 1 are designed to ensure that only articles with high relevance and adequate scientific quality are analyzed in this study. Articles included in the inclusive criteria encompass empirical research that has undergone peer review and been published in indexed journals, specifically in the Scopus database, with a publication period between 2020 and 2024. The selection of this time range is intended to ensure the currency of research findings and alignment with the latest developments in the field of e-module development in science learning. Additionally, only English-language articles available in full-text format are included, to enable in-depth analysis of the methodology, results, and discussions presented. The selected articles must also explicitly discuss e-module development trends focused on science learning, thereby aligning with the objectives of this research. Conversely, articles categorized under exclusion criteria include conceptual works, literature reviews, book chapters, or proceedings that have not undergone peer review. Articles not indexed in Scopus, published before 2020, written in languages other than English, or available only in abstract form are also excluded from analysis. Similarly, articles focusing on e-modules outside the context of science learning are not considered.

Result and Discussion

This systematic literature review yielded comprehensive findings regarding e-module research trends in science learning during the 2020-2024 period. Through thematic analysis of 20 articles that passed the PRISMA selection stages, six main areas of focus in research were identified: development based on learning models, enhancement of higher-order thinking skills, scientific literacy, technology integration, learning effectiveness, and local contextualization. These findings provide a comprehensive picture of how e-module research in science learning has developed and in what direction this research is moving.

Table 2 presents the distribution of e-module research focus in science learning based on frequency of occurrence and author contributions. This categorization was obtained through thematic analysis of the 20 selected articles.

Table 2. Research Focus of E-Modules in Science Learning

Research Focus	Frequency	Percentage(%)	Authors
Development based on learning models	15	75	(Asrizal et al., 2024; Astalini et al., 2024; Chen et al., 2024; Desnita et al., 2022; P. S. Dewi & Kuswanto, 2023; Hardeli et al., 2023; Kuit & Osman, 2021; Pertiwi et al., 2024; Rusli et al., 2024; Sedayu et al., 2024; Sujanem & Suwindra, 2023; Sulistyana et al., 2023; Tobing et al., 2022; Yerimadesi et al., 2023)
Enhancement of higher-order thinking skills	12	60	(Asrizal et al., 2024; Astalini et al., 2024; Desnita et al., 2022; P. S. Dewi & Kuswanto, 2023; Hardeli et al., 2023; Pertiwi et al., 2024; Rusli et al., 2024; Sedayu et al., 2024; Sujanem & Suwindra, 2023; Sulistyana et al., 2023; Tobing et al., 2022; Yerimadesi et al., 2023)
Scientific literacy and conceptual understanding	6	30	(Asfiya et al., 2024; Asrizal et al., 2024; Pertiwi et al., 2024; Susanta et al., 2022; Winangun et al., 2024; Yuliatun et al., 2024)
Digital technology integration	8	40	(Asfiya et al., 2024; Asrizal et al., 2024; Chen et al., 2024; C. A. Dewi et al., 2022; P. S. Dewi & Kuswanto, 2023; Kuit & Osman, 2021; Winangun et al., 2024; Yuliatun et al., 2024)
Effectiveness on learning outcomes	11	55	(Asfiya et al., 2024; Astalini et al., 2024; Chen et al., 2024; Desnita et al., 2022; Hardeli et al., 2023; Kuit & Osman, 2021; Pertiwi et al., 2024; Rusli et al., 2024; Sedayu et al., 2024; Sulistyana et al., 2023; Tobing et al., 2022)
Local contextualization and wisdom	6	30	(Asfiya et al., 2024; Asrizal et al., 2024; P. S. Dewi & Kuswanto, 2023; Susanta et al., 2022; Winangun et al., 2024; Yuliatun et al., 2024)

Table 2 shows that the greatest attention is directed toward the development of e-modules based on learning models, with 15 articles (75%) examining this theme. This indicates a paradigm shift from merely developing digital media to more complex pedagogical integration. Higher-order thinking skills became the second focus with 12 articles (60%), reflecting awareness of the importance of developing 21st-century competencies through e-modules. Learning effectiveness received attention from 11 articles (55%), indicating that empirical validation of e-module impact remains a research priority.

Learning Models Integrated in E-Modules

Table 3 presents the distribution of learning models frequently integrated in e-module development for science learning, along with main characteristics and supporting references.

Table 3. Distribution of Learning Models in Science E-Module Development

Learning Model	Articles	Percentage (%)	Main Characteristics	Authors
Problem Based Learning (PBL)	7	35	Contextual problem-based learning, promoting problem-solving and scientific reasoning	(Astalini et al., 2024; Desnita et al., 2022; Hardeli et al., 2023; Pertiwi et al., 2024; Rusli et al., 2024; Sedayu et al., 2024; Sujanem & Suwindra, 2023)
Discovery Learning	5	25	Discovery-based learning, students construct knowledge through independent investigation	(Dewi et al., 2022; Hardeli et al., 2023; Sulistyana et al., 2023; Tobing et al., 2022; Yerimadesi et al., 2023)
STEM Education	4	20	Integration of Science, Technology, Engineering, Mathematics for interdisciplinary learning	(Asrizal et al., 2024; Chen et al., 2024; Dewi & Kuswanto, 2023; Pertiwi et al., 2024)

Learning Model	Articles	Percentage (%)	Main Characteristics	Authors
Guided Inquiry	3	15	Guided inquiry learning with teacher scaffolding	(Asfiya et al., 2024; Sulistyana et al., 2023; Winangun et al., 2024)
Contextual Teaching Learning (CTL)	2	10	Contextual learning connecting material to real life	(Desnita et al., 2022; Susanta et al., 2022)
Blended Learning	1	5	Combination of online and offline learning	(Sujanem & Suwindra, 2023)

Table 3 illustrates that Problem Based Learning (PBL) dominates with 7 articles (35%), followed by Discovery Learning with 5 articles (25%), and STEM Education with 4 articles (20%). The dominance of PBL indicates researchers' preference for learning approaches that emphasize contextual problem-solving. These models are selected due to their suitability with the characteristics of science learning that emphasize scientific processes, investigation, and concept application in real life (Pertiwi et al., 2024; Rusli et al., 2024; Sari & Wiyono, 2025; Sedayu et al., 2024).

Outcome Variables Examined in E-Module Research

Table 4 presents the categorization of outcome variables that become the focus of measuring e-module impact in science learning, showing the diversity of aspects evaluated by researchers.

Table 4. Outcome Variables in Science E-Module Research

Variable Category	Specific Variable	Frequency	Authors
Cognitive Skills	Critical Thinking Skills	8	(Asrizal et al., 2024; Astalini et al., 2024; Desnita et al., 2022; P. S. Dewi & Kuswanto, 2023; Pertiwi et al., 2024; Rusli et al., 2024; Sedayu et al., 2024; Sujanem & Suwindra, 2023)
	Creative Thinking Skills	4	(Asrizal et al., 2024; Astalini et al., 2024; Desnita et al., 2022; Sedayu et al., 2024)
	Higher Order Thinking Skills	5	(Hardeli et al., 2023; Pertiwi et al., 2024; Rusli et al., 2024; Tobing et al., 2022; Yerimadesi et al., 2023)
Literacy and Competence	Scientific Literacy	6	(Asfiya et al., 2024; Asrizal et al., 2024; Pertiwi et al., 2024; Susanta et al., 2022; Winangun et al., 2024; Yuliatun et al., 2024)
	Digital Literacy	3	(Asfiya et al., 2024; Chen et al., 2024; C. A. Dewi et al., 2022; P. S. Dewi & Kuswanto, 2023)
	Communication Skills	2	(Asrizal et al., 2024; P. S. Dewi & Kuswanto, 2023)
Conceptual Understanding	Conceptual Understanding	7	(Asfiya et al., 2024; Asrizal et al., 2024; Chen et al., 2024; Hardeli et al., 2023; Kuit & Osman, 2021; Pertiwi et al., 2024; Yuliatun et al., 2024)
Affective Aspects	Self-Efficacy	2	(Astalini et al., 2024; Sedayu et al., 2024)
	Curiosity & Perseverance	1	(Astalini et al., 2024)
	Argumentation Skills	1	(Astalini et al., 2024)

Table 4 reveals that critical thinking skills are the most frequently studied outcome variable, appearing in 8 articles. This aligns with the 21st-century curriculum that emphasizes the development of higher-order thinking skills. Conceptual understanding ranks second with 7 articles, indicating that despite pedagogical innovations developing, conceptual mastery remains a priority in science learning. Scientific literacy appears in 6 articles, reflecting awareness of the importance of preparing students to face science-based challenges in daily life.

Technology Integration in Science E-Modules

Table 5 describes various forms of technology integration applied in e-module development, showing trends in digital technology utilization.

Table 5. Technology Integration in Science Learning E-Modules

Technology Type	Application Description	Frequency	Percentage(%)	Authors
Interactive Multimedia	Combination of video, animation, and interactive simulation	8	40	(Asrizal et al., 2024; Astalini et al., 2024; Desnita et al., 2022; Rusli et al., 2024; Sujanem & Suwindra, 2023; Sulistyana et al., 2023; Winangun et al., 2024; Yerimadesi et al., 2023)

Technology Type	Application Description	Frequency	Percentage(%)	Authors
Android-Based Platform	Mobile application-based e-module for flexible access	4	20	(Asfiya et al., 2024; Chen et al., 2024; C. A. Dewi et al., 2022; Yuliatun et al., 2024)
Virtual Experiments	Virtual laboratory simulation for practical work	3	15	(Asfiya et al., 2024; C. A. Dewi et al., 2022; Yuliatun et al., 2024)
Augmented Reality	3D visualization of abstract chemistry and physics concepts	2	10	(P. S. Dewi & Kuswanto, 2023; Kuit & Osman, 2021)
Web-Based E-Module	Web-based platform with online access	2	10	(Pertiwi et al., 2024; Susanta et al., 2022)
OER (Open Education Resource)	Integrated open learning resources	1	5	(Sedayu et al., 2024)

Table 5 shows that interactive multimedia is the most widely integrated technology (8 articles, 40%), followed by Android-based platforms (4 articles, 20%). Interestingly, emerging technologies such as Augmented Reality and virtual experiments have begun to receive attention, although still limited (2-3 articles). This indicates a transition from simple text-based digital e-modules toward more immersive and interactive learning media.

Gaps and Limitations in Current Research

Table 6 identifies the main gaps found through systematic analysis of the 20 articles, providing a roadmap for future research.

Table 6. Identification of Research Gaps in E-Module Studies

Gap Aspect	Description	Frequency	Findings
Methodological Limitations	Dominance of R&D design (60%) with pre-experimental approaches; lack of longitudinal studies and randomized controlled trials	12 R&D articles	Causal validity of effectiveness claims remains weak Limited generalizability due to threats to internal validity Rigorous experimental designs are needed Long-term impact studies are absent
Limited Geographic Coverage	85% of studies from Indonesia; minimal cross-national comparative studies	17 Indonesian articles	Contextual perspectives limited to Indonesian settings Cross-cultural and cross-educational system validation not conducted International collaboration remains very limited Findings may be context-specific and difficult to generalize
Focus on Product Development	75% focus on development and validation stages; insufficient exploration of long-term implementation	15 articles at validation stage	Gap between product development and sustained adoption Minimal data on implementation sustainability Institutionalization mechanisms not explored Studies terminate at validation without implementation follow-up
Limited Comparative Studies	Minimal studies comparing effectiveness of various pedagogical models or technologies in e-modules	2 comparative articles	Best practices in e-module design difficult to identify Evidence for informed decision-making very limited Conditional effectiveness (which model for which context) not understood Systematic comparative studies needed to identify optimal designs

The systematic analysis revealed four critical research gaps in e-module studies (Table 6). Methodologically, 60% of studies (n=12) employed R&D designs with pre-experimental approaches, lacking rigorous randomized controlled trials and longitudinal designs, which weakens causal validity and limits generalizability. Geographically, 85% of studies (n=17) originated from Indonesia, constraining cross-cultural validation and international applicability of findings. Developmentally, 75% of research (n=15) focused on product development and validation stages without examining long-term implementation, sustainability, or institutionalization mechanisms, creating a gap between product creation and sustained educational practice. Comparatively, only two studies examined relative effectiveness of different pedagogical models or technological integrations, preventing identification of evidence-based best practices. These gaps indicate that future research should adopt rigorous experimental designs with longitudinal components, conduct cross-national comparative studies, extend investigations beyond validation to implementation phases, and perform systematic comparisons to establish conditional effectiveness frameworks specifying optimal e-module designs for specific contexts and learner characteristics.

The results of this systematic review reveal that e-module research in science learning during the 2020–2024 period shows four main finding patterns: dominance of problem-based and inquiry learning models, strong orientation toward cognitive domain outcome variables, pragmatic technology integration, and several methodological and implementation context gaps that remain unresolved. These four findings provide a comprehensive picture of the direction of e-module research development while also showing that although innovation has developed rapidly, there are aspects that require strengthening for e-modules to function optimally as tools for pedagogical transformation.

The first finding indicates that Problem-Based Learning (PBL) is the most dominant learning model integrated into e-modules. Previous studies consistently show that PBL-based e-modules are effective in promoting active student engagement in identifying problems, formulating hypotheses, and evaluating alternative solutions (Rusli et al., 2024; Sedayu et al., 2024; Sujanem & Suwindra, 2023). The use of PBL in e-modules aligns with the demands of 21st-century science learning, which requires strong problem-solving abilities and higher-order thinking skills. In addition, empirical findings indicate that the implementation of PBL-based e-modules significantly improves critical thinking skills, collaboration, and scientific literacy (Ardi et al., 2025; Hafifah et al., 2025; Nurussalamah et al., 2025; Risnawati & Purwaningsih, 2025). This confirms that PBL is not only theoretically aligned with constructivist learning principles but also empirically effective across various learning contexts.

Furthermore, other learning models such as Discovery Learning and STEM approaches also play an important role in e-module development. Discovery-based e-modules provide opportunities for students to engage in guided exploration, facilitating cognitive conflict that leads to deeper conceptual change (Hardeli et al., 2023; Yerimadesi et al., 2023). Meanwhile, STEM-based e-modules enhance interdisciplinary thinking and connect learning with real-world problem contexts (Asrizal et al., 2024; Liunima et al., 2025; Mirwandi & Aini, 2025; Pertiwi et al., 2024). However, variations in the depth of learning model implementation indicate that some studies only adopt models at a conceptual level without fully integrating them into instructional design. This suggests that not all studies have achieved substantive pedagogical integration, particularly in terms of aligning content, activities, and assessment with the selected learning model.

The second finding shows that outcome variables in e-module research are predominantly focused on the cognitive domain. Critical thinking, conceptual understanding, scientific literacy, and higher-order thinking skills are the most frequently examined variables (Desnita et al., 2022; Pertiwi et al., 2024; Rusli et al., 2024). This dominance reflects global trends in science education that emphasize cognitive competencies as key indicators of learning success. Supporting studies also demonstrate that e-modules significantly improve higher-order thinking skills and learning outcomes across different contexts (Anjarwati et al., 2025; Liunima et al., 2025; Oksila et al., 2025; Zaini et al., 2025).

However, affective and dispositional variables remain underexplored. Although some studies have begun to examine aspects such as curiosity, perseverance, and self-efficacy (Astalini et al., 2024; Sedayu et al., 2024), their proportion is still significantly lower compared to cognitive variables. This limitation is critical because scientific literacy encompasses not only cognitive abilities but also scientific attitudes, interest, and persistence in solving problems. Furthermore, previous studies indicate that interactive e-modules can enhance students' learning motivation and engagement (Wahdaniyah & Zulherman, 2025). Therefore, the dominance of cognitive variables suggests a reductionist approach to evaluating learning effectiveness, where improvements in test scores are often equated with overall learning success. A more holistic evaluation framework is needed to integrate cognitive, affective, and behavioral dimensions.

The third finding indicates that technology integration in e-modules tends to be pragmatic and adapted to existing educational infrastructure conditions. Interactive multimedia is the most widely used technology, as it provides multimodal learning experiences that support student engagement and conceptual understanding (Asrizal et al., 2024; Desnita et al., 2022; Sujanem & Suwindra, 2023). Android-based platforms are also commonly used, reflecting an adaptive strategy to high smartphone penetration among students (Dewi et al., 2022; Yuliatun et al., 2024). Supporting studies confirm that mobile-based e-modules enhance accessibility, flexibility, and learning motivation (Deviana et al., 2025; Tartiyoso, 2025; Wahdaniyah & Zulherman, 2025; Zaini et al., 2025).

However, advanced technologies such as Augmented Reality and virtual laboratories remain underutilized. Although previous studies show that these technologies can enhance visualization of abstract concepts and improve critical thinking skills (P. S. Dewi & Kuswanto, 2023; Ilma & Kuswanto, 2025; Kuit & Osman, 2021; Maharaja et al., 2025; Pertiwi et al., 2024), their adoption is still limited due to factors such as device requirements, teacher digital competence, and lack of institutional support. This indicates that technological innovation in e-module development is still constrained by practical considerations. Moreover, the absence of studies examining technology sustainability, implementation costs, and digital access equity highlights an important research gap that needs further investigation.

Methodological gaps are also evident in current e-module research. Most studies employ quasi-experimental designs or early-stage development (R&D) approaches, often with limited sample sizes and short intervention durations (Hardeli et al., 2023; Rusli et al., 2024; Yani et al., 2025; Yosa et al., 2025). These limitations reduce the generalizability and robustness of research findings. In addition, few studies examine contextual factors such as teacher readiness, school leadership, or digital policy, even though these factors play a crucial role in the successful implementation of digital learning innovations.

Another significant gap is the lack of attention to digital equity. Existing studies rarely explore disparities in access to devices, internet connectivity, or technological resources among students (Dewi et al., 2022; Yuliatun et al., 2024). This is a critical issue, as unequal access may significantly affect the effectiveness of e-module implementation. Furthermore, most studies are conducted within a single national context, limiting cross-cultural and cross-contextual comparisons.

Overall, these findings indicate that e-module research in science learning has experienced significant development, particularly in integrating learning models and improving cognitive outcomes. However, further research is needed to strengthen methodological rigor, expand outcome variables to include affective and dispositional aspects, and explore contextual factors such as teacher readiness and digital equity. In addition, the integration of emerging technologies should be accompanied by feasibility and sustainability analyses to ensure long-term impact on learning processes and outcomes.

Conclusion

This study reveals that e-module research in science learning during the 2020–2024 period is predominantly focused on development based on learning models (75.00%), with Problem-Based Learning as the most frequently applied model (35.00%). The findings also show that cognitive outcomes dominate, particularly higher-order thinking skills (60.00%) and critical thinking skills (40.00%), while affective aspects remain underexplored. In terms of technology, interactive multimedia (40.00%) and Android-based platforms (20.00%) are the most commonly used, reflecting a pragmatic approach to digital learning implementation, whereas advanced technologies such as Augmented Reality and virtual laboratories are still limited. These results indicate that although e-module research has contributed significantly to improving cognitive learning outcomes, several gaps remain, particularly in affective dimensions, methodological rigor, digital equity, and contextual factors such as teacher readiness and institutional support. Therefore, future research should emphasize more rigorous experimental designs, holistic learning outcomes, and broader contextual studies to support sustainable and effective digital learning in science education.

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