



The Evolution of E-Module Development in Secondary Education: A Systematic Review of Trends and Emerging Practices

Annisa Nurbaiti*, Robinson Situmorang, Iva Sarifah, Imam Fitri Rahmadi
Master of Education Technology Study Program, Faculty of Educational Sciences,
Universitas Negeri Jakarta, Indonesia.

*Corresponding Author. Email: annisa.nurbaiti@mhs.unj.ac.id

Abstract: This study aims to systematically examine the evolution of e-module development in secondary education between 2020 and 2024. Employing a Systematic Literature Review (SLR) method guided by the PRISMA 2020 protocol, the study explores emerging trends in instructional design, pedagogical frameworks, and technological integration. A total of 27 Scopus-indexed empirical studies were analyzed through four thematic lenses: disciplinary distribution, pedagogical approaches, levels of interactivity, and reported learning outcomes. Data were analysed using thematic analysis following Braun and Clarke (2006). The results reveal a pronounced STEM concentration (n = 23; 85.2%), with Physics and Chemistry dominating, while non-STEM disciplines account for only 14.8% (n = 4). Constructivist pedagogies, particularly Problem-Based Learning (n = 8; 29.6%), are dominant, effectively supporting higher-order cognitive outcomes such as Critical Thinking Skills (n = 12; 44.4%). However, Collaboration Skills receive critically minimal attention (n = 1; 3.7%), revealing a systematic gap in addressing social learning competencies essential to 21st-century education. These findings establish e-modules as effective digital frameworks when researchers align pedagogical design with technological affordances. Two urgent recommendations emerge: first, researchers must investigate e-modules in non-STEM disciplines; second, future studies must prioritise collaborative features to address the critical gap in 21st-century skill development.

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Introduction

Digital transformation has fundamentally reshaped the educational landscape, creating new forms of interaction among teachers, students, and learning resources. At the Senior High School (SHS) level—a critical transitional phase to higher education requiring independent learning and increasingly complex cognitive skills—technology integration enhances the learning process by making it more engaging and accessible, catering to different learning styles and preferences (Hosen et al., 2023). Electronic modules (e-modules) offer flexibility, interactivity, and personalisation in teaching and learning, which are particularly suited to the cognitive development of SHS students. E-modules function not only as learning media but also as tools to strengthen learner autonomy, conceptual understanding, and 21st-century skills. Integrating e-modules into the SHS curriculum generally enhances student engagement and learning outcomes; however, although several studies suggest that digital tools enhance students' conceptual understanding and motivation, the extent of their impact on collaboration and problem-solving remains open to further investigation (Rahmatullah et al., 2025). Consequently, while e-modules facilitate adaptive



teaching, their effectiveness depends on how teachers contextualise them, positioning e-modules as a key tool in modern learner-centred education.

Despite the growth of e-modules, persistent issues remain regarding their quality, design, and technological sophistication. Most digital modules focus solely on digitising printed materials without leveraging interactivity, personalisation, or adaptive systems (Cardona-Acevedo et al., 2025). This raises questions about whether pedagogical quality keeps pace with technological progress. As a transitional stage preparing students for higher education, the SHS level demands e-modules that actively cultivate independent learning and 21st-century competencies. However, recent scholarship reveals a structural imbalance within the Technological Pedagogical Content Knowledge (TPACK) framework: Valtonen et al. (2023) found that Technological Pedagogical Knowledge (TPK), which refers to the understanding of how technology transforms teaching methods, is frequently neglected relative to Content Knowledge (CK) and Technological Content Knowledge (TCK). This imbalance may perpetuate research bias toward specific subjects, and the novelty of this study lies in its systematic mapping of whether such TPACK imbalances also occur in e-module development at the SHS level, examined through four concurrent thematic lenses: disciplinary distribution, pedagogical approaches, interactivity levels, and learning outcomes.

This systematic review employs an integrated theoretical framework combining constructivist learning theory and the TPACK model. Grounded in constructivist epistemology, which asserts that learners actively construct knowledge rather than passively receive it (Do et al., 2023), the framework emphasises student-centred learning where learners act as active agents in knowledge acquisition. Modern e-modules operationalise these principles by providing interactive activities, self-directed exploration, and multimedia resources that support dynamic knowledge construction. The global educational agenda further underscores constructivism's relevance by emphasising 21st-century competencies—Communication, Collaboration, Critical Thinking, and Creativity (the 4Cs)—as defining benchmarks for quality digital learning materials (Herlinawati et al., 2024).

This study aims to systematically analyse the development of educational e-modules over the past five years using the PRISMA 2020 protocol, focusing on disciplinary patterns, pedagogical integration, technological characteristics, and learning outcomes to guide future innovations in digital learning.

Research Method

This study employed a Systematic Literature Review (SLR) approach to rigorously and transparently identify, evaluate, and synthesise prior research on e-module development and implementation. The review adheres to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring transparency, traceability, and methodological rigour (Page et al., 2021).

The literature search was conducted in September 2025 using the Scopus database with the query: TITLE-ABS-KEY ("e-module") AND PUBYEAR > 2019 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")). This search specifically targeted peer-reviewed English-language journal articles published between 2020 and 2024. The researcher manually screened all retrieved records according to predefined inclusion and exclusion criteria, involving evaluation of titles and abstracts for relevance, followed by full-text assessment of potentially eligible studies. These criteria detailing scope, study type, publication period, and quality standards are summarised in Table 1.



Table 1. Inclusion and Exclusion Criteria

| Category | Inclusion Criteria | Exclusion Criteria |
|-------------------|---|--|
| Publication Type | Peer-reviewed journal articles indexed in Scopus | Conference papers, book chapters, review articles, or non-peer-reviewed publications |
| Publication Year | Published between 2020 and 2024 | Published before 2020 or after 2024 |
| Language | English | Non-English articles |
| Educational Level | Secondary and high school education | Primary, higher education, or non-formal education |
| Content Focus | Studies focusing on development, implementation, or evaluation of e-modules | Studies that do not analyse e-module development or implementation |

Following the application of these criteria, the complete study selection process was documented using the PRISMA 2020 flow diagram, as illustrated in Figure 1.

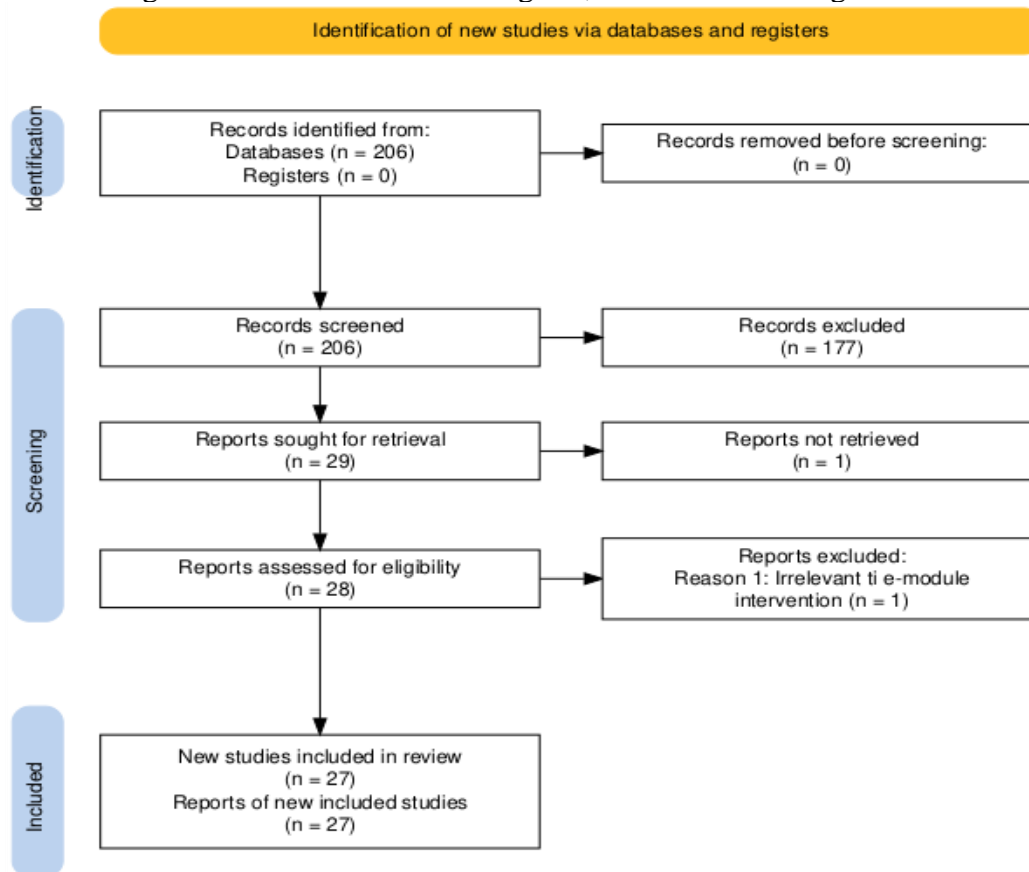


Figure 1. PRISMA Diagram

Figure 1 presents the study selection procedure following the PRISMA 2020 flow diagram. The initial search of the Scopus database identified 206 records. No duplicates were found or removed, and no records were marked as ineligible by automation tools. All 206 articles were manually screened by title and abstract for relevance to Senior High School education contexts. During this phase, 177 records were excluded, leaving 29 potentially relevant articles. Of these, one report could not be retrieved due to paywall restrictions, resulting in 28 reports undergoing full-text eligibility assessment. During this stage, one additional study was excluded because its primary focus was not on electronic modules as



defined by the inclusion criteria. Consequently, 27 studies met all eligibility criteria and were included in the final qualitative synthesis and thematic analysis. A structured data extraction form captured authorship, design, subject, pedagogy, interactivity, and learning outcomes. Thematic analysis across four areas followed, with coding verified through iterative researcher-advisor discussion until consensus was reached (Braun & Clarke, 2006).

Results and Discussion

Distribution based on field of study (STEM vs. Non-STEM)

Based on an analysis of the reviewed articles, research on e-modules shows a clear disciplinary trend, with an intense concentration in STEM fields and comparatively limited adoption in non-STEM contexts. This pattern highlights how e-modules are primarily positioned as digital learning media to address abstract, procedural, and technical learning demands.

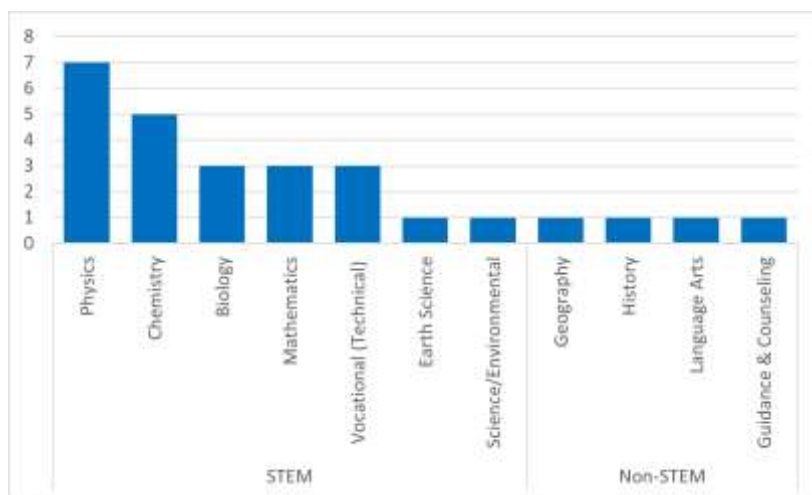


Figure 2. Distribution of E-Module Studies Across Fields of Study (STEM vs. Non-STEM)

Figure 2 illustrates the distribution of e-module studies across fields of study, revealing a pronounced dominance of STEM disciplines. Physics emerges as the most frequently investigated subject ($n = 7$; 25.9%), followed by Chemistry ($n = 5$; 18.5%), with Biology and Mathematics each contributing three studies ($n = 3$; 11.1% each). Research in these areas consistently frames e-modules as practical tools for enhancing conceptual understanding, visualisation of complex phenomena, learner engagement, and problem-solving skills (Asrizal et al., 2024; Astalini et al., 2024; Rusli et al., 2024). Vocational and technical subjects are moderately represented ($n = 3$; 11.1%), while Earth Science and Environmental Science are minimally represented ($n = 1$; 3.7% each). Collectively, STEM disciplines account for 85.2% of the total sample ($n = 23$ out of 27). Table 2 presents a detailed breakdown of these distributions.

Table 2. Distribution of Studies Across STEM and Non-STEM Fields

| Category | Subject Area | Frequency (n) |
|----------|------------------------|---------------|
| STEM | Physics | 7 |
| | Chemistry | 5 |
| | Biology | 3 |
| | Mathematics | 3 |
| | Vocational (Technical) | 3 |
| | Earth Science | 1 |



| Category | Subject Area | Frequency (n) |
|----------|-----------------------|---------------|
| Non-STEM | Science/Environmental | 1 |
| | Geography | 1 |
| | History | 1 |
| | Language Arts | 1 |
| | Guidance & Counseling | 1 |

Non-STEM fields account for (n = 4; 14.8%) of the total sample, with Geography, History, Language Arts, and Guidance and Counseling each represented by one study, demonstrating that e-modules also support narrative-based and affective learning competencies (Marta et al., 2023; Wijayanto et al., 2023). This imbalance signals substantial opportunities for future research in non-STEM fields.

Distribution of Pedagogical Approaches

The analysis shows that e-module research is dominated by constructivist-oriented pedagogical approaches, with Problem-Based Learning (PBL) emerging as the most prominent strategy. This pattern indicates that e-modules are designed mainly to support active learning, inquiry, and learner-centered knowledge construction.

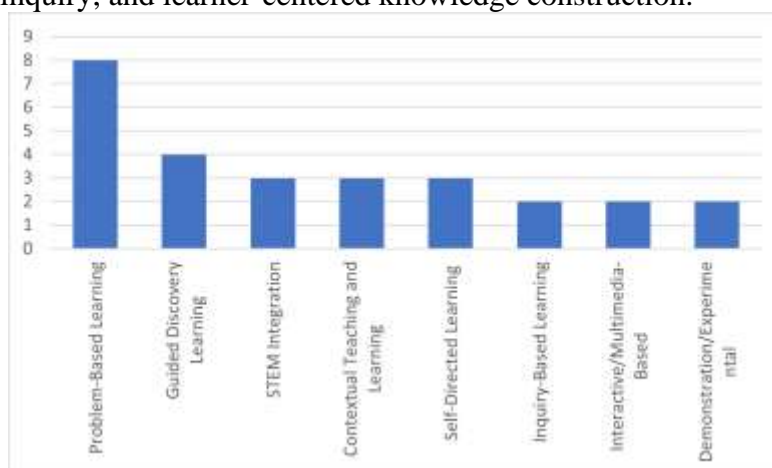


Figure 3. Distribution of Pedagogical Approaches in E-Module Research

The distribution of pedagogical approaches in e-module design reveals a clear preference for constructivist instructional philosophies. As illustrated in Figure 3, PBL accounts for the most significant proportion of studies (n = 8; 29.6%). Research by Pitorini et al. (2024), Rusli et al. (2024), and Sujanem and Suwindra (2023) positions PBL-based e-modules as practical tools for fostering problem-solving skills, conceptual understanding, and learner engagement through real-world problem contexts. Guided Discovery Learning follows as the second most frequently adopted approach (n = 4; 14.8%), emphasizing structured exploration and scaffolding to support learners’ conceptual development (Hardeli et al., 2023; Yerimadesi et al., 2023).

Table 3. Distribution of Pedagogical Approaches in E-Module Research

| Pedagogical Approach | Frequency (n) |
|----------------------------------|---------------|
| Problem-Based Learning | 8 |
| Guided Discovery Learning | 4 |
| STEM Integration | 3 |
| Contextual Teaching and Learning | 3 |
| Self-Directed Learning | 3 |



| | |
|------------------------------|---|
| Inquiry-Based Learning | 2 |
| Interactive/Multimedia-Based | 2 |
| Demonstration/Experimental | 2 |

As summarised in Table 3, STEM Integration, CTL, and Self-Directed Learning each account for (n = 3; 11.1%), while Inquiry-Based Learning, Interactive/Multimedia-Based, and Demonstration/Experimental models each represent (n = 2; 7.4%). These findings confirm that e-module design aligns closely with active, contextual, and student-centred learning approaches.

Distribution of e-module types and interactivity levels

The analysis shows that trends in e-module development have shifted from predominantly low-interactivity formats to more interactive, technologically enriched designs, particularly after 2020.

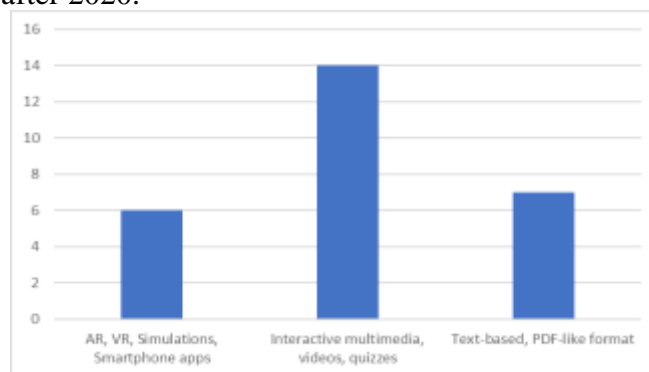


Figure 4. Distribution of E-Module Interactivity Level

E-module development has evolved significantly in terms of interactivity and technological complexity. Early studies were characterised mainly by low-interactivity e-modules resembling digital textbooks or PDF-based materials that primarily supported content delivery. Over time, the most prominent pattern has been the growing dominance of medium-interactivity e-modules integrating videos, animations, quizzes, and interactive multimedia elements, reflecting researchers' increasing emphasis on learner engagement, conceptual understanding, and guided self-learning (Aziz & Suparman, 2020; Handayani et al., 2021; Yerimadesi et al., 2023). Recent studies also demonstrate diversification toward highly interactive e-modules incorporating augmented reality (AR), virtual reality (VR), simulations, and smartphone-based applications, moving toward immersive and experiential learning environments (Astalini et al., 2024; Dewi & Kuswanto, 2023; Pertiwi et al., 2024).

Table 4. Distribution of E-Module Interactivity Levels

| Level | Characteristics | Frequency (n) |
|--------|---|---------------|
| High | AR, VR, Simulations, Smartphone apps | 6 |
| Medium | Interactive multimedia, videos, quizzes | 14 |
| Low | Text-based, PDF-like format | 7 |

Table 4 summarises this trend quantitatively. Medium-interactivity e-modules constitute the most significant proportion (n = 14; 51.9%), indicating that most studies prioritise a balanced integration of interactivity and instructional structure. Low-interactivity e-modules account for (n = 7; 25.9%), while high-interactivity e-modules represent (n = 6; 22.2%). These findings confirm that e-module research is progressing both technologically and



pedagogically, from static digital materials to more interactive, learner-centred digital learning environments.

Learning outcomes and 21st-century competencies

The analysis shows that e-module research strongly prioritises cognitive learning outcomes, particularly higher-level thinking skills, while social and collaborative competencies receive minimal attention.

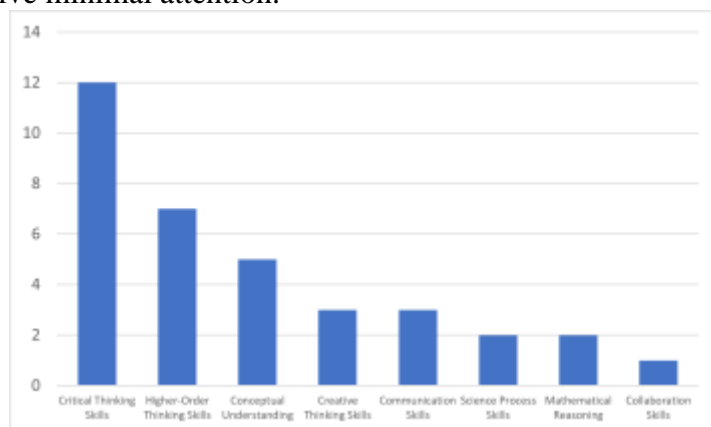


Figure 5. Distribution of Learning Outcomes and 21st-Century Competencies in E-Module Research

E-module research predominantly targets cognitive outcomes. Critical Thinking Skills dominate reported outcomes (n = 12; 44.4%), with studies such as Syahfitri and Muntahanah (2024), Astalini et al. (2024), Asrizal et al. (2024), and Serevina et al. (2022) consistently positioning e-modules as tools that foster analytical reasoning, evaluation, and problem-solving abilities. As illustrated in Figure 5, this cognitive orientation is further reinforced by the substantial focus on Higher-Order Thinking Skills (HOTS) (n = 7; 25.9%), indicating that e-modules are frequently designed to support advanced levels of Bloom's taxonomy rather than basic knowledge acquisition.

Table 5. Distribution of Learning Outcomes and 21st-Century Competencies in E-Module Research

| Learning Outcomes and 21st-Century Competencies | Frequency (n) |
|---|---------------|
| Critical Thinking Skills | 12 |
| Higher-Order Thinking Skills | 7 |
| Conceptual Understanding | 5 |
| Creative Thinking Skills | 3 |
| Communication Skills | 3 |
| Science Process Skills | 2 |
| Mathematical Reasoning | 2 |
| Collaboration Skills | 1 |

In line with this trend, other cognitively oriented outcomes such as Conceptual Understanding (n = 5; 18.5%), Creative Thinking Skills (n = 3; 11.1%), and domain-specific abilities like Science Process Skills and Mathematical Reasoning (each n = 2; 7.4%) also appear in the literature. Collaboration Skills are largely neglected, with only (n = 1; 3.7%) study addressing this outcome (Asrizal et al., 2024). This imbalance suggests that, although



e-modules are increasingly aligned with higher-level cognitive skills, their potential to support collaborative and socially mediated learning remains underexplored.

Discussion

Disciplinary distribution and STEM concentration

The dominance of STEM subjects, particularly Physics ($n = 7$) and Chemistry ($n = 5$), extends the findings reported by Cardona-Acevedo et al. (2025), who noted that e-learning technologies at the secondary level predominantly serve science education; however, this review provides more granular evidence that non-STEM disciplines account for merely 14.8% ($n = 4$) of the research landscape, suggesting e-module research has developed along subject-specific trajectories. The Technological Content Knowledge (TCK) component of TPACK explains this concentration: science subjects naturally leverage visualization technologies to enhance mastery of abstract content (Shambare & Jita, 2024), and Physics and Chemistry concepts such as electromagnetic fields, molecular structures, and reaction mechanisms require sophisticated visual representations and interactive simulations that e-modules uniquely provide, producing immediately demonstrable learning gains (Pertiwi et al., 2024; Serevina et al., 2022).

Beyond TCK, this concentration is also reinforced by broader global education policy trends. The Global STEM Agenda, reflected in frameworks such as UNESCO's Education for Sustainable Development goals, OECD's PISA priorities, and numerous national STEM education initiatives, has systematically directed institutional funding, curriculum reform, and research incentives toward STEM fields, creating structural conditions that amplify the TCK-driven bias. Consequently, the observed STEM concentration reflects not only the pedagogical suitability of science content for digital visualisation but also a research funding landscape that disproportionately rewards STEM innovation. Addressing this imbalance requires deliberate policy interventions that incentivise e-module development in non-STEM disciplines.

Pedagogical approaches and constructivist preference

The prevalence of Problem-Based Learning ($n = 8$; 29.6%) confirms the constructivist emphasis documented in the literature, aligning with Do et al. (2023), who argued that constructivist learning environments foster greater motivation and more effective learning strategies. The effectiveness of PBL in e-module contexts, as reported by Rusli et al. (2024) and Wijayanto et al. (2023), demonstrates that authentic problem scenarios promote higher-order thinking through digital platforms. Guided Discovery Learning ($n = 4$; 14.8%) further operationalises constructivist principles, as confirmed by Mudinillah et al. (2024) regarding 21st-century skill development.

Interactivity levels and technological integration

Contrary to expectations of rapid technological advancement toward immersive platforms, medium-interactivity modules constitute the majority ($n = 14$; 51.9%), while high-interactivity AR/VR-based modules account for ($n = 6$; 22.2%). Rather than indicating technological stagnation, this distribution reflects pragmatic considerations. The Technological Knowledge (TK) component of TPACK reminds us that technology integration must account for available resources, teacher competencies, and institutional constraints. High-interactivity AR/VR modules require infrastructure investments that many SHS institutions cannot sustain (Astalini et al., 2024; Dewi & Kuswanto, 2023). Thus, the predominance of medium-interactivity solutions represents not a failure of innovation but a successful adaptation to diverse educational contexts.



Learning outcomes and the critical collaboration gap

Collaboration Skills received minimal attention ($n = 1$; 3.7%) despite being a core 4C competency (Herlinawati et al., 2024). This finding directly contradicts the constructivist theoretical foundation of this review, which emphasizes that peers actively and socially construct knowledge through collaboration (Do et al., 2023). While Critical Thinking ($n = 12$; 44.4%) and HOTS ($n = 7$; 25.9%) show robust attention, the near-absence of collaboration research reveals a systematic blind spot.

This gap reflects the TPACK imbalance identified by Valtonen et al. (2023) — researchers frequently neglect Technological Pedagogical Knowledge (TPK)—the understanding of how technology transforms teaching methods—in favour of CK and TCK. Designing collaborative features requires sophisticated TPK: developers must understand not merely how to present content digitally, but how to facilitate social interaction, peer feedback, and shared knowledge construction. Furthermore, Schmid et al. (2024) noted that collaboration remains an unresolved theoretical and methodological issue within TPACK itself, suggesting insufficient framework guidance for collaborative e-module design. Three practical factors compound this theoretical challenge: collaborative features require more complex technical infrastructure; assessing collaboration presents methodological difficulties; and the self-paced nature of e-modules creates tension with synchronous collaborative activities. Only Asrizal et al. (2024) explicitly addressed collaboration among the 27 reviewed studies, demonstrating that while technically feasible, collaborative e-module design remains an underexplored frontier.

Conclusion

This systematic review of 27 studies reveals three critical findings about e-module development at the Senior High School level. First, research is heavily concentrated in STEM disciplines ($n = 23$; 85.2%), leaving non-STEM subjects significantly underrepresented ($n = 4$; 14.8%). This concentration is driven by both TCK-based subject suitability and global STEM policy incentives. Second, constructivist pedagogies, particularly Problem-Based Learning ($n = 8$; 29.6%), effectively support cognitive outcomes such as Critical Thinking Skills ($n = 12$; 44.4%). Third, and most critically, Collaboration Skills receive minimal attention ($n = 1$; 3.7%), revealing a systematic gap in addressing social learning competencies essential to 21st-century education. While e-modules effectively foster individual cognitive development, their design remains underdeveloped for collaborative learning. Future research must urgently investigate e-module applications in non-STEM disciplines and explicitly integrate collaborative features to address this critical gap.

Recommendation

Based on the findings of this review, future researchers should urgently investigate e-module applications in non-STEM disciplines to address the pronounced disciplinary inequity ($n = 4$; 14.8%), and conduct longitudinal or mixed-methods studies to examine how collaborative learning can be meaningfully embedded within e-module architectures using validated instruments that measure 21st-century competencies. Comparative studies should also clarify whether high-interactivity AR/VR modules yield significantly better learning gains than medium-interactivity alternatives under real institutional conditions.

For instructional media developers, collaborative features such as shared workspaces, peer feedback mechanisms, and discussion forums should be integrated into e-module architectures without compromising self-paced flexibility, with design decisions grounded in



constructivist principles and the TPACK framework. For teachers and school practitioners, e-module use should be complemented with structured collaborative activities, while professional development should prioritise operationalising Problem-Based Learning and Guided Discovery in digital environments and building Technological Pedagogical Knowledge (TPK) to ensure e-modules serve as purposeful, evidence-informed tools for both cognitive development and collaborative knowledge construction.

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