



## Mapping The Landscape of E-Module Development to Enhance 21st Century Skills in Indonesia: Evidence from a Prisma-Based Systematic Review

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**Abstract:** Digital transformation has accelerated the adoption of e-modules in Indonesian education; however, evidence regarding their contribution to 21st-century skills remains fragmented. This systematic literature review examines e-module development, pedagogical integration, targeted 4C skills, effectiveness, and implementation challenges in Indonesia. Following the PRISMA 2020 guidelines, 27 studies published between 2020 and 2025 were identified from SINTA, Scopus, and DOAJ. The data were analyzed thematically to identify research trends, subject areas, and patterns of effectiveness. Research was concentrated in STEM subjects, particularly Physics, Biology, and Mathematics, and primarily at the senior high school level. Critical thinking was the most frequently targeted skill (81.5%), followed by creativity (51.9%), communication (44.4%), and collaboration (33.3%); only 25.9% of the studies integrated all four skills. Most studies reported positive effects on learning outcomes (88.9%) and critical thinking (86.4%), although the predominance of quasi-experimental and pre-experimental designs limits causal interpretation. Implementation challenges included technological infrastructure, teacher readiness, student self-regulation, and long-term sustainability. The findings suggest that e-modules are most pedagogically meaningful when their technological features are aligned with authentic, scaffolded, and student-centered learning activities that intentionally foster 4C skills. The review highlights the need for holistic integration of the 4C skills, broader educational contexts, more rigorous research designs, and sustainable implementation support.

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## Introduction

The rapid advancement of information and communication technology has transformed educational practices in Indonesia, shifting learning toward technology-supported approaches that address 21st century competencies (UNESCO, 2021). Beyond content mastery, education increasingly emphasizes critical thinking, creativity, communication, and collaboration (4C) as essential competencies (Partnership for 21st Century Learning, 2019). In this context, e-modules have emerged as digital learning media that integrate multimedia elements to support more interactive and meaningful learning experiences, with their use accelerating following the COVID-19 pandemic (Sugiarto & Hidayat, 2021; Rahiem, 2020). The potential of e-modules to support 4C development can be understood through the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the interaction of technological, pedagogical, and content knowledge, and through a constructivist perspective that views learning as active knowledge



construction through interaction with content, peers, and teachers (Mishra & Koehler, 2006; Vygotsky, 1978).

Accordingly, e-modules can facilitate 4C skills when interactive features are deliberately aligned with pedagogical strategies such as inquiry, problem solving, discussion, collaboration, and creative production. Previous studies have reported positive effects on motivation, engagement, learning outcomes, and selected higher-order skills (Prastowo, 2020; Desnita et al., 2022; Cynthia et al., 2023); however, the four competencies are not necessarily integrated or evaluated consistently across Indonesian e-module research. Although e-module development in Indonesia has increased, evidence from 2020–2025 remains fragmented because studies differ in pedagogical targets, learning approaches, and evaluation priorities. Development studies have addressed critical thinking through Problem-Based Learning and STEM approaches, while others have targeted communication and collaboration through project-based learning (Pitorini et al., 2024; Yani et al., 2024; Aprilia et al., 2024). Research has also examined higher-order thinking and digital literacy outcomes (Santosa, 2024; Sumiati et al., 2024). These studies demonstrate the potential of e-modules to support different 21st century competencies, but they do not yet provide a coherent picture of how critical thinking, creativity, communication, and collaboration are addressed as an interconnected set of competencies. Systematic mapping is therefore needed to identify patterns, gaps, and directions for more integrated e-module development in Indonesia.

A further issue concerns how e-module effectiveness is established. In several development studies, validity and practicality are emphasized as indicators of product quality, but these measures do not by themselves demonstrate changes in students' 4C skills or higher-order thinking. For example, Pitorini et al. (2024) and Aprilia et al. (2024) emphasized validity and practicality, whereas Amalia et al. (2024) used a pretest–posttest control-group design to examine effects on critical thinking. Thus, the central gap is not the absence of e-modules that mention 4C, but the limited and inconsistent alignment among instructional design, targeted competencies, and outcome measures. A systematic review is consequently needed to synthesize evidence on e-module development and implementation, distinguish product feasibility from evidence of learning and skill outcomes, and identify areas where evidence remains insufficient.

Therefore, this study aims to analyze trends and characteristics of e-module development for enhancing 21st century skills in Indonesia through a Systematic Literature Review (SLR) guided by the PRISMA 2020 protocol (Page et al., 2021). Specifically, the review examines publication trends, subject areas and educational levels, e-module characteristics and pedagogical approaches, 4C competencies targeted, effectiveness indicators and outcomes, and implementation challenges. Through this synthesis, the study seeks to provide an empirical foundation for understanding how e-modules are currently designed and evaluated in Indonesia and to identify directions for more integrated, pedagogically meaningful, and evidence-based development of 21st century skills.

## **Research Method**

This study employs a Systematic Literature Review (SLR) method following the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) 2020 guidelines (Page et al., 2021). SLR is recognized as a rigorous, transparent, and replicable approach for synthesizing research evidence in education and social sciences (Aromataris & Pearson, 2014; Matos et al., 2023). The PRISMA framework provides a structured protocol for identifying, screening, and synthesizing relevant literature while minimizing bias and



ensuring methodological rigor (Moher et al., 2009, 2016). The review process consisted of four main phases: (1) identification of relevant studies through database searching, (2) screening of titles and abstracts based on inclusion criteria, (3) eligibility assessment through full text review, and (4) inclusion of studies for qualitative synthesis (Page et al., 2021).

The literature search was conducted across three academic databases, namely the Science and Technology Index (SINTA), Scopus, and the Directory of Open Access Journals (DOAJ), to improve the comprehensiveness of the evidence base and reduce the possibility of database-specific selection bias. SINTA was retained because it comprehensively indexes research published in accredited Indonesian journals and is therefore relevant for mapping e-module research within the Indonesian educational context. Scopus was included to capture internationally indexed peer-reviewed research, while DOAJ was included to identify relevant peer-reviewed open-access publications that may not be represented in SINTA. The search was conducted using predefined Boolean operators and the following keywords: (“e-modul” OR “modul elektronik” OR “electronic module”) AND (“21st century skills” OR “4C” OR “critical thinking” OR “creativity” OR “communication” OR “collaboration”).

To maintain consistency across databases, the same conceptual search terms and eligibility criteria were applied as far as supported by each database's search interface. Search results from SINTA, Scopus, and DOAJ were exported or recorded and subsequently combined into a single reference set. Duplicate records identified across the databases were removed before title and abstract screening. The search was limited to studies published between 2020 and 2025 and focused on e-module development or implementation in Indonesian educational contexts. The final number of records identified from each database, the number of duplicates removed, and the number of records excluded at each PRISMA stage should be reported separately and then combined in the PRISMA 2020 flow diagram. Inclusion criteria were established based on relevance, methodological rigor, and alignment with the research objectives. Articles were included if they: (1) focused on e-module development or implementation in Indonesian educational contexts; (2) explicitly addressed one or more 21st century skills (4C); (3) employed empirical research methods (experimental, quasi-experimental, development research, or case studies); (4) were published in peer-reviewed journals indexed in at least one of the selected databases (SINTA, Scopus, or DOAJ); and (5) were published between 2020 and 2025. Exclusion criteria included: (1) articles not related to educational contexts; (2) studies without empirical data or clear methodology; (3) conceptual papers, editorials, or book reviews; (4) duplicate publications; and (5) articles not accessible in full text. The complete inclusion and exclusion criteria are presented in Table 1.

**Table 1. summarizes the inclusion and exclusion criteria used to ensure the methodological quality of the selected studies.**

| Criteria    | Inclusion                                                             | Exclusion                                                           |
|-------------|-----------------------------------------------------------------------|---------------------------------------------------------------------|
| Context     | E-module development/implementation in Indonesian education           | Non educational contexts or studies outside Indonesia               |
| Focus       | Explicitly addresses one or more 21 <sup>st</sup> century skills (4C) | Studies without clear connection to 21 <sup>st</sup> century skills |
| Methodology | Empirical research                                                    | Conceptual papers, literature reviews, editorials, book reviews     |



|               |                                                                                    |                                                                                                                |
|---------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Publication   | Published in a peer-reviewed journal indexed in SINTA, Scopus, or DOAJ (2020–2025) | Non-peer-reviewed publications, conference papers, theses, or publications outside the selected database scope |
| Accessibility | Full text available                                                                | Abstract only, inaccessible full text                                                                          |

Following PRISMA 2020, study selection proceeded through identification, screening, eligibility, and inclusion. After removing duplicates, titles and abstracts were screened, followed by full-text assessment using the predefined conceptual inclusion and exclusion criteria in Table 1. Eligible full-text studies then underwent quality assessment, resulting in 27 articles that met the eligibility and quality requirements for final synthesis. Data were extracted systematically using a standardized form covering seven domains: (1) bibliographic information, including author, year, journal, and SINTA accreditation level; (2) study characteristics, including design, sample size, educational level, and subject area; (3) e-module characteristics, including development model, multimedia features, and interactivity; (4) targeted 21st century skills; (5) intervention details and implementation context; (6) measured outcomes; and (7) key findings and effectiveness indicators. Two reviewers conducted the extraction independently, with discrepancies resolved through discussion and consensus. Study quality was assessed using adapted criteria from the Brock Education Journal systematic review guidelines (Pantic & Hamilton, 2024) and German et al. (2024), covering research clarity, methodological appropriateness, sampling, instrument validity and reliability, data analysis, interpretation, and limitations. Findings were synthesized through thematic analysis following Ritmayanti et al. (2025), involving data familiarization, initial coding, theme development and refinement, and final synthesis. The analysis focused on publication trends, subject areas, educational levels, e-module development models, targeted 21st century skills, effectiveness indicators, and implementation challenges. Frequencies and percentages were used to describe quantitative patterns, while narrative synthesis was applied to interpret cross-study findings and contextualize the identified themes.

## Results and Discussion

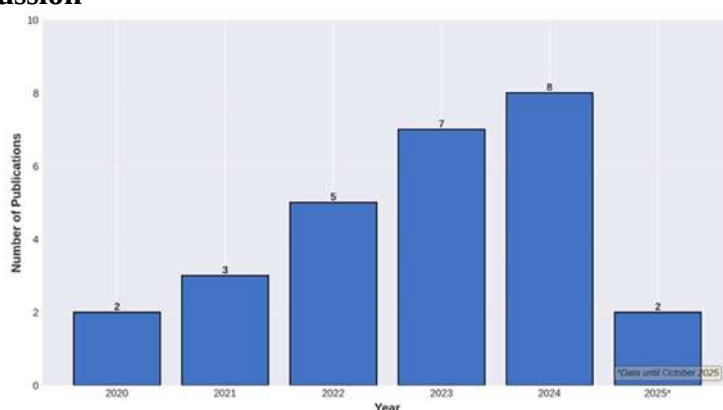


**Figure 1. Publication Trends of E-Module Research (2020-2025)**

Analysis of the 27 included studies revealed a notable increasing trend in e-module research publications between 2020 and 2025. As shown in Figure 2, the distribution showed: 2020 (n=2, 7.4%), 2021 (n=3, 11.1%), 2022 (n=5, 18.5%), 2023 (n=7, 25.9%), 2024 (n=8, 29.6%), and 2025 (n=2, 7.4% - noting that 2025 data only covers January-October). This upward trend aligns with the broader acceleration of digital learning adoption in Indonesia



following the COVID-19 pandemic, which catalyzed significant investment in educational technology infrastructure and digital content development (Rahiem, 2020). The sustained growth in publications suggests that e-modules have become an established research focus within Indonesian educational technology discourse, reflecting both practitioner interest and policy emphasis on digital transformation in education.

Regarding subject area distribution, the review identified a strong concentration in STEM fields, particularly Physics (n=8, 29.6%), Biology (n=6, 22.2%), and Mathematics (n=5, 18.5%). Chemistry (n=3, 11.1%), Geography (n=2, 7.4%), and other subjects including Indonesian Language, Civics, and Economics (n=3, 11.1%) were less frequently represented, as illustrated in Figure 3. This STEM dominance reflects the historical emphasis in Indonesian education policy on strengthening science and mathematics education as foundations for technological development and economic competitiveness. However, this pattern also reveals a significant gap in e-module research for humanities and social science subjects, where 21st-century skill development is equally critical. The limited representation of non-STEM subjects (22.2% combined) suggests an opportunity for future research to extend e-module innovations across the curriculum to ensure equitable access to technology-enhanced learning opportunities.

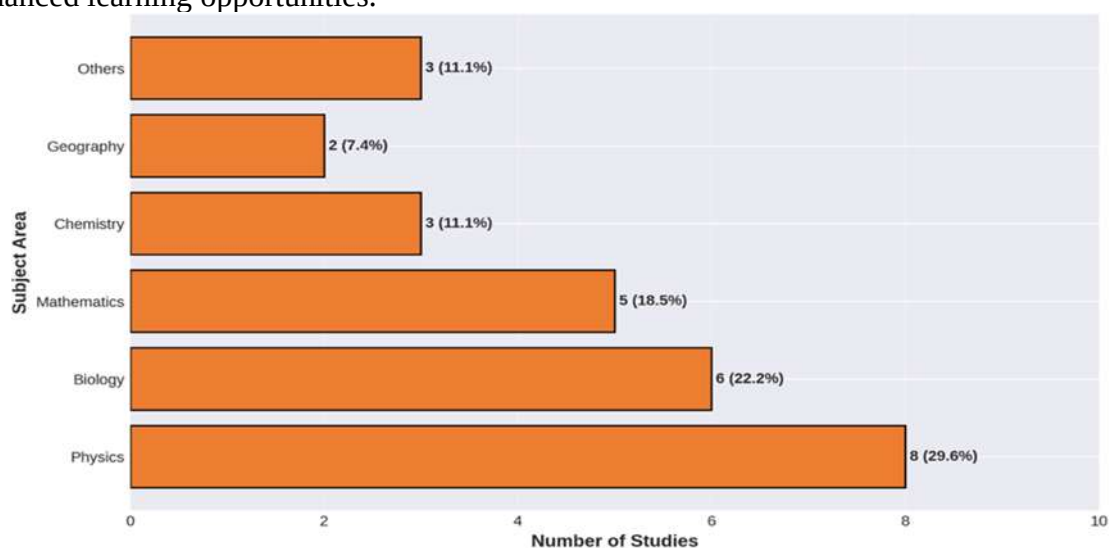


**Figure 2. Distribution of E-Modules Studies by Subject Area**

Educational level analysis revealed that senior high school (SMA/MA) was the predominant focus (n=18, 66.7%), followed by junior high school (SMP/MTs) (n=6, 22.2%), and elementary school (SD/MI) (n=3, 11.1%), as depicted in Figure 4. The concentration at the senior high school level may be attributed to several factors: (1) greater alignment between senior high school curriculum and advanced 21st-century competencies, (2) higher technological readiness and digital literacy among senior high school students, (3) increased emphasis on preparing students for higher education and workforce entry, and (4) greater research accessibility to senior high school contexts. The limited representation of elementary level research (11.1%) indicates a critical gap, particularly given that early foundational development of 21<sup>st</sup> century skills is recognized as essential for long-term competency building. This finding highlights the need for expanded research attention to e-module development for younger learners, with age-appropriate design considerations and pedagogical approaches.

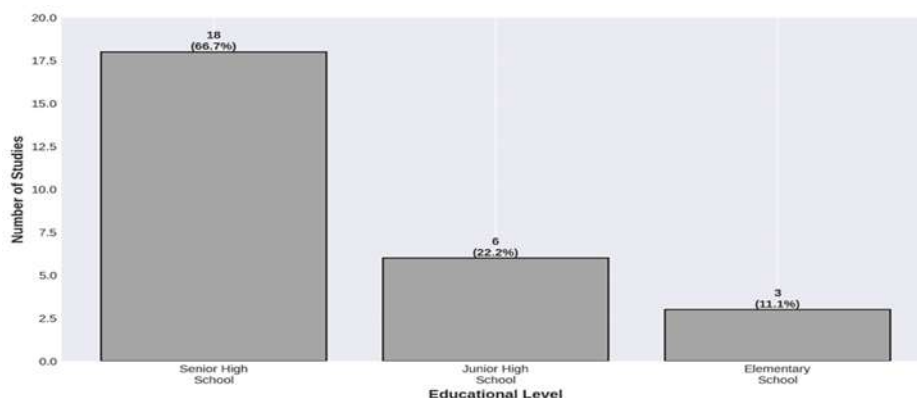


**Figure 3. Distribution of Studies by Educational Level**

### **E-Module Development Models and Characteristics**

Analysis of development models employed in e-module creation revealed diverse approaches, with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model being most prevalent (n=12, 44.4%), followed by 4D (Define, Design, Develop, Disseminate) model (n=8, 29.6%), and Borg & Gall development research model (n=7, 25.9%), as shown in Figure 5. The dominance of ADDIE reflects its widespread recognition as a systematic, flexible, and comprehensive instructional design framework suitable for digital learning material development (Sugiarto & Hidayat, 2021). The 4D model's popularity, particularly in Indonesian research contexts, can be attributed to its streamlined approach that balances rigor with practical feasibility, making it accessible for graduate student research and teacher researchers working within resource constraints. The diversity of development models employed suggests methodological maturity in the field, with researchers selecting frameworks aligned with specific project requirements and institutional contexts.

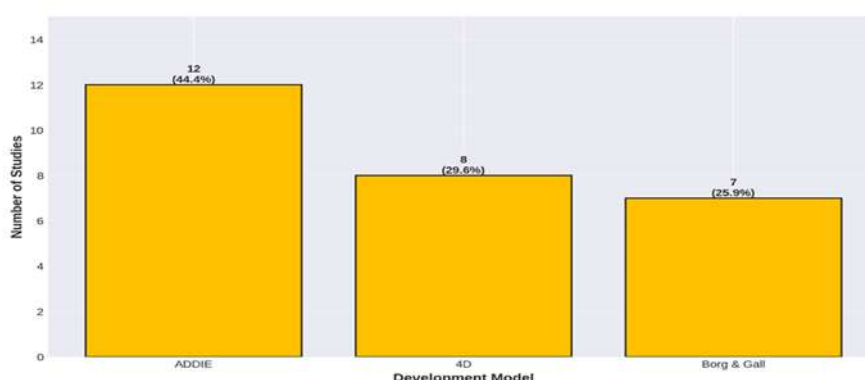


**Figure 4. E-Modules Development Models Used**

Regarding multimedia and interactive features, the included studies demonstrated varying levels of technological sophistication. As illustrated in Figure 5, common features included: navigation buttons and hyperlinks (n=27, 100%), static images and diagrams (n=25, 92.6%), videos and animations (n=21, 77.8%), interactive quizzes and assessments (n=19, 70.4%), simulations and virtual experiments (n=12, 44.4%), and adaptive learning pathways (n=5, 18.5%). This finding indicates opportunities for future development to leverage more sophisticated technologies, including artificial intelligence driven personalization and immersive learning environments, to enhance engagement and learning effectiveness.

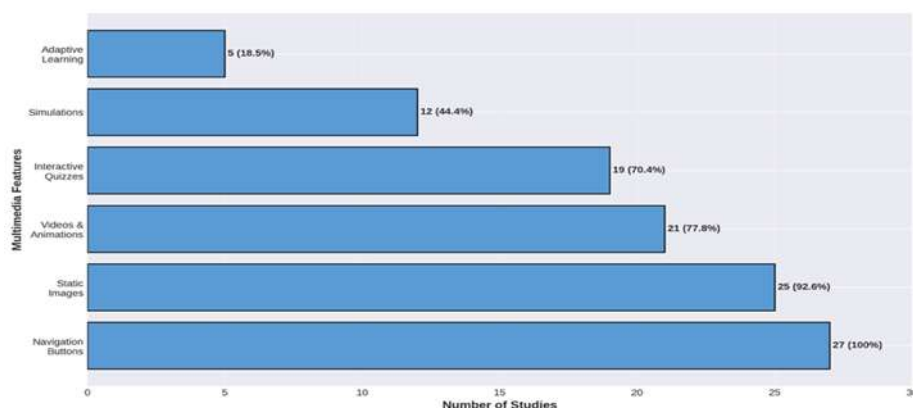


**Figure 5. Implementation of Multimedia and Interactive Features**

Pedagogical integration analysis revealed that most e-modules incorporated specific learning approaches aligned with 21<sup>st</sup> century skill development. As presented in Figure 6, Problem Based Learning (PBL) was most frequently integrated (n=11, 40.7%), followed by inquiry-based learning (n=8, 29.6%), project based learning (n=6, 22.2%), and STEM/STEAM approaches (n=5, 18.5%). The prominence of PBL aligns with research demonstrating its effectiveness in developing critical thinking and problem-solving skills through authentic, contextualized challenges (Hendriyani & Ansyar, 2021). The integration of these active learning pedagogies within e-module designs represents a significant advancement beyond traditional expository approaches, positioning e-modules as vehicles for transformative learning experiences rather than merely digitized textbooks. However, the review also noted that pedagogical integration depth varied considerably, with some studies implementing comprehensive PBL frameworks while others incorporated only surface-level elements.

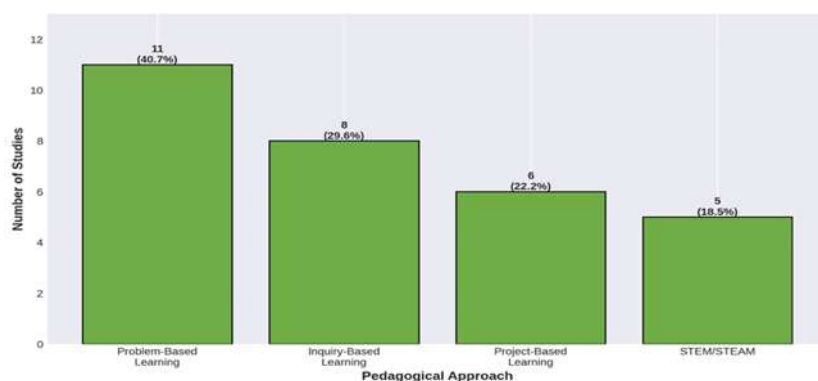


**Figure 6. Pedagogical Approaches Integrated in E-Modules**

### 21<sup>st</sup> Century Skills Development

Analysis of the 27 studies revealed an uneven distribution across the 4C framework. As shown in Figure 8, critical thinking was the most frequently targeted skill (n=22, 81.5%), followed by creativity (n=14, 51.9%), communication (n=12, 44.4%), and collaboration (n=9, 33.3%). Critical thinking was commonly developed through problem-solving, case analysis, evaluation, and argumentation activities, and was more consistently assessed using established tests or rubrics. Its prominence may reflect both its central role in 21st-century learning and the availability of established assessment instruments.

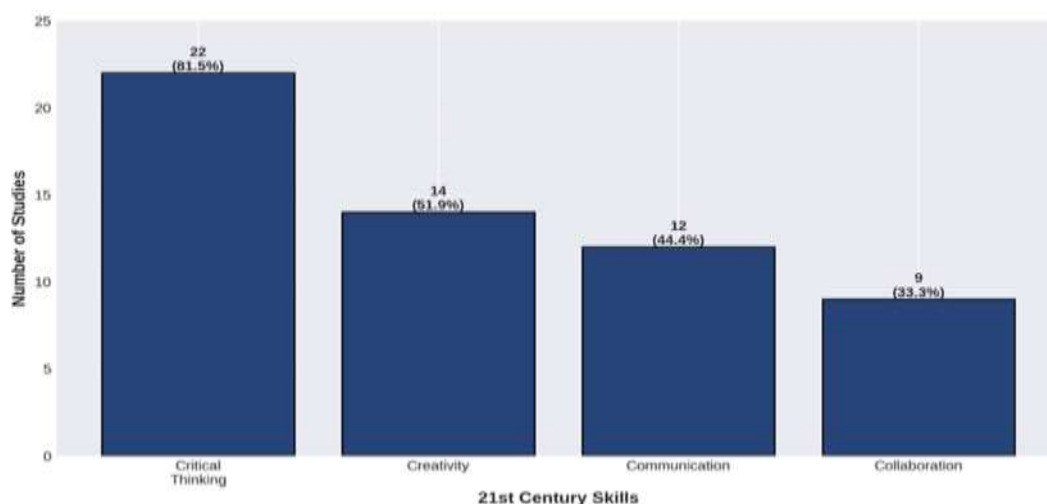


**Figure 7. 21<sup>st</sup> Century Skills Explicitly Targeted in E-Modules**

Creativity, addressed in 51.9% of studies, was fostered through design challenges, open-ended projects, alternative-solution tasks, and artistic production. However, its assessment was less standardized than that of critical thinking, relying on approaches such as the Torrance Tests of Creative Thinking, product-evaluation rubrics, and observation. This variation indicates continuing challenges in defining and measuring creativity, particularly in subjects traditionally associated with more convergent learning objectives. Communication (44.4%) and collaboration (33.3%) were less frequently identified as explicit learning outcomes. Communication was developed through presentations, written reports, peer explanation, and multimedia production, while collaboration involved group projects, peer review, and discussion forums. Their lower representation may be partly related to the individual and asynchronous nature of many e-module activities, although some studies may have embedded these skills without explicitly measuring them as outcomes. A key finding was that only 7 studies (25.9%) explicitly integrated all four 4C skills. Most focused on one or two skills, typically critical thinking combined with creativity or communication, suggesting that 4C development remains relatively fragmented. Because these competencies are interconnected and mutually reinforcing, future e-module designs should move beyond isolated skill targeting by using scaffolded, authentic learning sequences in which students simultaneously communicate, collaborate, evaluate alternatives, and generate solutions. Such integration would strengthen the potential of e-modules to support holistic 21st-century competency development.

### **Implementation Challenges and Barriers**

Despite the predominantly positive effectiveness findings, the review identified several implementation barriers that can moderate the benefits of e-modules. Technological infrastructure was the most frequently reported challenge (n=15, 55.6%), particularly inadequate internet connectivity, limited device availability, and gaps in digital literacy among teachers and students. These constraints were more evident in rural and economically disadvantaged contexts, where unstable connectivity could prevent students from accessing multimedia content or completing interactive activities. Thus, the effectiveness of an e-module depends not only on its instructional quality but also on the availability and reliability of the infrastructure required to use it. Despite the predominantly positive effectiveness findings, the review identified several implementation barriers that can moderate the benefits of e-modules. Technological infrastructure was the most frequently reported challenge (n=15,



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Teacher readiness and pedagogical adaptation were the second major barrier (n=13, 48.1%). Effective implementation requires teachers to move beyond conventional instructor-centered practices toward facilitative roles involving guidance, feedback, learning management, and formative assessment. Some teachers reported limited confidence with digital tools and difficulty integrating e-modules into existing curricula and time constraints. The findings therefore indicate that professional development should combine technical competence with pedagogical preparation in student-centered learning, formative assessment, and differentiated instruction (Akram et al., 2022; Bui, 2022; Gudmundsdottir & Hatlevik, 2023). Student-related factors also influenced implementation, particularly the self-direction required by e-module learning. Some students experienced difficulties with time management, persistence, and independent navigation, while students with lower prior achievement or learning difficulties could become overwhelmed by complex content without adequate teacher support. These findings suggest that e-modules should not be implemented as fully independent learning tools; rather, clear learning goals, scaffolding, monitoring, self-assessment, and teacher facilitation are needed to strengthen students' self-regulated learning and ensure equitable participation (Alvarez et al., 2022; Dong et al., 2024; Devolder et al., 2012).

Sustainability and scalability were reported in 8 studies (29.6%), indicating a further gap between e-module development and long-term educational use. Many e-modules were developed for individual research projects, while relatively few studies described mechanisms for continued hosting, updating, quality assurance, licensing, or dissemination through institutional learning management systems. This limits the broader impact of otherwise effective innovations. Sustainable implementation therefore requires institutional support, maintenance mechanisms, teacher capacity, and systems for sharing and continuously improving digital learning resources. Overall, the barriers identified in the review are interconnected: infrastructure enables access, teacher readiness enables meaningful pedagogical use, student support enables effective engagement, and sustainability determines whether successful e-module innovations can be maintained and scaled.

## **Conclusion**

This systematic literature review provides comprehensive evidence regarding e-module effectiveness in enhancing 21<sup>st</sup> century skills within Indonesian educational contexts. Analysis of 27 studies published between 2020-2025 reveals several key conclusions. First, e-module research in Indonesia has experienced sustained growth, particularly following the COVID-19 pandemic, reflecting accelerated digital transformation in education. Second, current research concentrates predominantly on STEM subjects (Physics, Biology, Mathematics) at the senior high school level, indicating opportunities for expanded research across humanities, social sciences, and elementary education levels. Third, while various development models are employed (ADDIE, 4D, Borg & Gall), pedagogical integration depth varies considerably, with Problem Based Learning being the most common approach. Fourth, regarding 21<sup>st</sup> century skill development, critical thinking receives the strongest research



attention (81.5% of studies), while creativity (51.9%), communication (44.4%), and collaboration (33.3%) are less frequently addressed. Only 25.9% of studies explicitly target all four 4C skills in integrated fashion, suggesting a need for more holistic approaches to 21<sup>st</sup> century competency development. Fifth, effectiveness evidence is predominantly positive, with 88.9% of studies reporting significant learning outcome improvements and 86.4% documenting critical thinking gains. Effect sizes are generally moderate to large, providing strong support for e-modules as effective instructional tools. Sixth, implementation challenges related to technological infrastructure, teacher readiness, student self regulation capacity, and sustainability mechanisms require systematic attention to ensure equitable and enduring impact.

The review's findings contribute to educational technology literature by providing empirical mapping of e-module research trends and effectiveness patterns specifically within the Indonesian context. Unlike previous studies examining e-modules in isolation or focusing narrowly on technical development aspects, this review adopts a comprehensive lens examining pedagogical integration, skill development outcomes, and implementation realities. The systematic application of PRISMA 2020 protocols enhances the review's methodological rigor and replicability. Findings provide actionable insights for multiple stakeholders: researchers can identify gaps warranting future investigation, developers can incorporate evidence-based design principles, educators can make informed adoption decisions, and policymakers can establish supportive infrastructure and professional development programs.

## **Recommendation**

**Implications for Practice & Instructional Design:** E-module developers, teachers, and policymakers should prioritize pedagogically purposeful e-module designs that integrate the four 21st-century skills (critical thinking, creativity, communication, and collaboration) through authentic, scaffolded, and student-centered learning activities, rather than relying primarily on technological features; particular attention should be given to collaborative and communicative tasks, formative assessment, self-regulated learning support, and age-appropriate differentiation, while teachers should receive professional development that combines technical competence with facilitative, student-centered, and formative instructional practices, and policymakers should strengthen equitable infrastructure, teacher support, and sustainable mechanisms for e-module hosting, quality assurance, dissemination, and maintenance, especially in resource-constrained contexts.

**Agenda for Future Research:** Future researchers should address the gaps identified in this SLR by investigating e-module implementation and effectiveness across underrepresented humanities and social science subjects, elementary and vocational education, and diverse urban-rural and socioeconomic contexts; studies should also examine all four 4C skills in an integrated manner using explicit and validated outcome measures, employ stronger comparative or experimental designs where feasible, and conduct longitudinal investigations to determine skill retention, transfer to novel contexts, and longer-term academic or career outcomes, while examining how teacher readiness, student support, institutional conditions, infrastructure, and sustainability mechanisms influence the effectiveness and scalability of e-module interventions.



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