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Literature Review on Development of Interactive E-Modules to Improve Science Learning Achievement in Elementary Schools

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Abstract
Advances in digital technology have driven the development of innovative learning media such as interactive e-modules; however, their use in elementary schools remains suboptimal. This study aims to describe the characteristics of interactive e-module development and identify opportunities for innovation based on limitations in previous studies. The method used is a Systematic Literature Review (SLR) following the Kitchenham and Charters model, analyzing six relevant articles from 2022–2025 using content and thematic analysis. The findings indicate that interactive e-modules positively impact students' learning outcomes, motivation, and participation. Their development generally employs structured models such as ADDIE and 4D combined with a constructivist approach, along with multimedia and digital platforms like web and Android to enhance accessibility and interaction. Therefore, interactive e-modules are considered effective in improving science learning at the elementary level. However, prior studies mainly focus on basic cognitive skills and have not fully supported deep learning approaches, highlighting the need for further development that emphasizes reflective, analytical, and exploratory activities to strengthen conceptual understanding and higher-order thinking skills.
Keywords: *deep learning, e-module, elementary school, interactive learning, science education*

Abstrak
Kemajuan teknologi digital mendorong lahirnya media pembelajaran inovatif seperti e-modul interaktif, namun pemanfaatannya di sekolah dasar masih belum optimal. Penelitian ini bertujuan mendeskripsikan karakteristik pengembangan e-modul interaktif serta mengidentifikasi peluang inovasi dari keterbatasan studi sebelumnya. Metode yang digunakan adalah Systematic Literature Review (SLR) model Kitchenham dan Charters terhadap enam artikel periode 2022–2025, dengan analisis konten dan tematik. Hasil kajian menunjukkan bahwa e-modul interaktif mampu meningkatkan hasil belajar, motivasi, dan partisipasi siswa. Pengembangannya umumnya menggunakan model ADDIE dan 4D berbasis konstruktivisme, serta memanfaatkan multimedia dan platform digital seperti web dan Android untuk meningkatkan aksesibilitas dan interaksi. E-modul interaktif dinilai efektif dalam pembelajaran IPA. Namun, penelitian sebelumnya masih berfokus pada keterampilan kognitif dasar dan belum mendukung pendekatan deep learning, sehingga diperlukan pengembangan yang menekankan aktivitas reflektif, analitis, dan eksploratif guna meningkatkan pemahaman konseptual dan kemampuan berpikir tingkat tinggi.
Kata kunci: *pembelajaran mendalam, e-modul, sekolah dasar, pembelajaran interaktif, pendidikan IPA*

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INTRODUCTION

The development of digital technology has contributed to and significantly influenced the development of education. This development has also impacted the learning process at the elementary school level (Humairah & Safutri, 2023). These changes encourage teachers to adapt to technological advancements through innovative learning media that are more engaging, effective, and tailored to student characteristics (Stumbrienė et al., 2024; Yao et al., 2021). One innovation that has been widely developed is the electronic module, commonly known as e-module (Ramadhina & Pranata, 2022). E-modules are digital teaching materials that can be accessed through electronic devices such as computers, tablets, and smartphones (Holisoh et al., 2025; Wulansari et al., 2023). E-modules provide a platform with high learning flexibility, enabling students to learn independently and providing a more meaningful learning experience through text, images, videos, animations, and other interactive media (DELITA et al., 2022; Gunawan et al., 2024).

From the perspective of Natural Science (IPA) learning in elementary schools, e-modules play a crucial and strategic role. This is because e-modules can help students understand abstract science concepts and natural phenomena that cannot be directly observed in the classroom (Christina Ismaniati & Baroroh Iskhamdhanah, 2023; Suwandi et al., 2023). This makes e-modules an innovative medium that can be used to improve students' learning outcomes, motivation, and scientific thinking skills (Sumarmi et al., 2021). Therefore, the implementation of e-modules in elementary school science learning needs to be expanded and increased.

However, the implementation of digital learning media in elementary schools still faces various obstacles. Elementary school learning generally relies on textbooks and lecture methods (Woods & Copur-Gencturk, 2024). This method tends to make students passive and less engaged in the classroom learning process (Hsia et al., 2021). Teachers are also not yet skilled in designing and utilizing interactive learning media due to limited time, technological capabilities, and other supporting facilities (Lorensius et al., 2023). This inevitably results in the failure to achieve science learning that fosters students' curiosity and scientific thinking skills. This situation clearly indicates that the use of e-modules as interactive learning media is still suboptimal at the elementary school level.

Various previous studies have been conducted in an effort to develop e-modules in the context of elementary school science learning.(Virginia Saragih et al., 2024) developed a contextual e-module approach that was proven effective in improving science learning outcomes. (Ramadhani & Andriani, 2024) developed an inquiry-based e-module that encourages students' scientific thinking skills. Meanwhile, (Apsari & Agustin, 2025) created a problem-based e-module that can improve problem-solving skills. Other studies by (Muhamad et al., 2022) and (Sitepu et al., 2023) developed web-based and Android-based e-modules on the Solar System, while (Rika Safitri & Dafit, 2025) integrated interactive multimedia features into a science e-module that has been proven to significantly improve learning outcomes. Various findings from these studies indicate that e-modules can function as a means to increase student engagement in the direct learning process.

Despite extensive research, several limitations of previous studies remain that need to be addressed. Some e-modules rely solely on linear information presentation without maximizing the potential of interactive media and enhancing students' independent learning. Furthermore, effectiveness tests conducted are generally limited to a small scope and do not fully represent diverse learning contexts. Most e-module development also focuses on validity and practicality. Their development fails to consider novel aspects such as gamification, adaptive learning, and integration with online learning platforms. This is evidenced by the scarcity of empirical research examining this topic in depth and comprehensively. These limitations certainly present a significant opportunity for further development of more dynamic e-modules that are more tailored to student needs in today's learning system.

Interactive e-modules have several advantages over conventional digital teaching materials. The use of interactive e-modules enables two-way communication between students and the media and serves as an effective communication tool between students and teachers (H et al., 2021; Tarigan et al., 2021). Effective interaction and communication enable students not only to receive information but also to directly participate through simulations, animations, and evaluations to maximize their learning outcomes. (Pratama et al., 2024) stated that the integration of interactivity in e-modules contributes significantly to increased student motivation, learning outcomes, and knowledge retention. This is in line with constructivism theory, which emphasizes that learning is an active process in which students construct their own understanding through experience and reflection facilitated by engaging and challenging learning media (Nurhasnah et al., 2024; Zajda, 2021).

Based on the research results, it appears that the development of interactive e-modules for science learning in elementary schools has progressed. However, there is still room for further improvement and innovation. To generate ideas for novel solutions, it is necessary to formulate these opportunities based on various previous studies. Therefore, a systematic review is needed that can map the patterns of research that have been conducted and identify their limitations for the development of more innovative and meaningful interactive e-modules. This Systematic Literature Review aims to describe how interactive e-modules are developed based on the findings of relevant previous studies. Furthermore, this study aims to identify aspects that can still be developed based on the limitations of previous developments. The findings and results of this review are expected to provide a comprehensive overview of the direction of interactive e-module development in the future and serve as the main basis for formulating learning innovations, specifically for e-modules at the elementary school level.

METHOD

This research is a Systematic Literature Review (SLR) adapted from the model (Kitchenham & Charters, 2007). This model was chosen because it provides a systematic and flexible framework for reviewing research on learning media development (Artanti et al., 2025), particularly interactive e-modules. This approach aims to provide an overview of the patterns and characteristics of e-module development that have been conducted. Furthermore, this approach will identify potential innovations that can be developed in the future based on previous research.

The review process consists of three main stages: planning, implementation, and reporting. The planning stage is used to formulate the study's focus and research questions. The research questions used are in accordance with the analysis objectives: 1) What are the characteristics of interactive e-module development in science/science learning in elementary schools and 2) What aspects can be further developed to improve the effectiveness of interactive e-modules. The implementation stage consists of searching, selecting, and extracting data from research articles. The search was conducted using the Google Scholar database using the keywords "development of interactive e-modules for elementary school science," "e-module for elementary school science," and "interactive e-module for elementary science." The publication range uses the most recent year, with a limit of 2022–2025, to capture the most recent and up-to-date research results.

Data sources or articles analyzed were selected based on specific criteria to ensure relevance to the research focus. This selection process is illustrated through inclusion and exclusion criteria. The criteria used are fully explained in Figure 1.

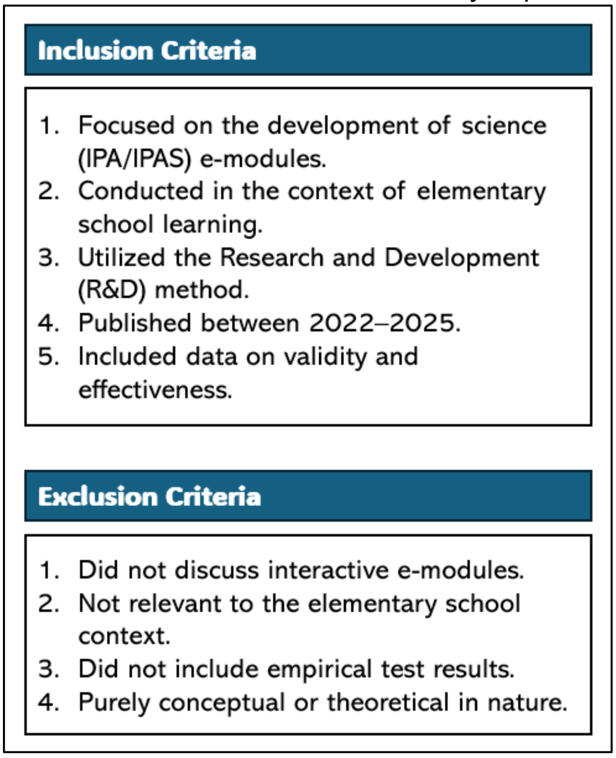

Figure 1. Inclusion and Exclusion Criteria (Artanti et al., 2025)

The articles were obtained through a search of the Google Scholar database to collect and identify all research articles related to the study. The keywords “development of interactive e-modules” and “science learning” were used to obtain a list of relevant articles published between 2022 and 2025. The search results are detailed as shown in the Table 1.

Table 1. Database articles published

Database	Result
Google scholar	663
Total	663

The initial search yielded 663 articles relevant to the topic of analysis. The next step involved screening and selecting articles based on inclusion and exclusion criteria. The screening and selection process was part of the planning phase, as presented in the Table 2.

Table 2. Stages of article selection and screening

Stage	Criteria	Result
Initial identification	Enter keywords into the database	663 article
First screening	Inclusion criteria	83 article
Second screening	Exclusion criteria	6 article
Result	Screening result	6 article

The initial screening and selection process yielded 663 articles. The application of inclusion criteria eliminated some articles, leaving 83 titles that were relevant to the research topic. The subsequent application of exclusion criteria further narrowed the selection, resulting in 6 articles that were relevant to the research topic. These six articles underwent in-depth analysis to identify their content according to the analysis theme. General information extracted from the articles included citations, development model, research approach, media, and main research findings. The six relevant articles also exhibit a pattern of similarity with the vosviewer application shown in the Figure 2.

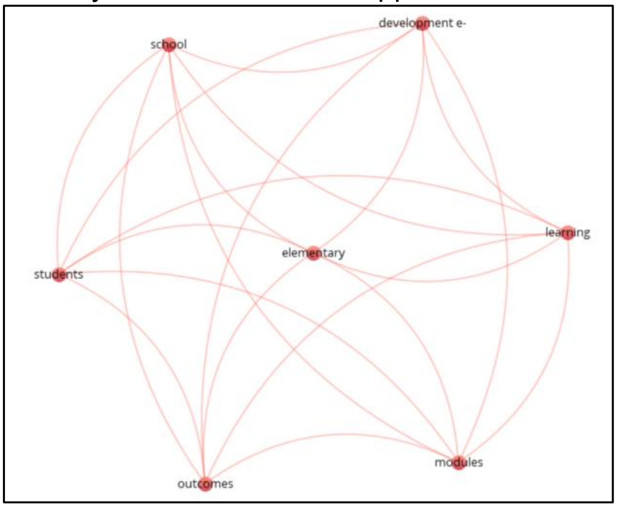

Figure 2. Visualization based on keywords

The visualization results show that elementary schools are the focus of the analysis. Research on elementary schools is related to other keywords such as students, schools, e-module development, learning, learning modules, and learning outcomes. These visualization results demonstrate the alignment of the analysis with the articles selected for analysis. The six articles were then analyzed using the predetermined analytical method.

The analysis was conducted using two methods: content analysis to extract factual data, and thematic analysis to group findings into main themes. The two main themes of this study were the applied development model and opportunities for future innovation. The synthesis results will provide an overview of general trends and identify research gaps relevant to the direction of developing more innovative and effective e-modules. To ensure the validity of the data obtained, literature triangulation and consistent application of selection criteria were conducted to avoid interpretation bias (Sindurnata et al., 2024).

RESULTS AND DISCUSSIONS

Characteristics and Development Patterns of Interactive Science E-Modules in Elementary Schools

The development of interactive e-modules in science learning in elementary schools has generally utilized a systematic model framework and is oriented toward active learning. The use of technology has also been implemented in several development projects, facilitating access to e-modules. Interactive e-modules serve as a medium for developing pedagogical skills through the use of technology. This can certainly create engaging and meaningful science learning tailored to student characteristics. A complete breakdown of the characteristics and development patterns is described in Table 3.

Table 3. Details of Article Synthesis Results

Writer	RnD model	Approach	Media	Results
(Virginia Saragih et al., 2024)	ADDIE	Contextual Teaching and Learning	PC-based digital e-module	The e-module meets the criteria for being very valid and effective in improving student learning outcomes.
(Ramadhani & Andriani, 2024)	ADDIE	Inquiry Learning	Computer-based interactive e-module	High validity and encourages increased learning outcomes in the moderate category
(Apsari & Agustin, 2025)	ADDIE	Problem-Based Learning (PBL)	Interactive e-module with problem solving activities	E-module meets validity and effectiveness tests with high N-gain
(Muhamad et al., 2022)	4D	Interactive exploration	Web Based	Validation and practicality test results in the high category
(Sitepu et al., 2023)	ADDIE	Interactive multimedia-based	Android Application	E-modules are proven to be valid, practical, and effective.
(Rika Safitri & Dafit, 2025)	ADDIE	Based on multimedia and constructivism	Interactive digital (multimedia)	Validation and practicality are in the high category and supported by good effectiveness.

A synthesis of six articles revealed that the development of interactive e-modules for science learning in elementary schools exhibits a relatively uniform and focused pattern. Each stage of Research and Development (R&D) predominantly refers to the ADDIE development model, with a few studies using the 4D model. Both models essentially share similar development stages, ranging from needs analysis, design, product development, limited implementation, and evaluation. This pattern demonstrates that e-module development at the elementary school level has been conducted appropriately and oriented to the needs of students at the elementary school level. Therefore, the e-module product can be applied in the learning process and has a significant impact.

The developed e-modules also utilize specific learning approaches in their implementation. This suggests a tendency for efforts and strategies to involve students directly in the learning process. Several studies have employed Contextual Teaching and Learning, Inquiry Learning, and Problem-Based Learning. These three approaches emphasize exploration, discovery, and problem-solving. The development of interactive e-modules is intended to enhance children's pedagogical skills through science learning in elementary schools. Therefore, students' learning outcomes in science concepts are obtained in a more in-depth and meaningful way.

The development of e-modules has also been integrated with various digital platforms such as multimedia-based computers, interactive web platforms, and Android applications. This variation demonstrates the diversity of technological developments and their potential to facilitate student accessibility in their learning process. Websites and Android platforms are the primary platforms due to their flexibility and ability to be used independently outside of class hours. Furthermore, their choice facilitates a variety of media, such as animation, video, images, and automated quizzes. This makes e-modules engaging teaching materials and can directly increase student participation. In the science context, they also facilitate students' understanding of abstract concepts, enabling them to better grasp them through their five senses.

Test results for the developed e-modules indicate relatively high levels of validity, practicality, and effectiveness. Validity scores are in the valid or even very valid categories. Furthermore, practicality test results also demonstrate positive responses from both teachers and students. Therefore, the e-modules meet the practical criteria for use in supporting science learning in elementary schools. The use of interactive e-modules also has a direct impact on improving conceptual understanding and student learning motivation, according to several synthesized research reports. In addition, the variable of active student involvement during the learning process also increased because students were directly involved in the learning process which emphasized interaction with digital media.

Limitations and Future Directions for Interactive E-Module Development

To explain opportunities for further development, this study also outlines the limitations of the research conducted based on the synthesis results. The development focused on achieving basic cognitive learning outcomes. Furthermore, the developed e-modules emphasized information delivery through visual media and interactive quizzes, but did not fully support the deep learning approach. This approach would encourage the development of conceptual, analytical, and reflective thinking skills. Learning using the developed e-modules was not fully integrated with in-depth understanding and connected to real-life contexts, as is the current concept of deep learning. Further development is open and potential, including developing e-modules that can foster higher-order thinking skills and implement learning with a deep learning approach.

The interactivity of e-modules as visual aids and as a means of thinking and constructing meaning in learning also presents an opportunity for development. Development directions that focus on designing interactive e-modules with a deep learning approach need to be actualized. E-modules must be able to integrate exploration, reflection, and in-depth analysis. More specifically, in the context of the Solar System, e-modules can be developed by presenting interactive simulations and conceptual visualizations. This will make it easier for students to identify and understand the relationship between solar system phenomena and everyday life. E-modules should also be supplemented with reflective questions and reasoning activities that help students construct their own understanding. This way, the knowledge gained becomes more meaningful and not simply a repetition of previously learned information.

Interactive e-modules should emphasize creating deep learning experiences that foster students' conceptual understanding and scientific awareness. E-modules can be used as digital learning spaces that encourage ongoing, in-depth thinking. Reinforcing deep learning principles in science e-modules can help students understand concepts based on natural phenomena holistically and reflectively. With this approach, interactive e-modules can serve as a means to foster deep and scientific thinking from the elementary school level.

Discussions

The findings of this article synthesis indicate that the development of interactive e-modules for science learning in elementary schools is carried out using R&D approaches such as ADDIE or 4D. Using an appropriate development approach can create e-modules for science learning for elementary school students with high validity. The development methods and approaches align with previous research that emphasizes the importance of needs analysis, media design, and product evaluation when creating digital teaching materials (Herman et al., 2024; Sakkir et al., 2021). Using an appropriate development approach can ensure that e-modules are not only developed quickly but also systematically planned to ensure validity and quality when implemented in science learning in elementary schools.

Several studies have shown that interactive e-modules using animation, simulation, video, and quizzes can increase student interest and engagement (Darpiyah & Sulastri, 2023; H et al., 2021). Furthermore, the use of flipbook e-modules has also been shown to increase motivation and knowledge of science concepts in elementary schools (Sari et al., 2024). However, the synthesis of findings shows that the developed modules still focus on mastering information and procedures, which are fundamental skills for students. This certainly needs further development to create digital learning tools that incorporate visual activities and can help students develop critical and reflective thinking skills.

Although interactive modules have been tested for effectiveness and proven to improve learning outcomes, studies explaining how students develop deep conceptual understanding or apply knowledge in new situations are rare. Similar research also shows that, despite easy access to visualizations and simulations, students are not guided to identify cause-and-effect relationships in various natural phenomena (Drastisianti et al., 2024). This clearly suggests that interactive e-modules in elementary schools need further development to support deep learning approaches.

In learning about the Solar System, research shows that the use of interactive simulations and visualizations can help students understand difficult and abstract concepts (Nurlita Rahmadhania et al., 2024). However, to ensure truly meaningful learning, module designs that foster student engagement are necessary (Logan et al., 2021). Therefore, further research can develop and test interactive e-modules with a deep learning approach in learning about the Solar System for elementary school students. These modules are expected to improve learning outcomes and students' higher-order thinking skills. Large-sample trials are also needed to assess the extent to which the developed modules help improve student learning outcomes. Thus, interactive e-modules can develop from mere learning aids into effective means to foster scientific thinking from an early age through a deep learning approach.

CONCLUSION

The conclusion of the article synthesis shows that the development of interactive e-modules in elementary school science learning has had a positive impact on student learning outcomes, motivation, and participation. Most studies use structured development models with approaches such as ADDIE or 4D. The development also applies constructivist approaches including contextual teaching and learning, inquiry learning, and problem-based learning that encourage students to play an active role in the learning process. The integration of multimedia and digital platforms such as web and Android applications has increased accessibility and interaction in learning. However, previous research has focused on basic cognitive achievement and has not explored the development of deep learning and higher-order thinking skills. Further development is needed by emphasizing reflective, analytical, and exploratory activities to strengthen conceptual understanding. Interactive e-modules should not only be simple digital learning tools but also serve as meaningful platforms for implementing active learning with a deep learning approach.

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