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Teachers Strategies in Implementing E-Modules in Biology Learning: A Systematic Literature Review

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Abstract

Education has an important role in improving the quality of each individual. One of the efforts teachers can make to create an active, innovative, and interactive classroom atmosphere is to provide learning materials that are interesting and relevant to technological developments. Electronic modules are an alternative to independent teaching materials according to student learning needs. This study aims to review the results of the Systematic Literature Review (SLR) related to teacher strategies in implementing E-Modules in biology learning. This study analyzed scientific articles from reputable sources such as Google Scholar, Springer Nature, ERIC, and Scopus, focusing on publications from 2020 to 2024. The review results show that teachers' strategies in implementing e-modules are generally integrated with active and constructivist learning approaches that support the development of 21st-century skills. However, challenges like limited technological infrastructure, teachers' readiness to design interactive media, and students' adaptation to digital learning are still significant obstacles. Therefore, collaboration between educators, educational institutions, and the government is needed to overcome these obstacles by providing training, professional assistance, and adequate resources. It is hoped that the results of this study can be a reference for educators and researchers to develop more effective e-module implementation strategies in biology learning in the future.

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INTRODUCTION

Everyone can improve their quality through education. Providing learning materials that are interesting and relevant to technological advances in one way for teachers to create an active, innovative and interactive classroom environment. The development of technology in the digital era has brought significant changes in the world of education. Technology has a very important role in various fields, especially in the world of education (Mulyatna et al., 2022). In facing the upcoming challanges throughout this era educators are asked to adjust thier teaching style and are required not to lag behind information technology (Cholid et al., 2024). Therefore, the integration of technology in learning is an important step to support the creation of a more adaptive educational process, which is able to adapt to the needs and charateristics of students and the times.

Learning is the process of arranging and organizing the environment around students so that they can develop and be motivated to learn (Firmansyah & Triwahyuni, 2022). Therefore, learning can be defined as the process of providing guidance and assistance to students in learning process activities. In this case, the teacher acts as a mentor for some students who are having difficulties. There are variations in the learning process, for example in understanding lessons, where some students may find difficulties (Firman & Anhusadar, 2022). With these differences, it is important for teachers to be able ti adjust to the needs of each learner (Gunawan et al., 2020).

E-Modules are currently a learning innovation in the 21 st century which can be understood as an educational medium that does not only use paper as material so that in the development of technology, information and communication can be used as a modern educational paradigm (Aulakh et al., 2023; Barteita et al., 2020; Stecuła, 2022). This learning concept makes it easier for learners and teachers to obtain learning resources that are easily accessible. Teaching materials include all types of resources used to assist educators in organizing teaching and learning activities in the classroom. This teaching material can be in the form of printed or electronic teaching materials (Rahmatina, 2020). One example of electronic teaching materials is *e-modules*. The use of e-modules can make the learning process more interesting (Kurniawan et al., 2019). E-modules are teaching materials that present scientific knowledge from the thoughts of the author. E-modules also provide features of assignments, exercises, or evaluation materials, as well as other supporting resources to support learning process activities. The e-modules display is presented in electronic format, which includes animation, audio, navigation that makes users more interactive (Marcelina et al., 2022). The utilization of e-modules can help overcome time constraints during the learning process. Teachers can carry out learning not only in the classroom with limited time but can also provide lessons outside the school environment (Khairinal et al., 2021). These various advantages make e-modules very relevant to be applied to Biology learning which requires in depth understanding and independent pratice.

Biology is one of main subjects in secondary school, often a challange for many students. Biology studies living thins and their relationship with the environment. Biology can be taught in writing or orally. To make it easier to understand, learning biology should be done contextually, which involves students actively. This is in accordance with the word "education", which means that holistic cognitive behavioral motion greatly influences learning, which places learners at the core of thier learning activities (Jayawardana et al., 2020).

Sofyan et al. (2022), stated that technology in education has created new methods that facilitate the learning process of students at schools. With technology, methods are created that attract students' attention in learning and facilitate understanding of the material. By using e-modules, teachers can overcome time constraints in the learning process. Teacher not only teach in the classroom with limited time, but can also utilize e-modules for learning outside the school environment. It is important for schools to pay attention to the creation of e-modules for all teachers, so that students in the future are more adaptive to technological development (Fatimah & Muamar, 2024; Liana et al., 2024).

From the description of the background above, this study aims to systematically review the literature on teacher strategies in implementing e-

modules in biology learning. The systemtaic review is used to synthesize various relevant research results, as well as represent information from various problems contained in the research. A systematic review is needed to provide a clear picture of the strategies, key findings, and assessments in previous research.

METHODS

This study uses the Systematic Literature Review (SLR) method, to collect and analyze various articles that focus on teacher strategies in implementing e-modules in biology learning. The SLR approach is specifically designed to thoroughly review various studies on a particular subject. To ensure credible and high-quality articles, the process begins with a thorough search through reliable and easily accessible databases (Prasetya, 2021). This systematic literature review uses PRISMA guidelines and flowcharts. The stages carried out in the Systematic Literature Review are as follows.

Searching Strategy

Online search engines are used to find relevant sources that focus on teacher strategies in implementing e-modules in biology learning. Some online search engines used are ERIC, Scopus, Google Schoolar, and Springer.

Selection Criteria

The keywords used are "E-Module" AND "Biology", "E-Module" AND " Implementation ". After going through these stages, the results of the data search will be describe in the PRISMA flowchart then the data will be analyzed by combining data that meets the inclusion criteria and descriptive research quality assessment to provide an overview of the problems in the research question.

Inclusion and Exclusion Criteria

To apply inclusion and exclusion criteria is an important first step in the SLR process. These criteria help researchers narrow down the literature to the most relevant sources, ensuring that the analysis remains focused on high quality and credible material (Mukhammad et al., 2023). Furthermore, the criteria for selecting article were included and excluded to ensure that the data obtained was valid.

Table 1. Shows the criteria for article included and excluded

Criteria	Inclusion	Exclusion
Publication Time	Articles published in the last 5 years, namely from 2020 to 2024	Articles published before 2020, except for highly relevant studies
Type of Study	Empirical, qualitative, quantitative or mixed research	Opionion, editorial, or essay articles that have no empirical data
Language	Articles written in English	Articles are written in languages other than English
Participant	Senior high school	Elementary and high school
Accessibility	Articles with full access through trusted databases	Articles that are not available in full text or are abstract only
Journal Source	Article from international journals indexed by Scopus or Sinta (ranked 1-2)	Articles from non-indexed journals or those in Sinta below rank 2
Type of Publication	Articles published in journals	Articles published in conference proceedings, books, websites, blogs, and other similiar sources

Data Analysis

The data reviewed was obtained through the thematic analysis method and used to analyze the data. Articles were analyzed based on the research questions to get the research topics. The research questions were organized as follows: RQ (1) How are the strategies used by teachers in implementing electronic modules in biology learning? RQ (2) What are the challenges faced by teachers in implementing electronic modules in biology learning ?

Study Selection

The PRISMA model is used to select the literature obtained with the stages of identification, screening, eligibility, and included (Moher et al., 2009). The four stages are charted in Figure 1.

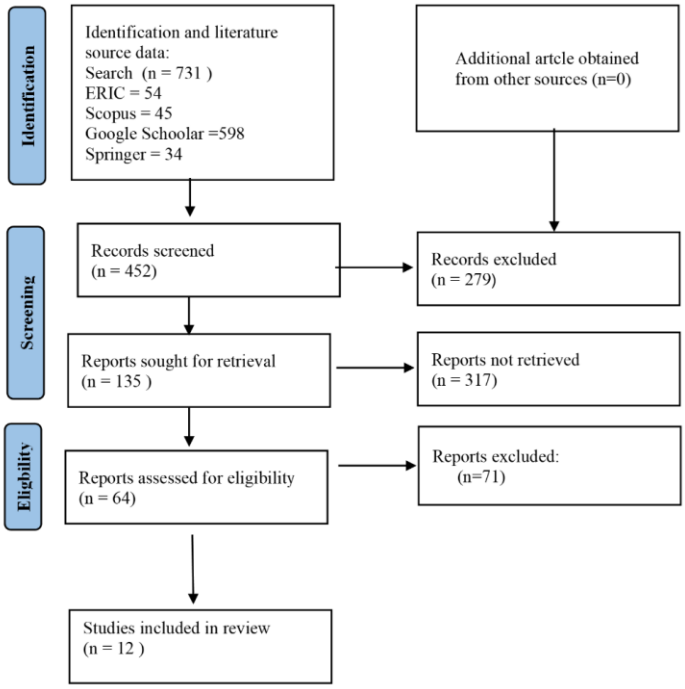

Figure 1. Literature Search and Screening Process Diagram

RESULTS AND DISCUSSION

Based on the results of the search process and the application of inclusion and exclusion criteria, as illustrated in the PRISMA flow chart, 731 articles were retrieved from several databased such as ERIC, Scopus, Google Schoolar, Springer. After the screening process, 452 article remained, and after eligibility assessment 64 articles were selected. Articles focusing on secondary school education were included, while those related to primary, junior secondary, university, and principal education were excluded. Finally, the 12 most relevant articles were analyzed in depth to answer the research questions.

Table 2. Literature Review Synthesis Results

No	Journal Name	Title	Author and Year	Results
1	E3S Web of Conferences	Development of PjBL Based Interactibe E-Modules with a Scientific Approach in Remediating Misconceptions in Biology Subject	Solviana et al. (2024)	The developed e-module is considered very feasible to use. After being implemented, this e-module is able to significantly reduce the level of misconceptions, so that learning becomes more effective. With student involvement through projects and scientific approaches, concept understanding becomes deeper.
2	International Journal of Instruction	The Effectiveness of STEAM Based Biotechnology Module Equipped with Flash Animation for Biology Learning in High School	Utomo et al. (2020)	STEM based biotechnology module equipped with flash animation proved to be valid and effective to be used in learning biology in high school. The use of this module is also

No	Journal Name	Title	Author and Year	Results
				able to significantly improve students understanding
3	International Journal of Learning, Teaching and Educational Research	Contructivist Learning Amid the COVID-19 Pandemic: Investigating Students Perceptions of Biology Self Learning Modules	Funa & Talaue (2021)	Most students rated the contructivism based biology learning module quite positively because it helps students to understand concepts and encourages independent learning even though it is used in an emergency situation of the covid 19 pandemic.
4	Jurnal Penelitian Pendidikan Sains (JPPS)	Development of CIRCSA Based E-module on Virus Materials to Improve Students Critical Thinking and Scientific Literacy	Irmasari et al. (2023)	The CIRCSA based e-module that integrates critical thinking and science literacy reached the criteria of highly valid. The feasibility of materials and media obtained a very valid category. In addition, student responses resulted in a very good category.
5	Journal of Physics Conference Series	The Development of Biology Module Based on Local Wisdom of West Lampung: Study of Ecosystem Material	Haka et al. (2020)	E-Modules based on local wisdom are declared feasible to use in the learning process based on the assessment of module quality by experts.
6	Jurnal Penelitian Pendidikan IPA (JPPIPA)	Development of E-Module Based on Science Technology Society (STS) on Immune System Material In Improving Students Critical Thinking Skills	Noviani & Hasanah (2024)	STS based e-modules are declared feasible and the results of limited trials of e-module use are declared practical.
7	Jurnal Penelitian Pendidikan IPA (JPPIPA)	Development of STEM based Biology E-Module to Improve Student Learning Outcomes	Irdawati et al. (2023)	The developed STEM based biology e-modules are considered highly valid, practical and effective to use. This e-modules helps improve student learning outcomes, both in terms of knowledge, attitudes and skills.
8	Jurnal Penelitian Pendidikan IPA (JPPIPA)	A Development of Flipped Claasroom Based on Electronic Module on Circulation System Material to Increase Student Learning Motivation	Samsil & Djukri (2024)	The use of this e-modules is proven to be feasible, effective and able to significantly increase student learning motivation in the classroom compared to conventional learning.
9	Jurnal Pendidikan Biologi (JPBIO)	Development of biology e-modules on environmental change integrated with wahdatul ulum	Nasution & Anas (2025)	Biology e-modules on environmental change material integratied with the concept of wahdatul ulum are declared very valid, practical, and quite effective to use.

No	Journal Name	Title	Author and Year	Results
10	Internastional Conference on Progressive Education	The Developing of e-module Flip Pdf Professional Based on Napai Ethnoscience to Improve Science Literacy on Biotechnology Materials	Juwita et al. (2023)	The developed Napai ethnoscience based professional flip PDF e-module is declared valid, very practical, and effective to use.
11	JIPI (Jurnal IPA dan Pembelajaran IPA)	Development of an Interactive E-Module Based Flipbook Protista Material To Improve Student Biology Learning Outcomes	Iwan et al. (2024)	The use of this e-module is proven to improve learning outcomes of biology learning because the design is interactive, interesting and makes it easier for students to understand the material through a combination of text, images, videos and animations.
12	Jurnal Biologi Inovasi Pendidikan (BIO-INOVED)	The validity of Biologi Module for Senior High School on Grade X in Even Semester Based on Critical Thinking Skills	Husna et al. (2021)	The developed critical thinking skills based biology module for grade X high school students was declared highly valid based on the experts assessment.

Based on Table 2, the authors author's identification of electronic module implementation in biology learning reveals that e-modules have become the main focus in many studies. These studies not only highlight improvement in student understanding, but also emphasize the importance of teacher strategies in facilitating independent learning, as well as their ability to design, adapt, and utilize e-modules to deliver biological content in a contextual and engaging manner supporting the achievement of 21st century competencies. This analysis confirms that teacher strategies play a crucial role in the successful implementation of electronic module through innovative approaches and the use of interactive media aligned with the characteristics of biology material (Munzil et al., 2022). Teachers strategies are essectial for effective e-module implementation as they serve as a bridge between technology and learners. Without teachers active involvement in adapting module content, selecting appropriate methods, and guiding learning, e-modules cannot function optimally (Prihatiningtyas et al., 2025). The success of e-modules heavily depends on teachers pedagogical skills and their innovation in creating interactive and critical thinking oriented learning experiences (Utari et al., 2024).

Amalia et al. (2024), argue that teachers act not only as facilitators, but also as guides and supporters in technology-based learning. In the context of the fourth Industrial Revolution, teachers are expected to integrate digital tools to make learning more contextual and interactive. Without the application of proper strategies, such as presenting foundational material or promoting two way discussions, students may become passive and struggle to develop critical thinking. According Khairunnisa (2024), emphasizes the strategic role of teachers in e-module success. In addition to delivering content, teachers must integrate interactive digital media and adopt strategies such as discovery learning based e-modules and the use of diverse online platforms. Their active role in designing, implementing, and evaluating e-modules is essential to strengthening students scientific process skills and critical thinking.

This finding also strengthens the relevance of the next discussion, which will explore more deeply how the strategy is implemented, as well as the obstacles it faces. Thus, the following discussion will focus on mapping strategies, challenges, and practical recommendations that support the optimization of the use of electronic modules in biology learning.

Strategies used by teachers in implementing electronic modules in biology learning

After reviewing articles relevant to the topic of biology learning, it was found that the strategies used in implementing electronic modules are generally integrated with various active learning approaches. Some studies show that teachers integrate e-modules with strategies that encourage student activeness and learning independence. For example, Solviana et al. (2024), combined Project Based Learning (PjBL) and the scientific approach in the design of interactive e-modules to facilitate students in designing, implementing, and evaluating real project, theraby developing their observation, reasoning, and commnication skills. This approach can be strengthened thThe scientific approach is applied by emphasizing through the integration of STEAM and flash, animations, as in (Utomo, 2020) research, which visualizes abstract biotechnology concepts to make them easier to understand. Chatri et al. (2023) also emphazied the use of interactive features (videos, animations) in STEM to conenct the material to real life and develop cognitive, affective, and psychomotor competencies.

Conversely, Funa & Talaue (2021), applied a constructivist based e-module through the 5E model (Engage, Explore, Explain, Elaborate, Evaluate), scaffolding, and remote assistance without STEM elements, with and emphasis on reflection and contextualization of concepts, especially during the pandemic. Irmasari et al. (2023), developed a CIRSA based e-module to enhance science literacy and critical thinking skills throguh reading, analyzing articles, group discussions, and scientific writing. Antother persepctive is offered by Hasanah, (2024) through the Science Technology Society (STS) approach, which connect biology material with real world issues in society, encouraging critical and reflective analysis of the science and technology relationship and the formulate of solutions. A number of studies also emphasize the integration of local cultural contexts as an important strategy in developing countries. Sari et al. (2020), Combine field pratices in e-modules to strengthen understanding of ecosystems while introducing students to culture and the enviroment. Juwita et al., (2023) integrate local napai cultural knowledge with science literacy through interactive digital features, while Hidayati & Waluyo (2020), demonstrate that the integration of local wisdom can maintain accessibility and engagement in learning despite infrastructure limitations. In line with this, Utari et al. (2024) emphasizes that in developing countries like Indonesia, the integration of socio-cultural elements in e-modules effectively improves science literacy and student engagement despite limited digital infrastructure.

When compared globally, these findings are in line with Barteit et al. (2020), which shows that in develop countries, including OECD member countries, the lack of technical barries allows for a focus on optimizing interactive features, personalizing learning, and technological innovation. In this context, e-module strategies can leverage stable digital infrastructure, high digital literacy, and mature readiness for online learning to maximize the integration of collborative, interactive, and data driven learning feautures. Converssely, in developing countries, e-module strategies must adapt to limitations in internet access, devices, and teacher training. Despite ongoing infrastructure development, innovative approaches such as bandwidth efficient design, support for offline and asynchronous learning, and gradual improvements in digital literacy can be implemented to enhance learning accessibility (Adnan et al., 2024; Alanoglu et al., 2025). As highlighted by Purbasari et al., (2025). The primary focus in this context is ensuring local relevance and cultural appropriateness to maintain learning effectiveness. Thus, the effectiveness of e-module strategies is significantly influenced by the socio cultural context, infrastructure readliness, and human resource capacity in each country (Simaremare et al., 2025).

Challenges faced by teachers in implementing electronic modules in biology learning

An analysis of articles reveals that the challenges faced by teachers in implementing electronic modules in biology learning are generally related to limited technological skills and teachers habits that still depend on conventional printed teaching materials (Taufiq et al., 2024; Nasution & Anas, 2025). Teachers are often not accustomed to designing interactive learning media, such as flipbook based e-modules that integrate multimedia elements to help students understand abstract

biological concepts (Iwan et al., 2024; Taufiq et al., 2022; Taufiq et al., 2024). In addition, the process of integrating learning materials with skills needed in the 21st century, such as critical thinking skills, is also still a challenge, because teachers need additional tme, references and knowledge in order to design in depth and relevant evaluations (Husna et al., 2021). Technical barriers such as the availability of supporting devices and school infrastructure readiness also affect the effectiviness of *e-module* implementation in the classroom, so effort to digitize biology learning require training, guidance, and adequate facility support to be implemented optimally (Samsi, 2023; Fazriah et al., 2023; Rungkat et al., 2023; Hartono et al., 2024).

In addition to the challenges in digital skills, limited experience in designing interactive media, and obstacles in integrating HOTS content previously described, the challenges of teachers in implementing electronic modules in biology learning also include efforts to instill metacognitive skills and science literacy that are relevant to 21st century needs. Based on research conducted (Munawaroh et al., 2023) although STEM biotechnology modules are effective in improving metacognitive skills, teachers still face the challenge of differentiating materials to suit the diverse academic abilities of students, especiallyin agricultural industrial areas. Meanwhile, Fajar & Suryani (2023) emphasized the importance of HOTS based biology learning evaluation modules and local wisdom values, indicating that teachers need to adapt the material to the cultural context and local values to make the module more meaningful. This is in line with Azmi et al. (2023) and Satria et al. (2022) in addition to limited time for technological literacy, the lack of device support in schools makes it difficult for teachers to ensure that modules are attractive, accessible, and relevant to contectual needs. This shows the importance of continuous training and facility support for e-modules to be truly effective in improving students science literacy and environmental awareness.

Thus, teachers challenges are not only focused on technical aspects and learning habits, but also on the ability to design contextual, innovative learning content and support multiple literacies that will be the demands of biology learning in the future . Therefore, continuous support in the form of professional training and mentoring is needed to improve teacher competence in designing, developing and optimally utilizing electronic modules. In addition, collaboration between teachers, schools and policy makers is also very important to ensure the availability of supporting facilities, such as technological devices and adequate internet access. This effort is expected to encourage teachers not only to become technology users, but also to become learning innovators who are able to design student learning experiences that are adaptive, relevant, and encourage students to think critically, creatively and care about the surrounding environment.

One of the main advantages of digital based teaching materials is their flexbility of access. Electronic modules allow students to access materials through their mobile devices, theraby supporting learning outside the classroom and at any time according to individual needs. Thus, e-modules not only facilitate independent learning, but also provide space fot students to explore materials expecially biology content in greater depth and contextually. In addition, the evaluation and monitoring features integrated into *e-modules* can provide immediate feedback, allowing teachers to monitor student progress in real time and provide guidance tailored to each individual's needs.

This study makes a significant contribution to the field of biology education by highlighting the strategic role of teachers in optimizing the implementation of e-modules as a contextual, interactive learning medium that supports the mastery of 21st century skills. Unlike previous studies that focused more on the technical aspects of e-modules development, the findings of this study emphasize that the effectiveness of e-module implementation is highly dependent on teacher readiness to design learning scenarios, select appropriate learning models (such as PjBL, STEM, STS, and flipped classroom), and their ability to adapt module content to students characteristics and the challanges of digital learning. These findings also have strategic implications for policymakers, particularly in designing teacher training programs and providing supporting infrastructure to strengthen the sustainable integration of e-modules into the biology learning process.

As a direction for futher development, subsequent research is recommended to explore innovations in e-module design, particularly in terms of content, visualization, and interactivity. Research can focus on developing adaptive content tailored to students needs and learning styles, contextual and representative visualization, and the integration of interactive elements such as simulations, animations, and automated feedback based asessements. Optimizing these elements is believed to enhance the effectiveness of e-modules in strengthening conceptual understanding, learning engagement, and the achievement of 21st century competencies. Thus, the development of e-modules not only addresses pedagogical demands but also responds to the dinamics and challanges of contemporary digital learning.

CONCLUSION

Based on the results of this systematic literature review, it can be concluded that the teachers strategies in implementing e-modules in biology learning play an important role in supporting a more innovative independent, and contextual learning process. Findings from several studies show that teachers utilize e-modules as a source of digital learning materials that can improve concepts understanding, expand learning access, and encourage active student engagement both inside and outside the classroom.

The strategies employed include structured instructional planning, careful selection of content relevant to students needs, and the preparation of interactive and engaging materials. Furthermore, the success of e-modules implementation is significantly influenced by teachers technology proficiency, creativity in instructional design, and the availability of adequate facilities and infrastructure. Nevertheless, several challanges remain, such as limited technoligical skills among some educators, insufficient training in e-module development, and technical constraints related to access and distribution. Accordingly, this review recommends enhancing teacher competence, improving infrastructure supports, and enacting institutional policies that promote the development and integration of digital learning materials to ensure the optimal and sustainable use of e-modules in biology education.

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