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Enhancing Global Warming Education Through A Discovery Learning-Based Heyzine Flipbook E-Module

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Abstract: This research aims to develop a discovery learning-based physics E-module using the heyzine flipbook platform to improve student learning outcomes on the topic of global warming in Grade X at SMAN 12 Medan. This study employed a Research and Development (R&D) method aimed at producing a valid, practical, and effective learning product. The development process followed the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. Data were collected through expert validation, practicality questionnaires for teachers and students, and pretest-posttest evaluations to measure effectiveness. The feasibility test results from content, design, and media experts indicated that the E-module is in the "very feasible" category. The practicality test results showed that both teachers and students considered the E-module easy to use and supportive of the learning process. The effectiveness test using the paired t-test showed a significant improvement in student learning outcomes, while the N-gain analysis indicated a medium category of learning gain. These results demonstrate that the heyzine flipbook-based E-module is not only feasible and practical but also effective in enhancing conceptual understanding. The study concludes that the integration of Discovery Learning with digital media can support independent and interactive learning and is recommended for wider implementation across science subjects.

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Introduction

The rapid advancement of digital technology has driven continuous innovation in the field of education, particularly in the delivery of instructional content (Alakrash & Razak, 2021; Astuti et al., 2022). Despite these advancements, many high schools still rely on traditional teacher-centered instruction that limits student engagement (Kristiawan, 2017). This discrepancy was evident in a public high school where this research was conducted. Based on classroom observations and interviews with science teachers, it was found that lessons especially on abstract topics such as global warming were still dominated by lectures, resulting in low student motivation and difficulty in understanding the material.

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One of the major challenges in 21st-century education is creating engaging, contextual, and meaningful learning experiences that foster students' critical thinking skills (Sulistiani & Sudikan, 2020). Global warming is a complex and real-world issue that requires not only conceptual understanding but also the cultivation of students' environmental awareness (Susanti et al., 2020). However, students in the observed school perceived the topic as monotonous and abstract, largely due to the lack of interactive and student-centered learning tools. This situation highlights the need for instructional approaches that not only deliver content but also actively involve students in the learning process.

To address these challenges, one effective approach is Discovery Learning, which encourages students to construct knowledge through exploration, inquiry, and problem-solving (Yadi et al., 2022). This model is particularly suitable for science topics because it stimulates curiosity and promotes a deeper understanding of concepts (Ozdem-Yilmaz & Bilican, 2020; Umah, 2023). When supported by appropriate media, Discovery Learning can transform passive learning environments into active and meaningful experiences. The use of digital learning media—such as e-modules—offers a promising solution, especially when they are designed to support interactive and inquiry-based learning.

Several previous studies have demonstrated the effectiveness of digital media in enhancing learning outcomes. For example, Mahardika et al. (2022) developed a Flipbook PDF-based e-module that successfully improved students' academic performance. Similarly, Lestari et al. (2022) showed that digital e-modules fostered students' critical thinking in science education. However, many of these studies utilized static formats, lacking the interactivity and multimedia integration necessary for truly engaging learning experiences. The Heyzine Flipbook platform, an HTML5-based digital tool that simulates the experience of flipping through a physical book while integrating multimedia components, has yet to be widely explored in this context (Nugraha et al., 2023; Saputri et al., 2024).

The scientific novelty of this study lies in the development of an interactive e-module using the Heyzine Flipbook platform, specifically designed with Discovery Learning principles to support the teaching of global warming in tenth-grade science classes. This e-module incorporates multimedia elements and structured navigation to facilitate student inquiry and engagement. Furthermore, its feasibility and practicality were assessed by content experts, media specialists, and classroom practitioners to ensure its relevance to the Independent Curriculum and current educational needs.

Based on the issues identified both in the literature and in the classroom context, this study addresses the following research question: How feasible and practical is the Heyzine Flipbook-based Discovery Learning e-module for teaching global warming in Grade X? Therefore, the purpose of this research is to present the development process, assess feasibility, and evaluate the practicality of the interactive e-module as an innovative and relevant learning solution in science education.

Research Method

This study employed a Research and Development (R&D) approach using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation) as proposed by (Sibuea et al., 2021). The purpose of this research was to develop a learning media product in the form of a *Heygine* flipbook-based e-module using the Discovery Learning approach, designed specifically for the topic of global warming for Grade X students at SMA Negeri 12 Medan. The following presents the development and research stages of this study, which are presented in Figure 1 below.

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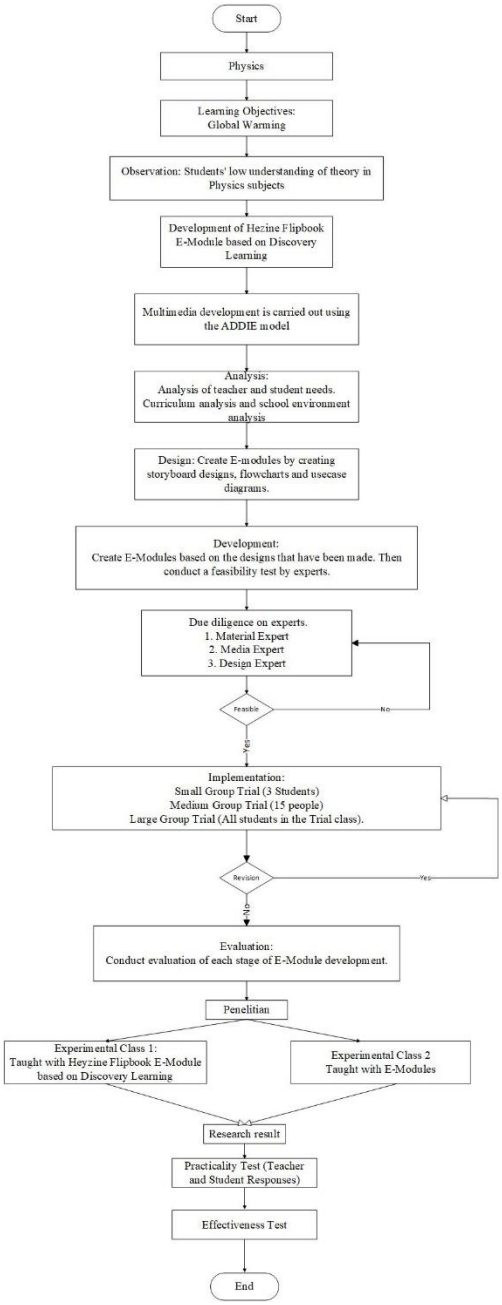

Figure 1. Research Stages

The research was conducted at SMA Negeri 12 Medan. The research schedule was aligned with the school academic calendar and the Physics subject schedule. The population of this study comprised all tenth-grade students (10 classes in total) at SMA Negeri 12 Medan. Samples were selected using the Cluster Random Sampling technique, as the population was considered homogeneous, allowing each student an equal opportunity to be selected (Panjaitan, 2010). The experimental class was class X.E-2, while class X.E-3 served as the control group. Data collection techniques in this study included observation, interviews, questionnaires, documentation, and learning outcome tests. Observations were conducted directly during the individual trials, small group trials, and field trials to identify difficulties encountered by

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students in using the *Heygine* e-module. Structured observation sheets were also used to monitor students' learning activities.

Interviews were conducted during the individual and small group trials to explore students' learning characteristics and styles, previous experiences with e-modules, and challenges faced by teachers in the learning process. Interviews followed a structured interview guide (Sugiyono, 2015). Questionnaires were distributed to gather responses from both teachers and students regarding the validity and practicality of the *Heygine* flipbook-based e-module. The questionnaires were used during the validation and implementation phases to assess the effectiveness of the product.

Learning outcomes were assessed through cognitive tests related to the global warming topic in Physics. The test instruments were developed based on a pre-established grid aligned with the learning objectives. This study also involved the use of specific tools and materials, namely digital devices such as smartphones or laptops/computers, which were required for the implementation of the e-module. Validation of the research results was ensured through triangulation of data sources, expert judgment during the validation phase, and consistency across trials.

The data collected from various sources (observations, interviews, questionnaires, documentation, and learning outcome tests) were analyzed both qualitatively and quantitatively to evaluate the effectiveness and feasibility of using the *Heygine* flipbook-based e-module in teaching the topic of global warming in Physics. Qualitative data from interviews, observations, and documentation were analyzed using a descriptive approach to identify recurring themes related to challenges faced by teachers and students during e-module usage, as well as their responses to the Discovery Learning method. This analysis involved coding the data and identifying patterns to improve the e-module's design and implementation strategies.

Quantitative data collected from the questionnaires and learning outcome tests were analyzed using descriptive statistics to assess the validity, practicality, and effectiveness of the e-module. The validity of the product was evaluated based on expert ratings and user feedback, with average scores from the validation questionnaires used to determine the e-module's suitability. The practicality of the product was measured through the teachers' and students' responses regarding ease of use during the learning process, and these responses were analyzed to determine the average practicality score. The effectiveness of the e-module in improving learning outcomes was assessed by comparing pretest and posttest scores using *t*-tests to determine if there was a significant improvement in students' knowledge of global warming.

Result and Discussion

Result

This section presents the results of testing and evaluating interactive multimedia based on Discovery Learning in environmental pollution material. The analysis is structured to address the feasibility, practicality, and effectiveness aspects of the developed product. The findings are scientifically examined based on the obtained data, relevant theories, and comparison with previous research to provide a comprehensive understanding of how and why the interactive media contributes to improved learning outcomes. Each test result is discussed not only descriptively but also analytically to reveal the scientific meaning behind the trends and patterns observed in the data.

The feasibility of the product was assessed through validation by three experts: material experts, design experts, and media experts. The validation aimed to evaluate the quality of

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content, design structure, and media functionality. The results of the feasibility test on media experts can be seen in Table 1 as follows

Table 1. Feasibility Test Results

No	Expert Type	Score	Category
1	Material Expert	90.90	Very Feasible
2	Design Expert	85.00	Very Feasible
3	Media Expert	86.00	Very Feasible

The results show that all experts rated the media as **"very feasible"**, indicating that the content is accurate, relevant, well-organized, and supported by appropriate visual and interactive elements. Scientifically, this result reflects the suitability of Discovery Learning-based media to support active and inquiry-based learning. According to (Ozdem-Yilmaz & Bilican, 2020), learning materials should encourage students to construct knowledge through exploration and discovery. The high score from material experts confirms that the media meets curriculum standards and supports meaningful learning processes. The design and media validation reinforce Lee & Owens (2004), which emphasizes that effective learning occurs when words and pictures are integrated coherently. The visual appeal and user-friendly navigation assessed by design and media experts increase engagement and usability, thus strengthening the foundation for subsequent learning effectiveness.

The practicality of the interactive media was assessed based on teacher and student responses after its implementation. The results of the practicality test can be seen in Table 2 below:

Table 2. Practicality Test Results

No	Respondents	Score	Category
1	Teacher Response	90.00	Very Practical
2	Student Response	85.23	Very Practical

The results show that both teachers and students rated the media as **"very practical,"** indicating that the product is easy to use, accessible, and well-integrated into the learning process. The high practicality score suggests that the media aligns with users' expectations and classroom needs. Teachers found it to be a helpful instructional tool, while students appreciated its ease of use and interactivity. These findings are consistent with the Technology Acceptance Model (Doulani, 2019), which states that perceived ease of use and perceived usefulness are key factors influencing the adoption of technology in education. Similar findings were reported by (Lai, 2017), who found that students responded positively to learning media that offered interactive navigation and could be accessed via digital platforms. Therefore, the practicality of the media further supports its potential for broad implementation in educational settings.

The effectiveness of the media was analyzed by comparing students' cognitive learning outcomes before and after using the media, using both N-Gain and t-test analysis.

Table 4. t-Test Results

Variable	t-count	t-table	Conclusion
Learning Outcomes	12.51	2.03	Significant difference ($p < 0.05$)

Table 3. Pretest, Posttest, and N-Gain Results

No	Test	Mean Score	N-Gain	Category
1	Pretest	47.92	0.62	Moderate
2	Posttest	80.42		

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The N-Gain value of 0.62 indicates a moderate increase in student learning achievement, while the t-test result shows a statistically significant improvement in posttest scores. This confirms the effectiveness of the media in enhancing students' understanding of environmental pollution concepts.

Discussion

The development of interactive multimedia based on the Discovery Learning model for environmental pollution material has proven to be feasible, practical, and effective. These findings not only demonstrate the quality of the developed media but also align with relevant educational theories and prior studies that emphasize the importance of student-centered, inquiry-based learning supported by appropriate technological tools. The high feasibility ratings from material, design, and media experts indicate that the media product has met academic, pedagogical, and technical standards. The material expert's score confirms that the content is accurate, relevant to the curriculum, and supports conceptual understanding. The validation from design and media experts shows that the media is visually appealing, structurally coherent, and functionally interactive.

These findings reflect the fundamental principles of Discovery Learning, which emphasize student exploration and active knowledge construction (Ozdem-Yilmaz & Bilican, 2020). Furthermore, they support the cognitive theory of multimedia learning proposed by Mohammadzadeh et al. (2019), which underlines the importance of integrating verbal and visual elements to enhance learning. The visual clarity and intuitive navigation observed in this study also affirm Alessi & Trollip (2000) perspective that multimedia should facilitate, not complicate, the learning process. These findings are consistent with previous research by Mahardika et al. (2022) and Lestari et al. (2022), who found that digital learning media especially those with interactive features are highly effective in supporting students' engagement and conceptual mastery.

The practicality test results from both teachers and students further reinforce the usability and relevance of the developed media in classroom contexts. With scores falling in the "very practical" category, it is evident that the media is accessible, easy to use, and meets the instructional needs of both educators and learners. Teachers found the media to be a supportive tool that complements classroom activities, while students appreciated its clarity, responsiveness, and the ability to interact directly with the content. These results align with the (TAM) proposed by Han & Sa (2022), which highlights the importance of perceived usefulness and ease of use in the adoption of educational technology. Almén & Bagga-Gupta (2023) and Siagian et al. (2014) also emphasized that interactive digital tools are more likely to be accepted and effectively implemented when users find them simple and helpful. The findings in this study echo these conclusions, indicating that the developed e-module not only supports the instructional process but also enhances students' willingness to engage with the material.

The effectiveness of the media was confirmed through a significant increase in students' cognitive learning outcomes, as evidenced by the N-Gain value of 0.62 and the t-test result of 12.51, which exceeds the t-table value of 2.03. This suggests a statistically significant improvement in students' understanding of environmental pollution concepts after using the media. These results are aligned with Bruner's theory of Discovery Learning, which posits that students learn more effectively when they are directly involved in the learning process through exploration and inquiry. The multimedia's interactive features such as embedded videos, simulations, and clickable content enabled students to control their own learning paths, which promotes deeper processing and higher retention. According to Dita et al. (2021), such

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interactivity is essential for developing critical thinking and improving learning outcomes. This study affirms those findings, demonstrating that students who engage with well-structured, interactive content can achieve better academic performance.

Overall, the results of this study highlight the value of combining pedagogical models like Discovery Learning with interactive multimedia platforms such as Heyzine Flipbook. This integration has resulted in a product that not only meets expert validation criteria but also responds to practical classroom challenges while significantly improving learning outcomes. The strong alignment between this study's results and previous research strengthens the argument for broader implementation of similar media in science education. It also demonstrates the urgency and relevance of shifting from conventional learning approaches to more dynamic and student-centered methods, particularly in delivering complex and abstract topics such as environmental pollution.

Conclusion

The development of the Heyzine Flipbook E-module based on Discovery Learning for physics instruction on global warming has produced significant and scientifically grounded outcomes. The research demonstrates that the E-module is highly feasible, as validated by expert assessments in content, design, and media, indicating its alignment with curriculum demands and instructional quality standards. Furthermore, the practicality of the E-module is evident from the positive responses of both teachers and students, who found the media easy to use, accessible, and seamlessly integrated into the learning process. Most importantly, the effectiveness of the E-module is supported by measurable improvements in student learning outcomes, with statistical analysis confirming a significant increase in post-test scores. These findings affirm that the Discovery Learning approach, when embedded in interactive digital media, fosters active engagement, critical thinking, and conceptual understanding, especially on complex topics like environmental issues. As such, the Heyzine Flipbook E-module offers a promising solution to enhance the quality of science education by making learning more meaningful, independent, and student-centered.

Recommendation

Based on the results and findings of this study, several recommendations can be made for future research and the continued development of digital learning media. First, it is suggested that the Heyzine Flipbook E-module based on Discovery Learning be implemented more widely across different schools and subject areas to test its adaptability and broader impact on student learning outcomes. Further studies can explore its integration with other learning models, such as Problem-Based Learning or Project-Based Learning, to enhance its pedagogical effectiveness. Additionally, future research should consider involving a larger and more diverse sample size to strengthen the generalizability of the results. Investigations into long-term retention and student motivation when using digital modules would also provide valuable insights into sustained learning impacts. Some challenges encountered during this study included limited digital literacy among some students and the availability of supporting devices or internet access, which may influence the consistency of media usage. These barriers should be addressed in subsequent research by developing offline-accessible versions of the module and incorporating training sessions for both students and educators in digital learning tools. In summary, the development of Discovery Learning-based digital modules holds great potential for transforming science education, but continuous improvement, contextual

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adaptation, and support systems are essential to optimize its benefits in diverse educational settings.

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