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Exploring Usability, Practicality, and Innovation of Flipbook-Based Interactive E-Books in Physics Education

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Abstract: Based on the development of digital technology in education, this study aims to explore the practicality of modern physics e-books based on interactive flipbooks in supporting student learning. This study focuses on improving the accessibility, interactivity, and readability of complex modern physics materials. The methodology used is research and development (R&D) with an evaluative approach involving prospective physics teacher students and lecturers. The study results show that this e-book has a high level of practicality, with the majority of criteria scoring above 80%. A broad-scale practicality evaluation showed that the feedback and assessment features had the highest level of practicality (96.53%), followed by visual design and aesthetics (95.83%). Lecturers' responses also showed positive results, averaging 91.67%, although the visual appeal aspect still needs improvement. The main contribution of this study is to provide an innovative model for the development of interactive digital teaching materials based on flipbooks, as well as insights for developing a technology-based physics education curriculum. With the improvement of AI-based adaptive features and integration with the Learning Management System (LMS), this e-book has the potential to be a more effective and personalized digital learning solution in the digital era.

Keywords: critical thinking; e-books; interactive learning; modern physics; student engagement

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INTRODUCTION

The development of digital technology has brought significant changes in the world of education, including in physics learning (Budiarti et al., 2022; Kokkonos et al., 2025). One of the innovations that plays a role in the transformation of learning is the electronic book (e-book), which offers flexibility in delivering material (Ardiansyah et al., 2024), high accessibility, and multimedia integration that can improve students' learning experience. Along with the development of the Industrial Revolution 4.0 and the shift towards society 5.0, the use of e-books in physics learning is increasingly becoming necessary, considering the characteristics of physics, which often require an understanding of complex abstract concepts (Marisda et al., 2024).

Previous studies have shown that e-books can improve understanding of physics concepts, primarily through interactive features that allow abstract concepts to be visualized more concretely (Tuyizere & Yadav, 2023). For example, Dewi et al. (2024) identified the difficulties experienced by prospective physics teacher students in modern physics lectures. The study showed 81.25% of students memorized physics formulas without understanding their physical meaning. In comparison, 75% of students stated that modern physics teaching materials were not available, so they had to find lecture materials themselves. In addition, 84.38% of students had difficulty accessing modern physics materials via mobile phones, so they had to use laptops or go to the library. These findings indicate that the lack of unique teaching materials for modern physics is a major challenge in learning (Marisda, Tolla, et al., 2024b). In addition, other studies have shown that integrating videos, simulations, animations, and virtual experiments in physics e-books can help students build a more concrete understanding of renewable energy. In addition, using flipbooks as digital media allows wider accessibility, increases student learning independence and provides a more engaging and interactive learning experience (Syukri et al., 2024).

In addition to cognitive aspects, e-books also contribute to increasing students' learning motivation. Hera et al. (2024) revealed that students who studied with augmented reality (AR)-based e-books in fluid dynamic content showed an increase in interest and higher engagement compared to when using conventional teaching materials (Kartika et al., 2024). This increase is associated with the interactive features in e-books that allow students to explore concepts more interestingly and dynamically. Furthermore, Lee and Park (2023) show that e-books that support multi-platform access (e.g., can be used on mobile phones, tablets, or computers) allow for more flexible learning, which is very relevant to blended learning and student-centered learning approaches in the digital era. This ease of access increases self-regulated learning, where students can learn at their own pace and style, thus creating a more effective learning experience (Skakov et al., 2025). However, most research on e-books in physics education still focuses on converting conventional teaching materials into

digital formats without considering how to design e-books that truly support constructivism-based learning and high-level problem-solving (Huang et al., 2023). Therefore, a new approach is needed in developing physics e-books that not only function as reading aids (Johan et al., 2022) but also integrate interactive elements designed to improve students' critical thinking skills, especially in understanding complex modern physics concepts.

Practicality is important in developing digital learning products such as interactive e-books. Practicality in developing digital-based teaching materials can be seen from the extent to which lecturers and students can easily use the product and provide maximum benefits in supporting learning. The practicality of a learning product can be measured based on the ease of its implementation in the context of learning and its effectiveness in improving learning outcomes (Akker et al., 1999). In line with that, Sugiyono (2019) stated that the practicality of a learning product includes three main aspects: ease of use, effectiveness in supporting learning, and suitability to user needs. Practical learning products must be easy to access and use, help students understand the material more efficiently, and follow the learning style of future physics teacher students.

In this context, interactive flipbooks are one of the technological solutions that can improve the practicality of e-books in physics learning. Flipbooks offer dynamic page-based navigation features, allowing students to read materials with an experience that is more similar to printed books but with the addition of multimedia elements such as animations, simulations, videos, and direct interactions (Marisda et al., 2024). The main advantages of flipbooks compared to other media in supporting the practicality of physics learning include increasing readability, maximizing interactivity, and facilitating accessibility (Yuyun et al., 2022). Regarding readability, flipbooks allow for the presentation of text, images, and videos in a more structured manner so that students can more easily understand complex physics concepts (Fauziyah et al., 2023). In terms of interactivity, flipbooks provide a more dynamic learning experience by allowing students to interact directly with the content, such as conducting simulations or answering questions in learning modules (Kurniawan et al., 2019). Meanwhile, in terms of accessibility, flipbooks can be accessed via various devices, such as laptops, tablets, or mobile phones, so students can study anytime and anywhere without relying on physical books.

In line with this, the results of a literature review of the trend of using interactive flipbooks in physics learning over the past decade (2014–2024) show that this media is increasingly being adopted in various educational institutions due to its ability to improve conceptual understanding, student engagement, and learning effectiveness. Technological developments have enabled the integration of more sophisticated features in flipbooks, including augmented reality (AR) and improved interactive interfaces, thus further strengthening their role in supporting digital-based learning (Marisda, Tolla, et al., 2024a). Furthermore, research conducted by Khaerunnisa (2023) shows that using digital learning media flipbooks based on guided inquiry for physics modules on sensor system material has a feasibility percentage of 80%, which is categorized as very good (feasible). This media is considered effective learning material because it can improve student understanding (Khaerunnisa et al., 2023). However, although research on interactive flipbooks has grown rapidly, studies that specifically discuss their use in modern physics lectures at the university level are still limited. Therefore, further research is needed to explore how interactive flipbooks can be a bridge in teaching abstract modern physics concepts, such as relativity and quantum mechanics. With a more innovative approach, interactive flipbook-based e-books can be an effective solution to improve readability, interactivity, and accessibility in modern physics learning so that students not only gain a better understanding but also develop critical thinking skills that are much needed in today's digital era.

Based on this urgency, this study aims to explore the practicality of interactive flipbook-based e-books in supporting physics learning. By utilizing interactive visualization features, simulations, and constructivism-based designs, it is expected that this e-book can improve students' critical thinking skills in learning modern physics. Although interactive flipbook-based physics e-books can be applied to various courses in physics, their use is not limited to one particular subject. However, in this study, the course chosen as the object of the trial was Modern Physics. The selection of this course was based on several considerations. First, Modern Physics is one of the courses that has many abstract concepts that are often difficult for students to understand, such as relativity, wave-particle dualism, and quantum mechanics. This material requires visual representation and interactive simulations to help students understand the concepts more deeply. Second, initial observations showed that teaching materials for Modern Physics courses are still limited in terms of availability and suitability to the needs of digital-based learning. Most students still rely on conventional textbooks or separate materials that they download from various sources on the internet, which are often not well structured. In addition, limitations in this study are also caused by time and resource factors. The development and testing of flipbook-based e-books require a fairly long process, starting from content design and interactive element development to validation and implementation. Therefore, for the study to be carried out effectively within the available time frame, the testing of the e-book was focused on one course first. Thus, this study can provide a more detailed and in-depth picture of the effectiveness of e-books in supporting physics learning before being expanded to other courses. In the future, the results of this study can be the basis for the development of interactive flipbook-based e-books in other physics courses, especially those that also require a visual and interactive approach to

delivering material. Thus, this study not only contributes to Modern Physics learning but can also be a model of innovation for developing digital teaching materials in various other branches of physics.

METHODS

This research is a research and development (R&D) study, as defined by (Sugiyono, 2019), which focuses on developing and validating educational products through systematic procedures. The development model used in this study is a modification of five instructional development models: ADDIE, 4D (Thiagarajan), Borg & Gall, Dick & Carey, and ASSURE. The modified model is called the DEWI development model (Define, Explore, Write, Implement). The DEWI model integrates key aspects of these five models to ensure a structured and iterative process in developing the flipbook-based interactive e-book, emphasizing the definition of needs, exploration of relevant literature and instructional strategies, content writing and design, and final implementation in classroom settings.

This research aims to evaluate the practicality and effectiveness of flipbook-based interactive e-books in enhancing students' critical thinking skills in Modern Physics courses. The study aims to determine how well the developed e-book aligns with learning objectives, its usability in classroom settings, and its impact on students' engagement and conceptual understanding. The evaluation process was conducted by collecting data from prospective physics teacher students and lecturers, who acted as product users. The study involved 18 prospective physics teacher students from a private university and 3 lecturers who teach or have previously taught Modern Physics courses. While students provided feedback on the usability and learning experience, lecturers assessed the quality, content alignment with the curriculum, and the effectiveness of the e-book in achieving learning outcomes.

The instruments used in this study consisted of a practicality questionnaire and a short interview through Focus Group Discussion (FGD) (Roberts, 2020) to obtain more in-depth data regarding user experiences in using flipbook-based e-books. The student practicality questionnaire was used to assess their experiences in using flipbook-based e-books with assessment indicators including readability and ease of use, content and learning materials, student interactivity and engagement, development of critical thinking skills (Critical thinking skills), feedback and assessment in e-books, visual design and aesthetics, accessibility, and compatibility of technology, and overall satisfaction with e-books (Fahmi et al., 2019). Meanwhile, the lecturer practicality questionnaire aims to evaluate the quality of flipbook-based interactive e-books from the perspective of teachers, with indicators including content quality in improving students' critical thinking skills, level of readability and understanding of the material, interactivity, and reader engagement, suitability to the curriculum and educational standards, visual appeal and graphic design (Wenno et al., 2022), ease of use and navigation, interactive features such as quizzes, animations, and videos in supporting critical thinking, the benefits of e-books in improving students' understanding and critical thinking skills, and support for students' independent learning. In addition, short interviews with students and lecturers were conducted to obtain more in-depth data regarding the practicality of flipbook-based e-books through Focus Group Discussions (FGD). This interview aims to explore user experiences, identify challenges faced using e-books, and obtain feedback for further development.

Before being used, the user practicality questionnaire (lecturers and students) was validated to ensure its reliability and validity (Hamed, 2016). Validation was carried out through expert validation (Aiken, 1980), which involved four experts with expertise in physics material, learning media, learning assessment and evaluation, and educational technology. The results of the quantitative assessment from the experts were analyzed using Aiken validation. From the analysis results, each indicator in the questionnaire obtained a validation value of 0.94, which was greater than the Aiken table value (0.92). Thus, the practicality questionnaire instrument was declared valid and suitable for use in research.

RESULT AND DISCUSSION

The validated and revised modern physics e-book was implemented in a limited-scale trial involving five students. This trial assesses the e-book's practicality in supporting modern physics learning. Practicality testing is crucial to test the developed product to obtain product perfection from user responses (Fardani et al., 2019). Practicality evaluation was done through direct observation and student responses to interactive flipbook-based e-books during the learning process. The detailed results of the limited trial can be seen in Table 1.

Table 1. Results of the Practicality Assessment of Modern Physics E-Books Based on Interactive Flipbooks in Limited Trials

Assessment Criteria	M1	M2	M3	M4	M5	Avg
Readability and Ease of Use	100.00	100.00	100.00	100.00	83,33	96,67
Learning Content and Materials	87.50	87.50	100.00	100.00	100.00	95.00
Interactivity and Engagement	85.00	90.00	100.00	95.00	85.00	91.00
Critical Thinking Skills Development	87.50	81,25	100.00	87.50	87.50	88,75
Feedback and Assessment	100.00	87.50	100.00	100.00	75.00	92.50
Visual Design and Aesthetics	87.50	100.00	100.00	87.50	87.50	92.50
Technology Accessibility and Compatibility	87.50	100.00	87.50	87.50	100.00	92.50
Benefits and Disadvantages	87.50	87.50	87.50	87.50	100.00	90.00
Overall Satisfaction	100	87.50	100.00	100.00	100.00	97.50

The results of the limited trial showed that the modern physics e-book received positive responses from students, who stated that the interactive features helped them understand the material more quickly and deeply. Data on practicality showed that this e-book has a high level of practicality, with most criteria scoring above 80%. This indicates that the e-book meets students' learning needs and effectively supports engagement and the development of critical thinking skills (Critical thinking skills). This finding is in line with Hendi (2024), who states that electronic teaching materials can help students understand concepts better (Septikasari et al., 2021), and students feel more prepared to enter the industrial world after using electronic teaching materials (Firdaus et al., 2024; Sebastian et al., 2023).

In addition to limited-scale trials, practicality testing was conducted widely. The wide-scale practicality test is intended to obtain a comprehensive picture of the developed product (Asrizal et al., 2021). The practicality test involved all physics education students taking the Modern Physics course. This test aims to provide a more comprehensive picture of the practicality of the interactive flipbook-based modern physics e-book in supporting the learning process. The detailed results of the practicality test are presented in Figure 1.

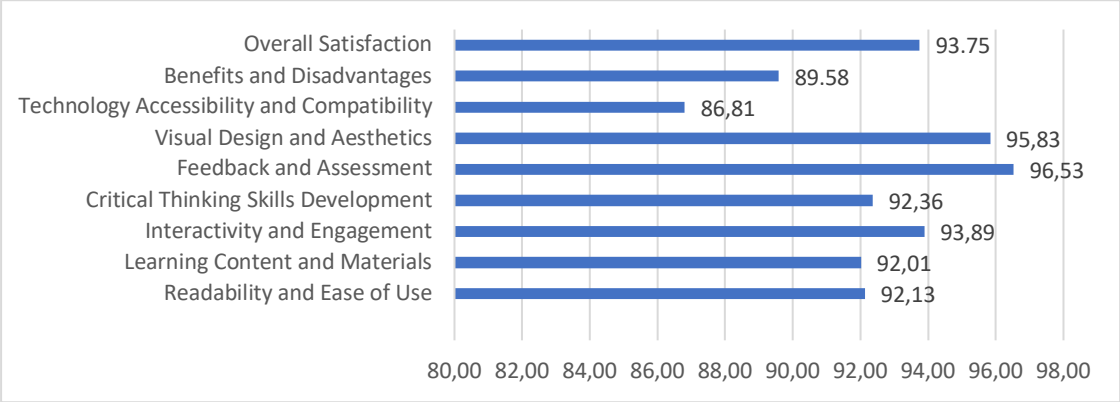

Figure 1. Practical Results of Modern Physics E-book in Large-Scale Trials

The results of the practicality test on a large scale showed that e-books have a very high level of practicality in various aspects. The highest percentage was obtained in the feedback and assessment criteria (96.53%), followed by visual design and aesthetics (95.83%) and interactivity and engagement (93.89%). The overall satisfaction criteria also showed a high score of 93.75%, indicating that students well received e-books. Meanwhile, the accessibility and technology compatibility criteria had the lowest percentage, namely 86.81%, which remained in the good practicality category. These results indicate that interactive flipbook-based e-books are very practical in modern physics learning. These results align with Su and Cheng (2015), who found that interactive multimedia-based teaching materials can significantly increase student learning motivation and engagement. In addition, Martín-Gutiérrez et al. (2017) stated that technology-based teaching materials that are compatible with various devices increase learning flexibility and expand the scope of their use (Martín-Gutiérrez et al., 2017). In addition to student evaluations, the practicality of interactive flipbook-based e-books is also assessed based on lecturers' responses. This evaluation reflects lecturers' assessments of various aspects of the e-book, such as content quality, readability, interactivity, suitability to the curriculum, visual appeal, ease of navigation, interactive features, benefits in developing critical thinking skills, and support for student independent learning. The results of the lecturer's practicality test in detail are presented in Figure 2.

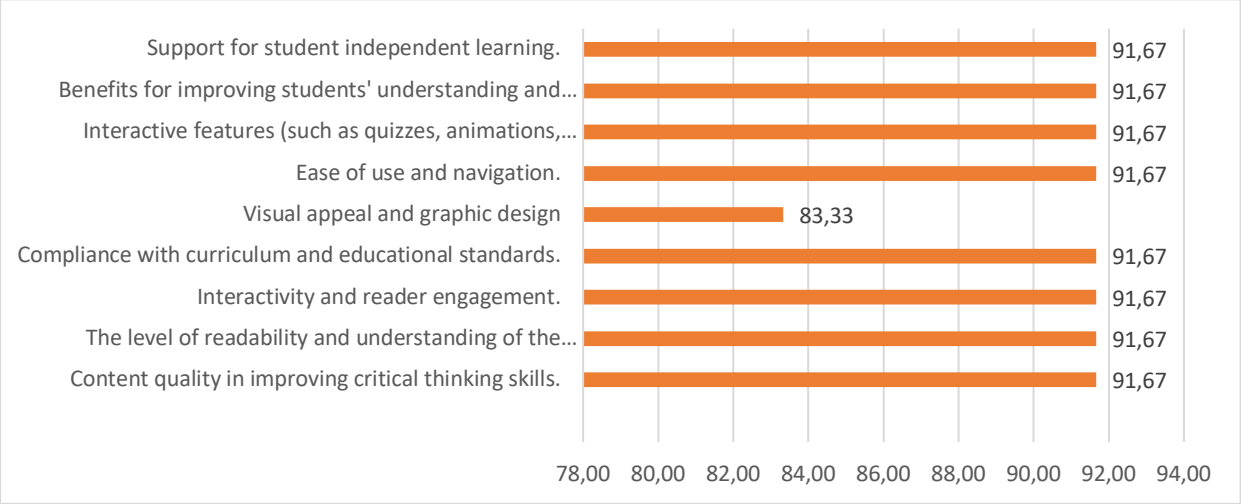

Figure 2. Practicality Results of Modern Physics E-Books Based on Lecturer Responses

The lecturer's responses in Figure 2 show that most criteria, such as content quality in improving Critical thinking skills, material readability, interactivity, curriculum suitability, ease of use, and benefits in supporting independent learning, obtained an average score of 91.67%. The only criteria with a lower score were visual appeal and graphic design, which obtained 83.33%. Overall, these results indicate that lecturers consider e-books very practical, with high scores on almost all aspects that support the quality of student learning. The high score on support for independent learning (91.67%) indicates that this e-book effectively facilitates students' independent learning. These results align with Liaw and Huang (2013), who state that technology-based teaching materials with interactive features allow students to manage their learning process. In addition, the ease of use and navigation aspects, which obtained 91.67%, indicate that the e-book interface is easy to use, supporting Kortum and Bangor (2013) who stated that intuitive navigation plays an important role in positive user experience.

However, the visual appeal and graphic design aspects obtained the lowest score (83.33%), which, although still in the good category, indicates that some layout and graphic quality improvements are needed to improve the aesthetics of the e-book. This result is consistent with Plass et al. (2014), who stated that high-quality visualization in digital teaching materials improves aesthetics and supports better understanding. The results of limited and large-scale trials indicate that the modern physics e-book based on interactive flipbooks is very practical and effective in supporting student learning. The high practicality scores in various aspects indicate that this e-book has succeeded in meeting students' learning needs by providing an interactive, interesting, and easily accessible learning experience. In addition, developing critical thinking skills obtained a high score, indicating that this e-book supports 21st-century learning that emphasizes analytical, evaluation, and problem-solving skills. These results follow Zheng et al. (2018), who show that interactive digital teaching materials can improve critical thinking skills through problem-based learning. The qualitative data obtained from limited interviews with students (FGD) are presented in Table 2.

Table 2. Qualitative Interview Analysis on the Practicality of Interactive Flipbook E-Books

Analysis Aspects	Findings from the Interview
Ease of Access and Use	The majority of students considered e-books easy to access via laptops and smartphones. The responsive display made navigation easier. However, some students experienced access problems due to internet connection.
Readability and presentation of material	The layout and visual design are very helpful in understanding modern physics material. Interactive diagrams and simulations make the material easier to understand. However, some text parts need to be shortened to be more focused.
Interactivity and engagement in learning	Interactive quizzes and simulations help test understanding before discussion sessions. Interactive elements increase engagement in learning, especially on abstract concepts such as relativity and quantum mechanics.
Critical Thinking Skills Development	This e-book encourages students to think critically through case studies and reflective questions. Problem-solving-based exercises help students analyze and find solutions from various perspectives.
Suggestions for further development	Students suggested integrating Augmented Reality (AR)- based technology to increase interactivity. They also suggested simplifying visual display in sections with long texts to increase reading comfort.

Table 2 shows that students generally considered the e-book effortless to access through various

devices, such as laptops and smartphones, although some experienced access problems due to limited internet connections. Regarding readability and presentation of materials, the layout and visual design were considered very helpful in understanding modern physics concepts, especially with interactive diagrams and simulations. This finding is in line with Kang and Wee (2015), who utilized interactive simulations using Easy Java/Javascript Simulations (EjsS) in e-books, which can make it easier for students to access physics materials via laptops and tablets, thereby increasing the understanding of physics concepts through interactive models by up to 87%. However, there are suggestions that some parts of the text be simplified to be more focused. Student interactivity and involvement in learning are also increased by the quiz and simulation features that allow students to test their understanding before the discussion session. These interactive elements are very helpful in understanding abstract concepts such as relativity and quantum mechanics. This is also in line with Zakaria et al. (2023), who developed ARDI (AR-Digital Book) on electromagnetic induction material, obtained research findings in the form of an increase in students' understanding of physics concepts in using AR-Digital Book by 92%. In addition, this e-book is also considered capable of encouraging students to think critically through case studies, reflective questions, and problem-solving-based exercises. As a suggestion for further development, students recommend the integration of Augmented Reality (AR)-based technology to increase interactivity and simplify the visual display in sections with long text to make them more comfortable to read. This development suggestion follows Vidak et al. (2024), which states that AR can facilitate physics learning through additional visualization, optimizing cognitive load, reducing task completion time, and supporting collaborative learning. This also aligns with Strzys et al. (2018), who found that AR improves students' understanding of thermodynamic concepts. Overall, this interactive flipbook-based physics e-book is considered very practical and effective in supporting student learning, with several aspects that can still be improved to provide a more optimal learning experience. Meanwhile, qualitative data from lecturer interviews are presented in Table 3.

Table 3. Lecturer Feedback on the Practicality and Development of Interactive Flipbook E-Books

Analysis Aspects	Findings from the Interview
Advantages of E-Books	Lecturers found e-books very helpful in explaining abstract concepts of modern physics. Interactive features such as simulations and animations enhance students' understanding. Ease of access and flexibility of use were also considered as added value.
Further development	Lecturers suggest further development by adding AI-based adaptive learning features to adjust the difficulty level of questions to students' abilities. Integration with other learning platforms, such as LMS, is also recommended to facilitate the monitoring of students' learning progress.

Table 3 shows lecturer feedback on the practicality of the modern physics e-book based on interactive flipbooks. Lecturers consider this e-book very helpful in explaining abstract concepts through interactive features such as simulations and animations that improve students' understanding (Roemintoyo & Budiarto, 2021). In addition, ease of access and flexibility are added value (Setianingrum et al., 2022). For further development, lecturers suggest the integration of AI-based adaptive learning so that the difficulty level of the questions can be adjusted to the students' abilities and connectivity with the LMS to facilitate the monitoring of learning progress. Although these results indicate a high level of practicality, further testing with a larger student population is needed to validate the results more widely. In addition, improvements in accessibility and visual design are needed to increase the convenience and appeal of e-books as a digital learning medium.

CONCLUSION

The results of this study indicate that the modern physics e-book based on interactive flipbooks has a very high level of practicality, both in limited and large-scale trials. The majority of criteria scored above 80%, with the category of "feedback and assessment" reaching 96.53% and "visual design and aesthetics" at 95.83%, while "accessibility and technology compatibility" had the lowest score (86.81%) but remained in a good category. Lecturer responses also showed positive results with an average practicality of 91.67%, although "visual appeal and graphic design" had a lower value (83.33%), indicating the need for improvement in the aesthetic aspect. Overall, this e-book is considered very practical and effective in supporting modern physics learning and the development of students' critical thinking skills, with the potential to become an innovative primary learning medium in physics education in the digital era. This study contributes to developing interactive digital learning media based on flipbooks to support modern physics learning. The study results indicate that this e-book has a high level of practicality, with interactive features that facilitate accessibility and readability of the material. In addition, this study provides a guide to evaluating the practicality of digital teaching materials. It supports the development of technology-based curricula in higher education, especially in the STEM field. These findings can be a reference for educational policies in integrating digital media to improve the quality of

physics learning. As a recommendation, the development of modern physics e-books based on interactive flipbooks can be continuously improved by considering accessibility and technology compatibility to make them more accessible on various devices, including offline mode. In addition, improving visual elements and graphic design is needed to increase the appeal and create a more interactive and immersive learning experience for students. Further research is also recommended to test the practicality of this e-book in various learning models, such as problem-based learning (PBL) or flipped classrooms, to explore its impact on student engagement and understanding of concepts more deeply. Furthermore, the development of adaptive features based on artificial intelligence (AI) can be an innovation to adjust the material to individual learning needs so that this e-book can be a more personalized and effective learning medium in supporting modern physics learning in the digital era.

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