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Effects of Digital Teaching Materials on Physics Learning Outcomes for High School Students: A Systematic Literature Review

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ABSTRACT

The development of digital technology encourages the utilization of digital teaching materials in physics learning to enhance the effectiveness of the learning process. This research focuses on identifying the influence of digital teaching materials on physics learning in senior high schools. The research was conducted using a Systematic Literature Review (SLR) method. Six national articles published between 2021–2025 were analyzed based on theme suitability, quality, and empirical findings. The study results show that digital teaching materials such as e-modules, E-Student Worksheet, interactive presentations, and application-based visual media have been proven to improve student learning outcomes, motivation, and critical thinking skills. The results indicate that digital teaching materials, such as e-modules, E-Student Worksheet, interactive presentations, and application-based visual media, have a positive impact on student learning outcomes, motivation, and critical thinking skills. In addition, these materials enhance conceptual understanding and increase student engagement through interactive learning experiences. Thus, digital teaching materials have a positive influence and are worthy of integration into high school physics learning to support adaptive and technology-relevant education.

INTRODUCTION

Advances in science and technology have become increasingly sophisticated today. The shift of the era to digital technology greatly influences various aspects of life, including the field of education (Bakri et al., 2016). The influence of science and technology on education is evident in the development, strategies, and implementation of learning activities, which must leverage technology to enhance learning efficiency and effectiveness (Muzijah et al., 2020). The improvement of efficiency and effectiveness in the quality of school education must align with the rapid advancements in technology and information developing in society.

In line with this transformation, traditional teaching materials have gradually evolved into digital learning resources that are more interactive, flexible, and accessible for students outside the classroom. Within the context of physics learning, digital teaching materials such as digital modules, experimental videos, virtual simulations, and learning platforms based on Learning Management Systems enable students to represent abstract concepts in a more visual and contextual manner, thereby supporting deeper conceptual understanding and increased motivation. Moreover, the integration of such digital materials into the school curriculum can foster student-centered learning and better align instruction with the habits and expectations of a generation that is accustomed to acquiring knowledge through electronic devices and the internet.

Another important advantage of digital teaching materials in physics is their potential to reduce the gap between school learning and real-world scientific practices. Through virtual labs and simulations, students can safely conduct experiments that would otherwise be limited by time, cost, or laboratory facilities, while still experiencing the process of data collection, analysis, and interpretation. These experiences help students connect theoretical formulas and laws with observable phenomena, strengthening their scientific reasoning and ability to apply physics concepts in everyday contexts. As a result, digital teaching materials not only improve access to learning but also deepen the quality of physics learning by making it more experiential, relevant, and aligned with contemporary scientific literacy goals.

One area of learning that utilizes advances in technology and information is physics. Physics learning itself must be integrated with technology and information (IT), which has become a necessity in the learning process. It has been demonstrated that this need can support the learning process, enhance and improve student understanding, and assist teachers in implementing learning. The impact of technological and information advancements on education, particularly in the classroom, can be achieved through the development of teaching materials. These materials are developed to improve the quality of learning and education and produce independent and creative students. Teaching materials that can be developed with the help of today's emerging technology and information can support learning presented digitally using computers/laptops or smartphones, one of which is digital teaching materials (Ramadayanty et al., 2021).

Digital teaching materials in physics not only provide convenience in accessing content anytime and anywhere, but also allow for more varied and engaging learning experiences. Through features such as interactive simulations, embedded quizzes, animated explanations, and instant feedback, students can explore physical phenomena dynamically and construct their own understanding at their own pace. This flexibility supports differentiated instruction, where learners with different levels of readiness can engage with the same material through multiple representations. Furthermore, digital teaching materials can bridge the gap between theory and real-world applications by integrating virtual experiments and multimedia cases, thus strengthening students' scientific reasoning and problem-solving skills in physics.

At the same time, the use of digital teaching materials encourages greater student autonomy and responsibility in the learning process. Because they can access explanations, practice exercises, and assessments independently, students are more likely to take initiative in identifying gaps in their understanding and seeking clarification outside of class. Teachers can then shift their role from being the main source of information to becoming facilitators who guide discussions, support collaborative problem-solving, and help students interpret simulation results. This repositioning of the teacher-student dynamic aligns well with constructivist and inquiry-based approaches in physics education, where conceptual understanding emerges from active exploration rather than passive reception of facts.

Digital teaching materials are electronic-based teaching materials designed by teachers for students to study independently and presented systematically. Digital teaching materials are electronic learning resources that offer advantages over printed modules by integrating audio, video, images, animations, and interactive quizzes that provide automatic feedback and support students in independently overcoming learning challenges (Cheva & Zainul, 2019). Digital teaching materials must be designed systematically, following the desired learning objectives, existing characteristics and needs, so that students can learn independently (Mardyansyah et al., 2013). Digital teaching materials themselves are defined as module teaching materials displayed on digital-based electronic devices (Bakri et al., 2018). Digital teaching materials are equivalent to printed teaching materials, but the digital version is believed to be able to help students learn independently and actively (Kurniawan & Syafriani, 2021). So, it can be concluded that digital teaching materials are electronic-based teaching materials that can be used in the learning process and are arranged in an orderly manner according to students' needs with the aim of enabling students to learn independently.

In addition, digital teaching materials can support a more personalized and student-centered learning environment in physics education. By allowing learners to control the pace, sequence, and repetition of the material, digital resources empower students to revisit difficult concepts and practice problem-solving until mastery is achieved. The integration of multimedia elements not only enhances engagement but also caters to diverse learning styles, such as visual and kinesthetic learners, which are often underrepresented in traditional printed modules. When well designed, digital teaching materials also align with modern pedagogical approaches, such as inquiry-based learning and flipped classroom models, by providing pre-learning content and interactive tasks that prepare students for deeper classroom discussions and hands-on activities.

Moreover, digital teaching materials in physics can facilitate formative assessment and continuous feedback, which are crucial for improving students' conceptual understanding. Interactive quizzes, embedded self-checks, and instant scoring allow students to monitor their own progress and adjust their learning strategies accordingly. For teachers, this provides real-time insight into students' difficulties, enabling timely interventions and differentiated instruction. In this way, digital teaching materials not only support individual learning but also strengthen the interaction between teacher and students, creating a more responsive and adaptive learning environment in physics classrooms.

The development of digital teaching materials will be tailored to the learning model required and meet student needs. The digital teaching materials will be designed to emerge from the learning plans created by students (Haspen et al., 2021). It can be argued that developing digital teaching materials requires first understanding the students' needs for their learning. This way, digital teaching materials can be developed specifically for these students. Despite technological advancements, the use of digital media in physics learning appears to be underutilized by educators. This activity is still largely limited to teacher and student textbooks (Puspita et al., 2020). The continued use of printed teaching materials, such as textbooks and whiteboards, is due to the increasing age of educators and their lack of technological expertise, making it difficult for them to operate these electronic devices. A lack of socialization and information regarding the development of digital technology in education also contributes to educators' lack of interest in using digital teaching materials. This, of course, leads to student boredom and a lack of student interest in learning. Therefore, the use of digital teaching materials is essential today. Besides helping teachers facilitate the teaching and learning process, in this modern era, elementary school students have the potential to receive a wealth of information easily, quickly, and continuously evolving. It's no surprise, then, that many students are more proficient and understand current technological developments than teachers who lived in the past.

To maximize the potential of digital teaching materials, schools and education policymakers need to provide adequate training and technical support for teachers so they can confidently integrate these resources into physics instruction. Professional development programs focused on digital literacy, multimedia design, and the use of learning management systems can bridge the gap between teachers’ experience and students’ digital fluency. Moreover, when digital teaching materials are designed collaboratively by teachers, students, and other stakeholders, they become more relevant, context-sensitive, and aligned with curriculum goals. This collaborative approach also encourages teachers to view technology not as a replacement for their role, but as a tool that enhances interaction, explanation, and assessment in the classroom. In turn, physics learning can become more meaningful, interactive, and responsive to the characteristics of today’s digital-native learners.

Furthermore, the integration of digital teaching materials into physics learning can foster a more active and inquiry-oriented classroom environment. Instead of passively receiving information from textbooks, students can explore virtual experiments, manipulate variables in simulations, and observe immediate results, which closely resemble real scientific practices. This experiential engagement supports the development of critical thinking, data analysis, and problem-solving skills that are central to physics education. At the same time, digital tools can generate learning analytics that help teachers monitor individual progress, identify misconceptions early, and provide targeted feedback. By systematically embedding digital teaching materials into lesson plans, schools can transform physics instruction into a dynamic, student-centered process that better prepares learners for the demands of the 21st-century world.

This study aims to examine the effect of using digital teaching materials on physics learning among high school students, both in terms of advantages and disadvantages for the world of education. The study focuses on how digital teaching materials influence student learning outcomes and engagement in physics learning. In addition, it seeks to provide a comprehensive understanding of the role of digital teaching materials as effective learning resources. The study entitled "The Effect of Digital Teaching Materials in Physics Learning on High School Student Learning Outcomes" is expected to help readers, especially educators, to be able to find out information and gain benefits in understanding teaching materials as an appropriate learning resource for students in today's increasingly advanced era.

METHODS

This research employed a Systematic Literature Review (SLR) approach. The method involves identifying, reviewing, evaluating, and interpreting relevant studies from the existing literature. Articles that aligned with the research questions were systematically examined by the researchers. The review process was conducted systematically and structured at each stage, following predetermined stages (Triandini et al., 2019). Subsequently, the researcher conducted an in-depth analysis of the selected articles. The

Systematic Literature Review process was implemented through five stages: (1) formulating research questions, (2) identifying and mapping relevant articles aligned with the research questions, (3) applying inclusion and exclusion criteria to select appropriate studies, (4) organizing and analyzing the data, and (5) interpreting the findings and drawing conclusions (Fitriani & Putra, 2022; Nurfadilah et al., 2022).

To ensure the quality and relevance of the selected studies, clear inclusion and exclusion criteria were established. The inclusion criteria consisted of: (1) research focusing on digital teaching materials in physics learning, (2) studies conducted at the senior high school level, (3) empirical studies employing quantitative or mixed methods, and (4) articles published in accredited national journals within the period of 2021–2025. Meanwhile, the exclusion criteria included: (1) studies that were not directly related to physics learning, (2) articles lacking clear methodology or research findings, and (3) duplicate or inaccessible publications. These criteria were applied systematically to ensure that only high-quality and relevant studies were included in the analysis.

The first step taken by the researcher was to determine the theme to be studied. The researcher chose the theme "digital teaching materials and physics learning" as the topic to be used in the research. Data collection for the literature study was conducted through a systematic search process for Google Scholar articles through the Publish or Perish (PoP) application using the keyword "Physics Learning in High Schools with Quantitative Methods." The researcher limited the number of articles to 200 from 2021 to 2025. Then, the researcher filtered through a one-by-one selection stage of the article content. After conducting the analysis, 13 articles were found that met the predetermined criteria. Next, from the various articles, the researcher selected six articles to be reviewed, analyzed, and re-examined in detail and related to the research theme. The following is a diagram of the stages taken by the researcher in conducting the SLR literature study through PoP.

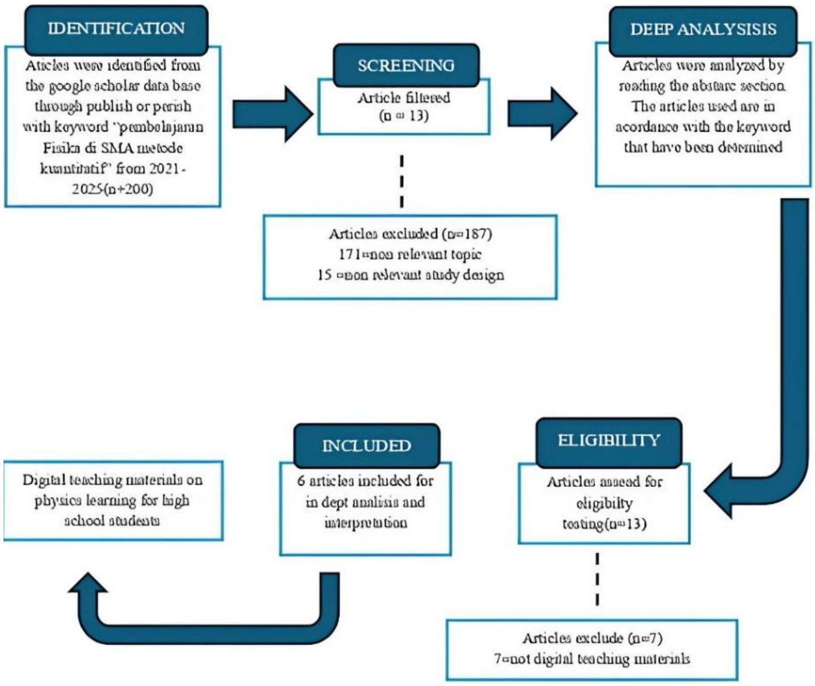

Figure 1. Flowchart of the Process of Exclusion and Inclusion of Articles in the Systematic Literature Review stage. Source: Musdary et al. (2021)

The data analysis in this study was conducted using a qualitative descriptive approach. The selected articles were analyzed by identifying key information, such as types of digital teaching materials and their effects on student learning outcomes. The data were then categorized and presented in tabular form to facilitate comparison between studies. Furthermore, the results were interpreted by identifying patterns, similarities, and differences across the reviewed articles. This analysis allows the researchers to draw conclusions regarding the effectiveness of digital teaching materials in physics learning.

In addition, a thematic analysis approach was employed to synthesize the findings from the selected studies. The researchers identified recurring themes, patterns, and relationships related to the implementation and impact of digital teaching materials. This approach allowed for a deeper interpretation of the data beyond simple comparison. Furthermore, cross-analysis between studies was conducted to identify consistencies and discrepancies in findings. This step was essential to strengthen the validity of the conclusions and reduce potential bias in interpreting the results of the literature review.

RESULTS AND DISCUSSION

The data used in this literature review consist of analyses and summaries of articles that examine the use of digital teaching materials in high school physics learning. These results focus on two main aspects: the type of digital teaching materials used and the student learning outcomes obtained after the implementation of digital teaching materials. The results are presented in tabular form to facilitate mapping of research findings, then discussed analytically by linking the results between studies and supported by relevant references. The results of the literature review of six articles indicate that the use of digital teaching materials in high school physics learning is implemented in various forms, such as e-modules, E-Student Worksheet, and digital presentation media, with diverse learning outcomes.

The variation in learning outcomes across the reviewed studies indicates that the effectiveness of digital teaching materials is influenced by several factors. These include the design quality of the materials, the level of interactivity provided, and the learning strategies applied by teachers. Studies that integrated digital teaching materials with active learning approaches tended to show better results compared to those that used them merely as presentation tools. This suggests that pedagogical integration plays a crucial role in maximizing the benefits of digital teaching materials.

Based on Type of Digital Teaching Materials

The results of the literature review related to the types of digital teaching materials used in high school physics learning are presented in Table 1. This table summarizes various forms of digital teaching materials identified from the selected articles, along with their characteristics and subject matter. The classification aims to provide a clear overview of how digital teaching materials are developed and implemented in physics learning. By presenting this information, it becomes easier to analyze the trends and dominant types of digital teaching materials used in previous studies.

Table 1. Types of Digital Teaching Materials in High School Physics Learning

Researcher (years)	Types of Teaching Materials	Material	Characteristics of Teaching Materials
Sari et al., (2021)	Ethnophysics-based e-module	Temperature and heat	Contextual, visual, integrated local wisdom
Amin & Sulistiyono (2021)	CTL-based e-handout	Various physics materials	Concise, contextual, supports learning activities
Nurnaifah & Razzaq (2022)	PowerPoint digital	Physics material for class XI	Visual, systematic, easy to use
Darise et al., (2022)	E-Student Worksheet	Various physics materials	Interactive, task-based, according to BSNP standards
Mahardika et al., (2022)	Inquiry-based E-Student Worksheet	Momentum and impulse	Encourage student inquiry activities
Idayanti & Suleman (2024)	Standalone e-module	Ecosystem	Flexible, supports independent learning

Based on Table 1, the most dominant types of digital teaching materials used in high school physics learning are e-modules and E-Student Worksheet. This finding indicates that structured and interactive digital teaching materials are preferred by researchers because they can support independent learning and student learning activities. This is in line with the opinion of Bakri et al. (2018) who stated that digital teaching materials allow for the systematic integration of text, images, animations, and evaluations, which helps improve students' understanding of physics concepts

The e-modules developed in the research by Sari et al. (2021) and Idayanti & Suleman (2024) emphasize structured presentation of material and conceptual visualization, making it easier for students to understand abstract material. These features allow learners to engage more effectively with the content and support independent learning. Meanwhile, inquiry-based E-Student Worksheet (Mahardika et al., 2022) plays a role in increasing student engagement through investigation and problem-solving activities. These findings reinforce the view that digital teaching materials function not only as sources of information but also as active learning tools that encourage student engagement (Ramadayanty et al., 2021).

Based on Student Learning Results

The results of the literature review related to student learning outcomes after the implementation of digital teaching materials are presented in Table 2. This table summarizes the indicators of learning outcomes, analysis techniques, and key findings reported in each selected study. The presentation aims to provide a clear comparison of how digital teaching materials influence physics learning outcomes across different research contexts. By examining these results, it becomes possible to identify patterns and variations in the effectiveness of digital teaching materials.

Table 2. Student Learning Outcomes after Using Digital Teaching Materials

Researcher (years)	Learning Outcome Indicators	Analysis Techniques	Key Results
Sari et al., (2021)	Percentage of learning outcomes	Descriptive	86.8% (very good)
Amin & Sulistiyono (2021)	N-gain	Pretest–posttest	0.22–0.27 (low)
Nurnaifah & Razzaq (2022)	Midterm Exam Scores	Correlation & t-test	Significantly influential ($p < 0.05$)
Darise et al., (2022)	Average value	Rasch Model	61.09–67.76 (fair–good)
Mahardika et al., (2022)	Average value	Hypothesis testing	H_0 rejected
Idayanti & Suleman (2024)	Class average	t test	Experimental class is higher

Based on Table 2, the use of digital learning materials generally has a positive impact on high school students' physics learning outcomes, although the level of improvement varies. Significant improvements in learning outcomes were seen in studies by Sari et al. (2021) and Idayanti & Suleman (2024), which showed that e-modules were able to improve learning outcomes to the good and excellent categories. This suggests that well-designed digital learning materials can help students understand physics concepts more effectively. In addition, structured and interactive content plays an important role in facilitating meaningful learning.

However, Amin & Sulistiyono (2021) showed different results, where the N-gain value was still relatively low. This finding indicates that the success of digital learning materials is determined not only by the media format, but also by learning strategies and student engagement. Other factors, such as instructional strategies and the level of student engagement, also play a crucial role in influencing learning outcomes. This aligns with the opinion of Cheva & Zainul (2019), who emphasized that digital learning materials need to be integrated with appropriate learning models to optimally impact learning outcomes.

Digital PowerPoint presentations also demonstrate a significant impact on student learning outcomes (Nurnaifah & Razzaq, 2022). Visual presentations help students understand physics concepts, but their effectiveness depends heavily on how teachers manage the learning. However, their effectiveness largely depends on how teachers manage and implement them in the learning process. Therefore, digital teaching materials are more effective when used as part of active learning, rather than simply as a one-way medium for conveying information.

Overall, these results and discussion indicate that the use of digital teaching materials has the potential to positively affect physics learning outcomes at the high school level. This finding suggests that digital teaching materials can support students in understanding concepts more effectively. This effectiveness is influenced by the type of teaching material, the quality of its design, and the learning model used. Therefore, the use of digital teaching materials needs to be designed systematically and contextually to maximize their impact on student learning outcomes.

Discussion

The findings of this study indicate that digital teaching materials have a generally positive effect on students' physics learning outcomes, although the degree of effectiveness varies across studies. This result is consistent with previous research which states that digital teaching materials, such as e-modules and E-Student Worksheet can enhance students' conceptual understanding, motivation, and engagement in learning (Bakri et al., 2018; Ramadayanty et al., 2021). The integration of multimedia elements, including text, images, animations, and interactive assessments, enables students to visualize abstract physics concepts more effectively, which is essential in physics learning (Muzijah et al., 2020).

Furthermore, the dominance of structured digital teaching materials such as e-modules and E- Student Worksheet indicates that organized and interactive content plays a significant role in supporting independent learning. This finding aligns with the constructivist learning theory, which emphasizes that students actively construct their knowledge through meaningful learning experiences (Cheva & Zainul, 2019). In addition, inquiry-based digital teaching materials have been shown to improve higher-order thinking skills, such as critical thinking and problem-solving, as they encourage students to engage in investigation and analysis (Mahardika et al., 2022; Kurniawan & Syafriani, 2021).

However, the variation in learning outcomes, such as the low N-gain reported in some studies, suggests that the effectiveness of digital teaching materials is influenced by several factors. These include instructional design, the suitability of learning models, and the level of student engagement during the learning process. Studies have shown that digital teaching materials are more effective when integrated with active learning strategies rather than being used as passive instructional media (Nurnaifah & Razzaq, 2022; Puspita et al., 2020). Therefore, the successful implementation of digital teaching materials requires not only well-designed content but also appropriate pedagogical approaches.

These findings have important implications for physics education practice. Teachers are encouraged to integrate digital teaching materials with appropriate instructional strategies, such as inquiry-based and problem-based learning, to enhance student engagement and understanding. In addition, schools should provide adequate technological infrastructure and training programs to support teachers in effectively utilizing digital resources. Moreover, the development of digital teaching materials should consider students' characteristics, learning needs, and contextual relevance. Well-designed materials that align with learning objectives can significantly improve both cognitive and affective learning outcomes.

This study has several limitations that should be considered. First, the number of articles analyzed is relatively limited, as only six studies were selected for in-depth review, which may not fully represent all existing research on digital teaching materials. Second, the study only focuses on national articles published between 2021–2025, which may limit the generalizability of the findings. Third, the analysis relies on secondary data from previous studies, so the results depend on the quality and scope of the selected articles. Therefore, future research is recommended to include a larger number of studies, incorporate international publications, and apply more comprehensive analysis methods to obtain more robust findings

Overall, the results of this study reinforce the importance of integrating digital teaching materials into physics learning to support 21st-century education. Digital teaching materials provide flexibility, accessibility, and interactivity that can enhance the quality of learning. However, their effectiveness depends on how they are designed and implemented in the classroom context. Thus, teachers need to be equipped with adequate digital literacy and pedagogical skills to maximize the benefits of digital teaching materials in physics education.

CONCLUSION

Based on the analysis of six reviewed articles, it can therefore be concluded that digital teaching materials positively influence high school students' physics learning outcomes. The most dominant types of teaching materials used are e-modules and E-Student Worksheet, which are effective due to their structured and interactive presentation. Improvements in student learning outcomes show variation, influenced by the design of the teaching materials and the learning model applied. Therefore, digital teaching materials need to be integrated with appropriate learning strategies to provide optimal impact on physics learning.

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