

DIGITAL MATERIAL DEVELOPMENT FOR SECONDARY EDUCATION

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ABSTRACT

The research on the creation, application, and efficacy of digital learning resources in secondary education is systematically reviewed in this study. To find new trends, design strategies, learning objectives, and pedagogical implications, fifteen peer-reviewed publications from 2020 to 2025 were examined. Results show that digital learning resources, including web-based platforms, multimedia content, animations, augmented reality, and e-interactive modules, greatly increase student motivation, engagement, and comprehension. The successful integration of digital materials was found to be significantly influenced by teacher digital competency, infrastructure preparedness, and institutional support. Additionally, this assessment emphasizes the necessity for inclusive and adaptable material design by highlighting ongoing gaps in students' digital skills. Overall, the study comes to the conclusion that the creation of digital materials raises the standard of secondary education when it is backed by a solid pedagogical basis and sufficient technological capability, offering significant guidance for future advancements in digital learning resources.

Keywords: *digital material, secondary education, instructional media, ICT, systematic literature review*

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1. INTRODUCTION

The development of digital technology has significantly altered secondary education teaching approaches. These shifts can be seen not only in how educators and students utilize digital devices but also in how they gather and handle information. Previously dominated by printed materials, learning resources have evolved into more dynamic, interactive digital resources that may accommodate students' contemporary learning preferences. Particularly for secondary school children who are in a stage of cognitive and social development that calls for the use of technology and critical thinking abilities, increased digital literacy has emerged as a crucial precondition for 21st-century education. Students are expected to be able to use a variety of platforms, comprehend multimodal information, and work together in technologically advanced settings as learning processes grow more digital.

Additionally, a variety of learning materials, such as multimedia content, simulations, programs connected with games, and virtual or augmented reality, have emerged as a result of the availability of quick digital platforms. These developments provide chances to customize education and give abstract ideas a more tangible, engaging quality. Additionally, digital resources can facilitate customized learning, enabling educators to adapt course content to students' varied skill levels, interests, and learning styles. This flexibility is especially crucial in the present secondary school environment, where students must acquire problem-solving and technological adaptation abilities in addition to subject-specific competencies that will help their future academic and career pathways.

In this situation, the utilization of digital resources is crucial to raising educational standards since it can make knowledge more accessible, boost educational possibilities, and promote more independent thought. By enabling students to access content at any time and from any location, digital materials can promote independent study and extend learning outside of the traditional classroom. Digital integration in education also gives teachers the chance to use more flexible and adaptable teaching strategies, according to (Hasnah et al., 2024). This flexibility enables educators to change their methods from a conventional teacher-centered approach to a more dynamic, student-centered classroom that promotes inquiry, teamwork, and creativity.

Nevertheless, there are drawbacks to integrating digital learning resources despite their advantages. Successful implementation is frequently hampered by problems including teacher preparedness, digital competency, and the accessibility of technology infrastructure. Because some students may find it difficult to use digital tools effectively, differences in pupils' levels of technological competency also contribute to uneven learning results. Additionally, it is challenging for schools to offer all children equitable learning opportunities when they lack suitable technology or dependable internet. This disparity emphasizes the value of systemic support and ongoing professional development for educators in order to guarantee fair access to technology.

In order to comprehend the process of creating digital learning materials, their efficacy, and the variables influencing their performance in secondary schools, systematic research is essential. Knowing these elements can help educators, curriculum designers, and legislators create digital resources that are contextually relevant, pedagogically sound, and student-centered. It is anticipated that research in this area will improve learning outcomes, increase digital literacy, and develop best practices for meaningfully and sustainably integrating technology into secondary education.

R1. To what extent has the creation of digital learning resources improved secondary school students' learning outcomes?

R2. What are the advantages and effects of employing digital learning resources on secondary school students' motivation, engagement, and educational experiences?

2. LITERATURE REVIEW

2.1 Cognitive Theory of Multimedia Learning

A theory known as the Cognitive Theory of Multimedia Learning (CTML) describes how people receive and comprehend information from a variety of media, especially text, audio, and pictures. According to Mayer, selecting, organizing, and integrating information are the three primary cognitive processes involved in multimedia learning. In order to create a text base and

an image base, students select pertinent verbal and visual information during the selection stage. This information is organized into verbal and visual models during the organizing step, and it is integrated into a comprehensive comprehension of the learning content during the integrating stage (AlShaikh et al., 2024).

In order to lessen cognitive load and improve the efficiency of information delivery, CTML places a strong emphasis on applying concepts like coherence, signaling, segmenting, and multimedia principles in the creation of learning media. According to recent research, these guidelines are especially pertinent when creating instructional films since they can reduce superfluous content, focus learners' attention on crucial elements, and create a presenting structure that is easier to follow. To put it another way, CTML provides a theoretical framework for instructional design that optimizes students' cognitive processing abilities by combining text, audio, and pictures in the right ways (Firdaus et al., 2024).

Furthermore, research in the article you gave demonstrates that CTML may be included into the creation of AI-based systems, including AI-Based Educational Video Assistants, which make use of Large Language Models (LLMs) and Automatic Speech Recognition (ASR) technology. Through features including transcribing, emphasizing key concepts, segmenting the learning process, and displaying concept maps or diagrams to facilitate the integration of verbal and visual knowledge, this system employs CTML principles. This demonstrates that CTML is not only applicable to traditional multimedia design but also has enormous promise when paired with contemporary generative technologies to produce a more efficient and customized educational experience. (AlShaikh et al., 2024)

2.2. Technological Pedagogical Content Knowledge

According to the Technological Pedagogical subject Knowledge (TPACK) framework, teachers must thoroughly integrate pedagogy, technology, and subject knowledge while creating digital instructional resources for secondary school. Only when technology integration is in line with the features of the subject matter and instructional techniques will it be successful. In order for digital teaching resources to actually enhance the quality of the learning process in the digital age, Nasution and Batubara stress that educators' proficiency in "developing technology-based learning" is a crucial prerequisite (Nasution & Batubara, 2020). In this situation, teachers are in charge of choosing materials as well as making sure that the media's form, depth, and presentation order are appropriate for the needs of the pupils. Mayer's presentation of multimedia development principles, such as coherence, spatiotemporal closeness, and visual integration, supports the notion that technology use must be based on a suitable pedagogical basis in order to prevent students' cognitive load from increasing (Nasution & Batubara, 2020).

Furthermore, the findings of Saputra et al.'s study support the necessity of TPACK by demonstrating that, in comparison to traditional approaches, digital teaching resources can greatly increase comprehension and motivation to learn. As demonstrated by the rise in literacy scores from 45 to 72 in the experimental group that used digital teaching materials, technology utilization goes beyond simply adding visual media to create interactive learning experiences that enhance literacy, interest, and student engagement (Saputra et al., 2024). This demonstrates that the design of digital teaching materials will be more relevant, engaging, and successful for 21st-century learning when educators can successfully integrate technology with pedagogical techniques and content requirements. Because it guarantees that technology is not only present as a tool but also as a strategic component of a high-quality learning process, the TPACK

framework thus becomes an important theoretical foundation in the production of digital resources for secondary education.

2.3. Constructivism Theory

According to constructivism, students actively create their own knowledge through interaction, firsthand experience, and active participation in the learning process. This approach highlights that technology should assist students in creating meaning rather than merely passively absorbing knowledge when creating digital products for secondary school. This is consistent with (Nafis, 2024) findings that monotonous learning reduces student engagement, as demonstrated by the learning issue of "monotonous learning," which leads to poor student learning outcomes. Through investigation, visualization, and engagement with the topic, interactive digital resources can offer a more comprehensive educational experience.

Constructivism also highlights the value of autonomous student participation in the learning process. It has been demonstrated that using AR-based digital media created by (Nafis, 2024), motivates students to take an active role in expanding their knowledge. According to the study, "students became more enthusiastic, so they paid more attention" because learning is no longer boring, which leads to increased student engagement and active participation in the process. In keeping with the core ideas of constructivism theory (Nafis, 2024), this demonstrates how interactive digital media not only boosts motivation but also gives students the chance to create knowledge through meaningful learning experiences.

3. METHODS

Finding, analyzing, and disseminating pertinent papers to address the researcher's inquiries is the aim of this study. When using the Systematic Literature Review (SLR) method, researchers go through a number of steps: they formulate questions based on the required topic; they search for sources, such as those on Google Scholar, PubMed, Scopus, and others; they choose different sources based on the data used; and they review and select results from previous processes, such as titles and abstracts that have been seen previously, to determine whether the research is relevant. A comprehensive explanation based on the tools and resources utilized is necessary for quantitative research. Quantitative research includes explanations of the presence of researchers, subjects, informants, data gathering methods, and data analysis.

All of this is a component of quantitative research. This study examines the development of digital materials for menengah education. The first method used by the researchers is to search for topics that will be used in Science Direct and Pubmed data bases during a period of five years, specifically from 2020 to 2025. The second step involves identifying journal articles from Google Scholar, Pubmed, Science Direct, and Scopus that are found and selected in order to obtain journal articles related to the selected topic. Out of all the articles that have been read and analyzed, the researchers have identified fifteen that are pertinent. Finally, the researchers conduct a thorough analysis of the article before comparing it to other journal articles and creating a summary.

Procedure

The author used a list of keywords created according to the research focus such as digital learning materials, technology integration in secondary education, digital media development, and ICT-based learning the author carried out an initial search. A multi-step selection procedure based on the PRISMA model was then used to every article that was located. a) Identification,

This phase involves collecting all relevant articles on the development and use of digital teaching materials in secondary education, gathered from various databases using the keywords. b) Screening is the process of eliminating articles that are irrelevant or do not directly address the development of digital teaching materials. Furthermore, articles that are too general or only discuss technology without an educational context are also removed from the list. c) Eligibility, which entails a more thorough examination of the abstract and article content to make sure the study actually deals with the creation, application, or assessment of digital teaching resources in secondary education. Articles that don't fit the criteria for the research focus are removed. d) Inclusion: Only genuinely pertinent articles those that bolster the examination of the creation, application, efficacy, and difficulties of digital teaching resources are incorporated as final data for systematic analysis during this stage.

Study selection criteria

Journal papers published between 2020 and 2025 that addressed the creation, application, or assessment of digital learning resources in secondary education specifically, English language learning and were available in full-text format met the study's inclusion criteria. The majority of articles either addressed motivational or perceptual pressures without presenting empirical findings, were unrelated to secondary education, only discussed general technology use without addressing development materials, or were not available in full-text format.

The data were analyzed using a thematic approach after the final pool of eligible articles was identified. Each article was carefully reviewed, and the results were categorized into key themes, such as the kinds of digital materials created for secondary school students, their use in English language classes, the impact of digital resources on student learning outcomes, and pedagogical factors influencing successful integration. A thorough synthesis of how digital learning resources promote English language learning in secondary education was produced as a consequence of the thematic analysis, which revealed trends and insights pertaining to the creation of digital materials.

Instrument(s)

For this Systematic Literature Review (SLR) study, the researchers developed a data extraction sheet to systematically and in accordance with PRISMA criteria gather and classify information from each publication discussing the development of digital materials in secondary schools, particularly English language learning. The year of publication, research design, participant education level, type and platform of podcast used, podcast implementation procedures, listening skills measured, research instruments used in primary studies, and findings related to improving students' listening skills were all covered by the 25 items on this data extraction sheet. This instrument included both closed-ended and open-ended items to enable researchers to collect a balance of quantitative and qualitative data, and it underwent an internal review procedure to assure its applicability and clarity prior to usage. It takes about 20 to 30 minutes to retrieve the data from each article. Even though the primary studies did not directly gather data from respondents, the instrument documented the measurement tools utilized in those research, such as listening comprehension tests, quizzes, performance assessments, or student perception questionnaires. Academic databases like ScienceDirect, PubMed, Mendeley, and Google Scholar were employed as methods to locate pertinent publications from 2020 to 2025.

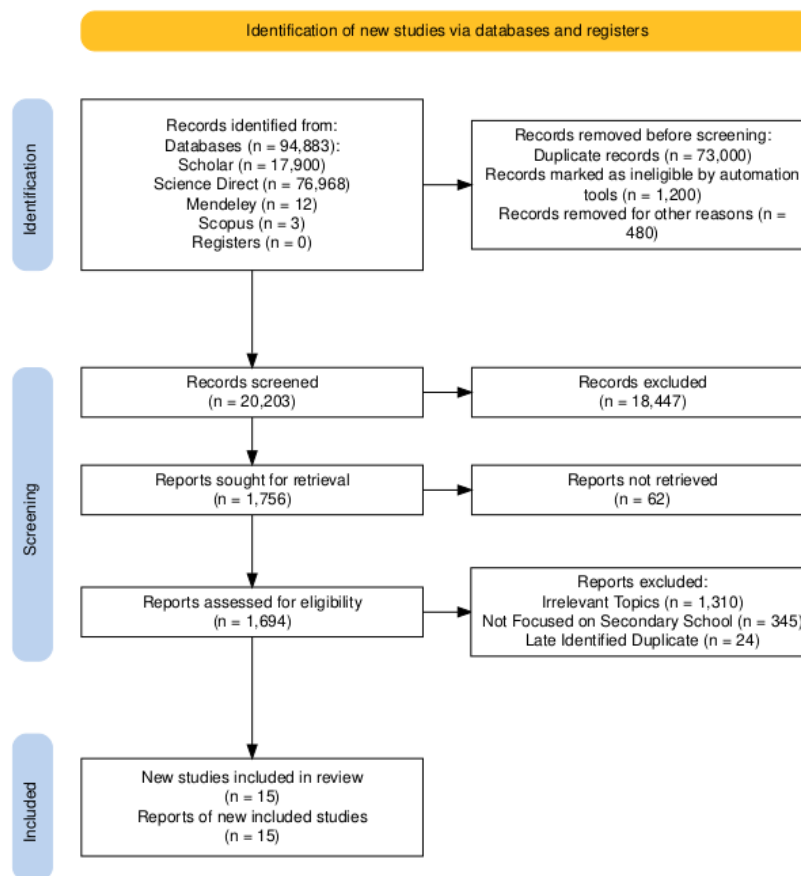


Figure 1. PRISMA Flowchart of the selection process.

4. RESULT AND DISCUSSION

TABLE 1. Summary of Findings of the Selected Final Studies.

No	Authors/Year/Country	Main Characteristics	Study Design/Measuring	Findings
1	Gnambs & Hawrot (2025), Germany	4872 German adolescents (ages 12-18) examined for development of digital competencies and inequalities (SES, gender, migration).	Longitudinal study; digital competence assessed 3 times using standardized achievement tests; latent growth curve analysis.	During adolescence, digital disparities continue to exist and change. Migration-related inequalities stayed constant, gender differences rose over time (favoring boys), and SES disparities were originally high but slightly decreased. Schools were not

				effectively addressing digital competence gaps, suggesting early interventions are needed.
2	Demissie, Labiso & Thuo (2022), Ethiopia	Teachers, principals, and pedagogical center coordinators from secondary schools in Ethiopia; focus on teachers' digital competencies and technology integration.	Survey + qualitative insights; TPACK framework used to measure technological, pedagogical, and content knowledge and their interactions	All knowledge areas positively predicted TPACK implementation, and teachers scored highly in content, pedagogical, and pedagogical-content knowledge. The best indicators of successful technology integration were good attitudes, in-service training, and technological expertise. Lack of professional development, assistance, and access were among the obstacles
3	Pedasto, Kallas & Baucal (2023), Estonia	836 primary and lower-secondary students (grades 3-9) in Estonia; development and validation of a digital competence test (Digitest).	IRT analysis + confirmatory factor analysis on 10 dimensions of digital competence.	The exam suited well and revealed nine distinct dimensions of digital competence. Higher-order skills fall into two categories: cognitive-behavioral and motivational. The findings show that pupils' digital competency varies across dimensions and requires a comprehensive evaluation.
4	Adu & Zondo', (2024), Africa	Secondary schools in South Africa; focus on teachers' digital skill	Case study; 4 schools; document analysis + semi-structured interviews.	Due to a lack of training and ambiguous curriculum direction, teachers' digital abilities were inadequate. ICT

		deficiencies and ICT integration in Economics subject.		champions, professional learning groups, and ongoing professional development were successful tactics for enhancing digital abilities. The curriculum had to be reorganized to incorporate resources like Moodle and links for video conferences.
5	Matuschek, & Hackenberg, (2025), Germany	35 teachers in Germany; explored competencies, attitudes, equipment, cooperation, and professional development influencing digital instructional development.	Qualitative semi-structured interviews; thematic/holistic analysis.	Teachers' digital instructional development was impacted by all conditional aspects (competencies, attitudes, equipment, cooperation, and professional development). The largest challenges were digital literacy and time restrictions. Enhancing digital instructional development required school autonomy, leadership support, and focused training.
6	Gleisner Villasmil (2024), Sweden	243 upper secondary school teachers from 23 Swedish schools.	Quantitative using a six-point scale; exploratory analysis (EFA) and confirmatory factor analysis used to identify influencing factors and dimensions of digital use.	The following five elements were shown to have an impact: (1) a supportive school environment; (2) social support; (3) prior work, education, and hobbies; (4) student-oriented factors; and (5) stress.
7	Nurdin, Putra & Hidayat	Twenty 8th-grade MTs students used	R&D using the model, with data expert validation,	The digital teaching resources supported by Google Sites received

	(2023), Indonesia	Google Sites-based digital math materials integrated with a PBL model to improve their mathematical critical-thinking skills.	onnaires, group and pretest-post results; ed using paired dependent t-tests	ratings of validity, usefulness, and efficacy. Students' mathematics critical-thinking abilities significantly improved after using the PBL digital teaching resources, according to pretest-posttest results (mean raised from 69.15 to 78.80).
8	Al Mulhim & Zaky (2023), Saudi Arabia & Egypt	336 first-year secondary students (14-16 years) in a Digital Skills course, comparing e-book users and printed-book users to examine the effect of digital materials on academic procrastination.	Causal comparative design with tural groups (e-s. printed-book data from a 24-procrastination analyzed using an ndent-samples t-	Academic procrastination did not differ statistically significantly between students who used paper textbooks and those who used e-books ($t = 0.357$, $p > 0.05$). Average scores for procrastination: Group of e-books: $M = 47.20$, Group of printed books: $M = 46.75$
9	Wicaksana et al. (2020), Indonesia	Senior high school students using e-modules to improve academic achievement.	Quasi-experiment; learning outcomes assessment d on critical-thinking aspects	By encouraging problem-solving, deeper comprehension, and organized autonomous study, the e-module greatly increased students' learning achievement.
10	Çetin & Türkan (2022), Turkey	Middle school (junior secondary) students learning science through	Quasi-experimental, experiment and e tests.	Students' science achievement and positive attitudes increased dramatically as a result of augmented reality; complicated subjects were simpler to

		augmented-reality (AR).		envision and comprehend.
11	Lohr, Sailer, Stadler & Fischer (2024), Germany	407 secondary school teachers in Bavaria were studied to examine factors influencing classroom use of digital resources and learning activities, focusing on BYOD, school-provided equipment, school support, and teachers' digital teaching skills.	Cross-sectional study using red telephone eews; data ed with structural on modeling Measured teacher skills, school t, digital ment, internet and types of learning es.	Training in tech-based teaching skills helps teachers design more active and constructive digital activities. School-provided devices have little effect on tech use or activity types. Teacher BYOD increases tech use but leads to more passive activities, while student BYOD reduces passive use and boosts constructive and interactive learning. Strong school support and fast internet are linked to higher-level interactive digital activities.
12	Şahin & Yilmaz (2020), Turkey	Middle school students learning science with AR-based materials.	Quasi-mental, ement tests and e scales.	Students said that learning was more enjoyable and tangible, and AR increased learning achievement and decreased challenges with abstract science topics.
13	Cevahir et al. (2022), Turkey	Secondary-level programming students using animation-based worked examples with AR support.	Quasi-ment; assessment evement, e, and tion.	When compared to traditional instruction, students in the AR-supported group demonstrated greater academic progress and motivation.
14	Ahmad et al. (2021), Indonesia	High school students learning	Quasi-mental; pretest-	Animation made difficult chemical processes easier to

		electrochemis try through interactive computer animation.	st achievement motivation tests.	understand and more visually appealing, which greatly increased student enthusiasm and accomplishment.
15	Hanif (2020), Indonesia	Primary and lower- secondary students learning science through motion- graphic animation.	Quasi- mental with g outcomes test.	Higher achievement was demonstrated by students who were taught using animation, which aided in the visualization of abstract scientific processes.

A consistent pattern emerges from the synthesis of 15 articles: (1) teachers' digital competency; (2) infrastructure readiness and school support; and (3) student characteristics as the primary users of digital materials. These factors have a significant impact on the development of digital materials for secondary school levels. According to the majority of research, educators who are more proficient with technology typically create digital resources that are more interactive, pertinent, and in line with students' learning objectives. According to research by (Demissie et al., 2022), in-service training and teachers' attitudes toward technology are the primary predictors of successful digital material development, and all TPACK domains have a positive relationship with teachers' ability to integrate technology.

School conditions and internal supporting factors appeared as significant variables in addition to teacher competency. According to research conducted in Germany, the effectiveness of developing digital teaching depends not only on the particular skills of teachers but also on teamwork among colleagues, school administration, and the availability of creative space for material design (Nasution & Batubara, 2020). While time restrictions and a lack of administrative assistance are major barriers, strong school support has been demonstrated to improve the quality of digital-based learning (Lohr et al., 2024). These results demonstrate that creating digital resources is a team effort that necessitates a supportive school environment, rather than just the duty of individual teachers.

Furthermore, it has been demonstrated that access to digital devices and infrastructure affects how well digital content may be created and utilized in the classroom. Although access to gadgets is still a prerequisite for facilitating technology-based active learning, a study by (Lohr et al., 2024) demonstrates that teachers' pedagogical-technological skills are significantly more significant than the availability of digital devices themselves. These conclusions are further supported by a study conducted in South Africa, which highlights the need for curriculum restructuring to provide clear guidelines for the use of digital materials and attributes the low quality of digital materials used in learning to a lack of training and inadequate ICT facilities (Adu & Zondo, 2024).

Additionally, the synthesis results demonstrate that the creation of digital products is indirectly impacted by students' deficiencies in digital proficiency. According to a longitudinal

study by (Nasution & Batubara, 2020), differences in socioeconomic class, gender, and immigrant background did not change over adolescence. This means that as students with limited digital competences might not be able to use digital resources to their full potential, digital materials created for secondary school levels must take inclusivity and differentiation into account (Nasution & Batubara, 2020). To put it another way, creating digital resources cannot be done in a "one size fits all" manner; instead, it must be adjusted to account for differences in students' technological access and skill levels.

Effective digital material development seems to have specific requirements, according to the study: content needs to be interactive, multimodal, contextual, and in line with the demands of students in the twenty-first century. When creating instructional materials, teachers with high levels of digital literacy are typically able to incorporate animation, video, interactive assessment, and simulation. However, this process necessitates time, technical expertise, and sufficient institutional support, as stated in a study on digital instructional development in Germany (Germany study, 2024). Therefore, a combination of teacher proficiency, suitable training environments, and institutional support from schools results in successful digital resources.

Overall, the results from the fifteen articles demonstrate that creating digital resources for secondary education is not only a technological innovation but also a way to enhance pedagogical quality, increase access to education, and get students ready for the demands of the digital age. However, equal access for all pupils, school assistance, and teacher competency are critical to this development's success. The creation of digital resources for secondary schools necessitates a thorough and methodical approach in order to be sustainable and have a major impact on learning, given the opportunities and difficulties noted by several research.

5. CONCLUSION

The findings of this systematic review demonstrate how the creation of digital resources significantly enhances secondary education learning opportunities. Well-designed digital resources, whether multimedia, animation, AR-based, or interactive platforms, consistently boost student enthusiasm, comprehension, and engagement, according to fifteen carefully chosen research. Studies like (Nasser & Mulhim, 2023). demonstrate how interactive and visual elements make learning more tangible and significant for secondary school students by simplifying abstract ideas. This is consistent with (Firdaus et al., 2024), who contend that by making lessons more accessible and structured, electronic teaching resources can enhance learning quality. Digital content can significantly improve academic results when it is in line with students' cognitive needs and backed by multimedia principles.

The review also demonstrates that the effectiveness of digital instructional materials is strongly influenced by school support structures, teacher competency, and digital preparedness. According to research by (Hasnah et al., 2024), even excellent digital teaching resources might not be used successfully if teachers lack sufficient digital literacy. In a similar vein, AlShaikh et al. (2024) stress that in order to minimize cognitive load and optimize comprehension, digital instructional materials must be based on cognitive multimedia principles. Therefore, even if digital teaching resources have a lot of potential, successful integration necessitates pedagogical alignment, infrastructure preparedness, and ongoing professional development for teachers.

As a result, the development of digital materials is a key factor in modernizing education, supporting learning that is in line with individual needs, and preparing students for the digital age. However, its success depends on a comprehensive approach that includes teacher preparation, technology infrastructure, student digital competency, and pedagogical quality. In the past, research has explored the impact of digital materials on learning outcomes and critical thinking, as well as analyzing implementation challenges in various educational contexts. Penguatan in these bidang-bidang will ensure that digital materials serve as essential components in creating an innovative and adil learning environment rather than merely serving as tools.

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