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Transforming Physics Learning Media in Indonesian Senior High Schools: A Decade of Systematic Innovation Review (2014–2024)

Aulia Silvina Anandita^{1*}, Ridho Adi Negoro², & Lusy Rahmawati³

^{1,2}Pendidikan Fisika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Semarang, Indonesia

³Teknik Sipil Infrastruktur Perkotaan, Jurusan Teknik, Politeknik Negeri Nunukan, Indonesia

*Corresponding author: auliaanandita@mail.unnes.ac.id

Abstract: Innovations in instructional media play a pivotal role in enhancing student engagement and conceptual understanding in secondary-level physics education. Over the past decade, Indonesian schools have witnessed a marked transition from conventional tools to digital technologies and environment-based approaches. This study systematically reviews the development and characteristics of physics learning media employed in Indonesian senior high schools from 2014 to 2024. Utilizing a systematic literature review method, it synthesizes findings from 24 articles published in nationally accredited journals and relevant scholarly sources. The review reveals a growing adoption of digital media—such as interactive simulations, augmented reality (AR), and learning management systems (LMS)—while conventional and context-based media remain pedagogically relevant in specific settings. The findings underscore the importance of integrating adaptive instructional media with local contextualization and infrastructure support to ensure sustainable innovation in physics education at the secondary level.

Keywords: conventional media, digital learning, environment-based learning, learning innovation, physics learning media

Transformasi Media Pembelajaran Fisika di SMA Indonesia: Kajian Sistematis Satu Dekade Inovasi (2014–2024)

Abstrak: Inovasi media pembelajaran dalam pendidikan fisika memiliki peran strategis dalam meningkatkan keterlibatan dan pemahaman konsep-konsep abstrak oleh siswa SMA. Dalam satu dekade terakhir, tren inovasi media pembelajaran di Indonesia menunjukkan pergeseran signifikan dari penggunaan alat bantu konvensional ke pemanfaatan teknologi digital dan pendekatan berbasis lingkungan. Artikel ini bertujuan untuk mengkaji perkembangan dan karakteristik media pembelajaran fisika yang digunakan di SMA Indonesia dalam kurun waktu 10 tahun terakhir, serta menganalisis implikasinya terhadap proses pembelajaran. Kajian ini menggunakan pendekatan *literature review* sistematis terhadap 24 artikel dari jurnal ilmiah nasional terakreditasi dan publikasi relevan lainnya yang diterbitkan antara tahun 2014–2024. Hasil kajian menunjukkan bahwa media pembelajaran digital seperti simulasi interaktif, *augmented reality* (AR), dan *learning management system* (LMS) semakin banyak digunakan, meskipun media konvensional dan media berbasis lingkungan tetap relevan dalam konteks tertentu. Disimpulkan bahwa integrasi media pembelajaran yang adaptif dengan karakteristik lokal serta dukungan infrastruktur sangat penting untuk keberlanjutan inovasi pembelajaran fisika di sekolah menengah.

Kata kunci: inovasi pembelajaran, media konvensional, media pembelajaran fisika, pembelajaran berbasis lingkungan, pembelajaran digital

INTRODUCTION

Physics education at the senior high school level serves a critical role in fostering students' scientific reasoning, critical thinking, and science literacy. However, physics is frequently perceived by students as an abstract and difficult subject. Nugraha et al. (2021) reported that many students struggle to comprehend physics concepts due to their limited ability to connect theoretical frameworks with real-world phenomena. Similarly, Astalini et al. (2019) found that students often exhibit negative attitudes toward physics, largely driven by monotonous and disengaging learning experiences. This issue is also reflected in students' limited critical thinking abilities in solving physics problems, as shown by Ariani (2020) in her analysis of high school students' responses to contextual physics questions.

This challenge complicates the implementation of Indonesia's national curriculum, which emphasizes active, meaningful, and contextual learning. According to Regulation of the Minister of Education and Culture No. 22 of 2016, learning processes are expected to develop 21st-century competencies through scientific approaches and the integration of technology. In this context, teachers are expected not only to master subject content but also to utilize engaging and innovative learning media that align with students' characteristics.

Instructional media play a strategic role in bridging abstract physics concepts with observable, real-life contexts. Sari et al. (2020) emphasized that instructional media enhance classroom communication effectiveness and enrich learning experiences through visual, auditory, and interactive stimuli. Furthermore, media facilitate differentiated instruction, enabling more personalized and responsive learning pathways for diverse student needs.

The rapid advancement of digital technology has catalyzed the emergence of increasingly innovative learning media. For example, Wijaya et al. (2022) demonstrated that the use of augmented reality (AR) in physics instruction significantly enhances students' scientific literacy. Likewise, Sudarman et al. (2023) highlighted the effectiveness of Android-based digital simulations in improving conceptual understanding of particle dynamics. These findings reflect a clear shift from conventional teaching aids toward more interactive and flexible digital media.

In parallel, environment-based media have emerged as another notable innovation in physics instruction. Yuliati & Anggraeni (2017) developed contextually grounded media using local natural resources to support learning. This approach has been shown to enhance student engagement while reinforcing the relevance of science to daily life. Ramadhan et al. (2022) further noted that environment-based media contribute to the development of environmental awareness and character education among students.

Despite these promising developments, the implementation of innovative media faces substantial obstacles. Susilawati et al. (2020) identified several persistent barriers, including inadequate infrastructure, limited digital literacy among teachers, and a lack of professional development and institutional support for media integration. These factors have contributed to disparities in instructional quality between urban and rural schools.

Given the strategic importance of learning media in improving physics education and the complexity of challenges faced, a comprehensive and systematic review of media innovation trends over the past decade is warranted. This article aims to: (1) describe the types and characteristics of physics instructional media developed in Indonesia between 2014 and 2024; (2) analyze the shift from conventional to digital and environment-based media; (3) identify the implementation challenges of innovative media in secondary-level physics education; and (4) propose strategic recommendations for the development of

relevant, adaptive, and sustainable instructional media in the Indonesian context. This study is expected to contribute meaningfully to the advancement of effective and context-responsive physics instruction at the senior high school level.

THEORETICAL FRAMEWORK

Instructional media constitute a crucial component of modern learning systems. Etymologically derived from the Latin word *medius*, meaning "in between" or "intermediary," media in education refer to tools used by educators to convey messages and information to students to enhance the effectiveness and efficiency of learning (Arsyad, 2017). Broadly, learning media encompass all forms of tools, resources, or technologies used in instructional processes to communicate educational content and facilitate instructional interaction between teachers and students (Heinich et al., 2002). Media can be physical or digital, visual or auditory, and often combine multiple formats (multimedia). When employed appropriately, media can help learners grasp abstract concepts, stimulate interest, and strengthen information retention.

According to Briggs (1977), instructional media include physical tools such as books, blackboards, slides, overhead projectors, computers, and videos used in delivering subject content. Gagné (1985) emphasized that media not only deliver content but also serve to motivate students and provide feedback. In physics education, the importance of media is amplified due to the inherently abstract nature of many physics concepts. For instance, understanding concepts such as force, magnetic fields, or electromagnetic waves often requires visual representations, 3D models, or simulations to make variable relationships observable and tangible. As noted by Sari et al. (2020), effective media can stimulate students' senses, spark curiosity, and foster more engaging and active learning experiences.

In the digital era, the definition of learning media has expanded toward digitalization. Media are no longer confined to static visual aids but now include interactive platforms such as computer-based applications, digital animations, interactive videos, and tools leveraging virtual and augmented reality. This shift aligns with the concept of Technology-Enhanced Learning (TEL), which refers to the integration of technology to enrich learning experiences and adapt to students' evolving needs (Laurillard, 2012). Effective learning media share several key characteristics: (1) clear and structured presentation of content, (2) alignment with instructional goals, (3) suitability for students' developmental levels, and (4) active engagement of learners (Arsyad, 2017; Mayer, 2009).

Thus, learning media are not merely supplementary instructional tools but integral components of pedagogical strategy. Selecting and designing appropriate media, particularly when adapted to local contexts and available school infrastructure, is a critical step toward improving the quality of physics instruction—especially in the Indonesian context.

Learning media vary widely in form and characteristics. Media can be classified based on delivery format, technology used, degree of interactivity, or resource origin. In reviewing a decade of physics media innovation, this study adopts a classification based on technological format and user characteristics, organizing media into three main categories: conventional, digital, and environment-based.

Conventional media remain widely used in physics instruction and typically involve pre-digital teaching aids such as diagrams, charts, concept cards, handmade models, posters, and 3D physical representations. These tools are often inexpensive, easily crafted from locally available materials, and visually concrete. Their primary advantage lies in ease of implementation and contextual flexibility, particularly in resource-limited schools. Yuliati & Anggraeni (2017) affirmed that, when designed contextually and with problem-

based approaches, conventional media remain highly effective. For instance, simple Newtonian apparatus constructed from wood or rubber can aid students in directly observing force and acceleration. Nonetheless, conventional media face limitations, especially in conveying dynamic, fast, or complex phenomena that resist static representation. As noted by Nasution et al. (2021), the lack of interactivity is a major constraint in modern classrooms.

The rise of information technology has led to the emergence of digital media as a prominent innovation in physics education. Digital media utilize information and communication technologies to deliver content in visual and interactive formats. These range from educational videos, interactive animations, and computer simulations (e.g., PhET), to mobile apps and more advanced tools like augmented reality (AR) and virtual reality (VR). Such media allow learners to explore abstract physics concepts not easily observed, such as projectile motion, electromagnetic waves, or relativistic effects. Wijaya et al. (2022) demonstrated that AR applications significantly enhance students' conceptual understanding and scientific curiosity. Globally, AR is recognized for its potential to increase student engagement, though challenges remain, such as technological requirements and pedagogical limitations (Akçayır & Akçayır, 2017).

Digital media integration in distance learning has become increasingly pronounced, particularly during the COVID-19 pandemic, which necessitated a shift to remote instruction. In this context, Learning Management Systems (LMS), such as Google Classroom and Moodle, have served as key platforms for organizing digital content. Nevertheless, Indonesia faces persistent barriers to digital media adoption, including infrastructure gaps, internet accessibility disparities, and limited teacher training in educational technology (Susilawati et al., 2020).

Equally important is the emergence of environment-based instructional media. These media leverage local resources, natural phenomena, or recycled materials readily available in students' surroundings. Examples include using kitchen utensils to demonstrate air pressure, plastic bottles to simulate buoyancy, or direct observation of natural occurrences as learning contexts. This approach aligns well with the principles of contextual learning, connecting physics content to students' everyday experiences. Barab & Luehmann (2003) advocate for science curricula that embrace local adaptation and promote sustainable, socially relevant learning.

Ramadhan et al. (2022) highlighted that environment-based media not only foster active participation but also cultivate curiosity and environmental awareness. These media support character development, nurturing values such as social responsibility, collaboration, and creativity. Many of these innovations are teacher-driven or originate from pre-service teacher research projects, blending local wisdom with educational needs. As such, environment-based media present pedagogically meaningful, socially grounded, and cost-effective alternatives.

Effective media design must be rooted in robust learning theories. Any instructional media should be developed with consideration of how learners process information, construct knowledge, and acquire skills. In the context of physics education, three foundational learning theories—cognitivism, constructivism, and behaviorism—are particularly relevant and often intersect in media development.

Cognitivism emphasizes internal mental processes such as attention, perception, memory, and problem-solving. Media, from this perspective, help structure and deliver information systematically to facilitate understanding and integration into prior knowledge. Gagné (1985) argued that logically ordered instructional content enhances cognitive processing. Building on this, Mayer's (2009) Cognitive Theory of Multimedia

Learning posits that learners process information through dual channels—visual and auditory. Clark & Mayer (2016) further emphasized principles such as segmentation, personalization, and the reduction of extraneous elements to optimize multimedia learning. In physics instruction, visualizations like projectile animations or interactive Newtonian simulations exemplify this theory. However, such media must also adhere to cognitive load principles to prevent overburdening students' working memory.

Constructivism views knowledge as actively constructed through experience and interaction with the environment. Media under this paradigm serve not merely as visual aids but as tools for exploration, experimentation, and meaning-making. Piaget (1970) proposed that learners assimilate and accommodate new information into existing cognitive structures. Vygotsky & Cole (1978) stressed the role of social interaction and cultural context in learning. Media that support collaboration, dialogue, experimentation, and real-world observation are well-suited to this approach. In physics instruction, these ideas are reflected in environment-based tools, hands-on experiments, manipulable simulations, and project-based learning grounded in authentic problems.

Behaviorism offers a contrasting perspective by focusing on observable responses to stimuli. Instructional media rooted in this theory provide reinforcement, repetition, and direct feedback. Skinner (1954) asserted that learning is more effective when correct responses are rewarded. Although behaviorism does not address higher-order thinking as robustly as other models, it remains relevant for drill-based tools, interactive quizzes, and gamification. In physics education, for example, apps that provide scoring and rewards for correctly answering force and motion questions exemplify behaviorist design, proven to boost student motivation and engagement.

In practice, effective physics learning media often integrate elements from all three theories. For instance, an Archimedes simulation app may utilize cognitive principles for visual design, constructivist methods for student exploration, and behaviorist elements for feedback. Similarly, environment-based media paired with instructional videos and collaborative reflection embody theoretical integration.

By grounding media design in sound learning theory, educators and developers can create instructional experiences that are not only informative but also exploratory and motivating. Thoughtfully selected and well-designed media—aligned with learner needs and supported by pedagogical principles—enable physics education to become more effective, enjoyable, and meaningful.

METHODS

This study adopts a *Systematic Literature Review* (SLR) approach—a methodologically rigorous and transparent process for collecting, evaluating, and synthesizing relevant prior studies (Kitchenham & Charters, 2007; Snyder, 2019). SLR facilitates a structured analysis of empirical evidence to provide a comprehensive understanding of trends in the innovation of physics learning media over the past decade. This review is qualitative in nature and based solely on documentary sources, meaning that data were drawn exclusively from scientific publications without involving primary field data collection (Snyder, 2019).

The literature was obtained from reputable national and international databases, including Garuda Ristekbrin, Google Scholar, the Directory of Open Access Journals (DOAJ), and SINTA (Science and Technology Index). The search employed keywords such as “media pembelajaran fisika” (physics instructional media), “inovasi media pembelajaran” (instructional media innovation), “media digital fisika SMA” (digital media for high school physics), “media konvensional dalam pembelajaran” (conventional media

in learning), “media berbasis lingkungan dalam pembelajaran fisika” (environment-based media in physics education), and “teknologi pembelajaran fisika” (physics learning technology). Both Indonesian and English search terms were used, with Boolean operators (AND, OR) and symbols (e.g., "+") to expand the search scope (Boell & Cecez-Kecmanovic, 2015).

To ensure analytical rigor, a set of inclusion and exclusion criteria was applied. Articles were included if they met the following criteria: (1) written in either Indonesian or English; (2) published between 2014 and 2024; (3) focused on physics instructional media at the senior high school level or equivalent; and (4) contained substantive information on the development, implementation, or evaluation of learning media. Only articles published in nationally accredited journals (minimum SINTA 5) or in reputable international journals were considered. Exclusion criteria included: (1) studies not focused on physics education; (2) non-scientific works such as opinion pieces or non-peer-reviewed essays; (3) insufficient methodological detail; (4) lack of full-text availability; and (5) duplicate publications.

The article selection process followed the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) framework (Page et al., 2021). The PRISMA flow diagram illustrates the stages of article identification, screening, eligibility assessment, and inclusion. Out of 420 articles identified across four main databases, 180 articles were excluded due to duplication and topic irrelevance. The remaining 240 articles were assessed based on abstracts and full-text availability, leaving 70 articles for in-depth evaluation. After applying the final inclusion and exclusion criteria, 24 articles were retained for comprehensive analysis. The selection process is visualized in Figure 1 PRISMA Flow Diagram.

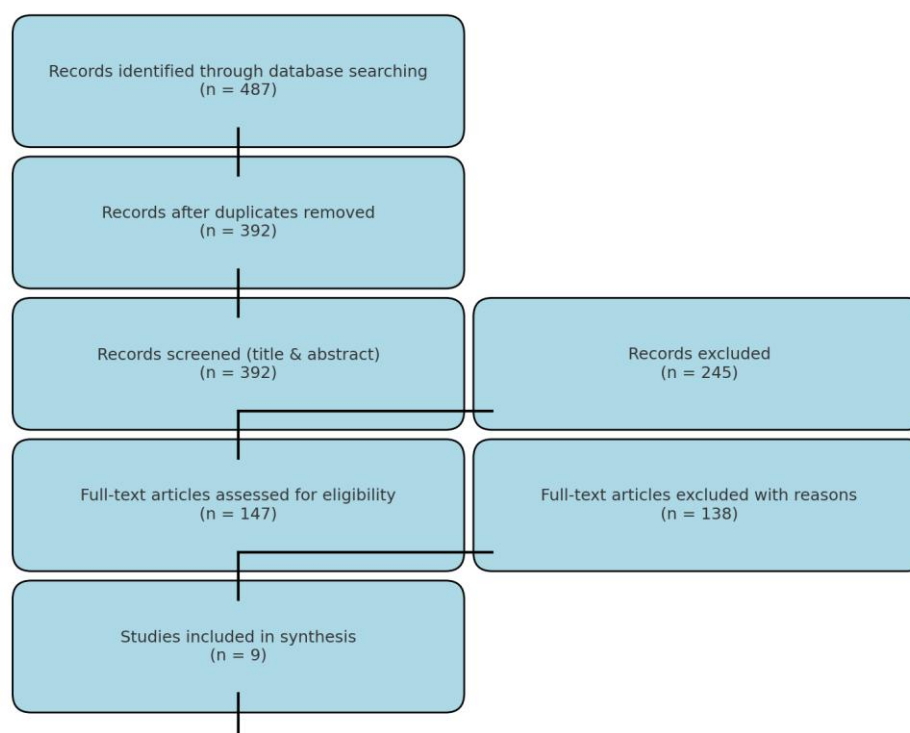


Figure 1. PRISMA Flow Diagram

After the relevant articles were collected and screened, a thematic analysis was conducted to categorize the studies based on the type of instructional media (i.e., conventional, digital, and environment-based), development objectives, modes of implementation, and their impact on the teaching and learning process. Additionally, the analysis examined the specific strengths and limitations associated with each category of media, as well as the temporal trends in their use over the ten-year period.

Each article included in the final dataset was systematically coded into a matrix table, allowing for structured comparison across themes and criteria. This coding process served as the foundation for constructing a narrative synthesis, providing a comprehensive depiction of the evolution of instructional media innovation in physics education throughout the review period.

RESULTS AND DISCUSSION

Based on the literature search and application of the defined inclusion and exclusion criteria, a total of 24 relevant articles were identified for analysis. These articles were examined through a thematic approach, focusing on the type of instructional media, educational level, research objectives, and key findings related to the effectiveness and innovation of physics learning media. Among the 24 articles, nine core studies were selected for in-depth thematic analysis, as they most closely aligned with the review's analytical framework. These studies were evaluated to illustrate the diversity of media types, implementation practices, and pedagogical impacts in secondary-level physics education. A summary of these nine studies is presented in the following Table 1.

Table 1. A Summary of These Nine Studies

No	Author(s) & Year	Media Type	Educational Level	Research Focus	Key Findings
1	Sari et al. (2020)	Digital (Android)	Senior High School	Development of interactive media	Enhanced student motivation and understanding of force concepts
2	Wijaya et al. (2022)	Digital (Augmented Reality)	Senior High School	Implementation of AR-based learning media	Improved scientific literacy and conceptual visualization
3	Yuliati & Anggraeni (2017)	Conventional (local teaching aids)	Senior High School	Contextual media development using local resources	Effective for schools with limited resources
4	Ramadhan et al. (2022)	Environment-based	Senior High School	Media using recycled materials	Increased learning interest and environmental awareness
5	Sudarman et al. (2023)	Digital (Simulation)	Senior High School	Android-based simulation for dynamics topic	Effective for teaching particle dynamics
6	Astalini et al. (2019)	Not specified	General	Students' attitudes toward physics	Many students exhibit negative attitudes toward physics

No	Author(s) & Year	Media Type	Educational Level	Research Focus	Key Findings
7	Purba & Simatupang (2020)	Digital (LMS)	Senior High School	Effectiveness of LMS in online learning	LMS supports distance learning effectively
8	Nasution et al. (2021)	Conventional	Senior High School	Limitations of conventional media	Less effective for dynamic and abstract physics topics
9	Susilawati et al. (2020)	Conventional	Senior High School	Impact of infrastructure limitations	Inadequate facilities reduce the effectiveness of instructional media

Conventional media—such as simple teaching aids, three-dimensional models, and concept cards—remain widely utilized, particularly in schools with limited access to digital infrastructure. Although not always technologically advanced, these types of media offer distinct advantages in terms of ease of use, low cost, and relevance to students' local contexts (Yuliati & Anggraeni, 2017). Some innovations have emerged through modifications of traditional materials using locally available resources or cultural wisdom. For instance, Pascal's Law has been effectively demonstrated using recycled plastic bottles and tubing to explain fluid pressure. Despite being static in nature, these media support concept comprehension through hands-on experiences and direct observation.

Digital media emerged as the most prevalent category among the reviewed studies, indicating a strong trend toward the digitalization of physics instruction at the secondary level. This category encompasses a wide range of formats, including educational videos, interactive animations, computer-based and Android-based simulations, as well as advanced technologies such as augmented reality (AR). Various studies confirm the positive impact of digital media on learning processes. A key advantage lies in their ability to visualize complex physics phenomena—such as force fields, waves, and microscopic interactions—that are otherwise difficult to observe directly (Wijaya et al., 2022). Moreover, digital media foster learner autonomy by allowing students to access content flexibly outside classroom hours (Sari et al., 2020). Their interactive features and engaging visual elements also contribute to a more enjoyable and less monotonous learning experience (Sudarman et al., 2023).

Digital media are particularly well-aligned with the characteristics of today's learners, who are generally more familiar with and receptive to technology-based learning environments. Nevertheless, their widespread implementation across Indonesia remains uneven. Major challenges include limited access to electronic devices, unstable internet connections in remote areas, and inadequate teacher training in the effective use of educational technologies (Susilawati et al., 2020).

Environment-based instructional media are developed by leveraging local materials and natural phenomena to facilitate the understanding of physics concepts. This approach aims to contextualize physics learning, making it more relatable to students' everyday lives. Examples of such media include hands-on experiments using household waste, environmental observation activities, and community-based physics projects designed around real-world problems.

One of the primary advantages of environment-based media is their affordability. Because they use readily available materials, they are ideal for schools with limited

resources. Additionally, these media have strong local relevance, enabling students to engage with physics through familiar and tangible contexts.

Beyond cognitive benefits, environment-based media also contribute to character development. Through direct engagement with their surroundings, students are encouraged to develop environmental and social awareness. This fosters values such as responsibility, collaboration, and ecological consciousness. Ramadhan et al. (2022) found that such media enhance both student interest in learning and environmental sensitivity. Although these media do not employ sophisticated technologies, they are highly consistent with constructivist and contextual learning principles. Students are not passive recipients of information but active constructors of knowledge, drawing meaning from real experiences and reflections on their environment. As such, environment-based media play a significant role in creating meaningful and contextually relevant physics learning experiences.

Over the past decade, the development of instructional media in physics education has exhibited dynamic trends. Initially, innovations emphasized concrete, environment-based tools grounded in local wisdom and experiential learning. However, a gradual shift toward digitalization has become increasingly evident. This shift can be traced temporally through distinct periods reflecting varying emphases in media usage.

Between 2014 and 2017, conventional media—such as physical teaching aids and static visual materials—dominated physics classrooms. During this period, early experimentation with environment-based media also began, often motivated by local resource availability and contextual instructional needs. From 2018 to 2020, there was a notable transition toward the use of basic digital media. Tools such as educational videos and animations gained popularity among physics teachers as responses to demands for more interactive and visually engaging instruction.

The most significant transformation occurred during the 2020–2024 period, characterized by the rapid expansion of digital instructional media. The COVID-19 pandemic acted as a catalyst for the adoption of technologies such as augmented reality (AR), mobile-based digital simulations, and learning management systems (LMS) in physics education. The urgent need for effective distance learning solutions pushed teachers and institutions to adopt digital tools more widely and systematically.

Despite these advances, conventional and environment-based media have not been rendered obsolete. These formats continue to be implemented in parallel with digital innovations, especially in regions with inadequate technological infrastructure or where pedagogical objectives prioritize hands-on experience, character education, and contextual relevance. In essence, the evolution of physics learning media in Indonesia has not followed a linear trajectory toward complete digitalization but has progressed dynamically and contextually based on local conditions and needs.

While the trajectory of innovation in physics instructional media has been largely positive, its practical implementation in the field continues to face significant challenges. The adoption of media—whether conventional, digital, or environment-based—has not been uniform across educational settings in Indonesia.

A primary challenge is infrastructure disparity, particularly in non-urban schools. Access to essential devices such as computers, projectors, and stable internet connections remains limited, impeding the optimal use of digital media. These inequalities result in significant disparities in instructional quality, as schools with better resources are more capable of implementing innovative learning strategies.

In addition, teacher capacity in developing and utilizing innovative instructional media remains a pressing concern. Many physics teachers lack formal training in educational

technology or adequate opportunities for professional development in this area. Consequently, the full potential of available technologies is often underutilized in practice.

Another persistent issue is the limited integration of instructional media innovation into formal curricula and assessment systems. Many media tools developed through research or teacher-led initiatives have not yet been formally adopted into education policy, leading to sustainability issues. Without systemic support and appropriate policy frameworks, innovations risk remaining isolated experimental efforts with limited scalability across the broader educational ecosystem.

CONCLUSION AND IMPLICATIONS

This systematic review of scholarly sources published over the past decade (2014–2024) reveals a significant shift in the use of instructional media for physics education at the senior high school level in Indonesia. The findings reflect a dynamic innovation landscape encompassing not only digital advancements but also the continued relevance of conventional and environment-based media. These transformations have unfolded within the broader context of societal change, technological progress, and evolving curriculum demands. Conventional media continue to hold a valuable place in physics instruction, particularly in areas with limited access to technological infrastructure. Although simple in form, such media remain relevant and effective when developed through contextual approaches that resonate with students' everyday experiences. In contrast, digital media have shown clear dominance in recent innovation trends. Tools such as interactive videos, Android-based simulations, augmented reality (AR), virtual reality (VR), and integration with Learning Management Systems (LMS) have demonstrated considerable potential to enhance conceptual understanding, increase learning motivation, and promote active student engagement. Equally important, environment-based media play a crucial role in bridging physics content with real-life applications. These approaches not only support contextualized understanding of physics concepts but also contribute to the development of students' character and environmental awareness. This makes environment-based media a strategic alternative for fostering meaningful, value-driven learning experiences.

Despite the promising potential of various media innovations, implementation in real-world educational settings remains constrained by a number of challenges. These include disparities in access to technology, limited teacher competencies in media development and adaptation, and insufficient policy support for sustainable and equitable media integration across educational institutions. The implications of these findings suggest a pressing need to enhance physics teachers' capacity to select, design, and adapt instructional media that are responsive to students' needs and the unique characteristics of their schools. Ongoing professional development in educational technology is essential for expanding pedagogical competence and innovation literacy. For media developers and researchers, further exploration is needed to integrate digital tools with local cultural values and to conduct longitudinal evaluations of media impacts on learning outcomes and student character development. From a policy perspective, it is critical to reinforce support for technological infrastructure in schools, encourage partnerships between schools and universities, and ensure that media innovations are systematically integrated into national curricula and assessment systems. Furthermore, teacher education institutions (LPTKs) should revitalize physics teacher preparation programs to be more adaptive to technological advancements and capable of addressing the instructional demands of 21st-century education.

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