



Journal of Educational Sciences

Journal homepage: <https://jes.ejournal.unri.ac.id/index.php/JES>



P-ISSN
2581-1657
E-ISSN
2581-2203

Trends in Interactive Learning Media for Science Education in Secondary Schools: A Systematic Literature Review

Nur Azmi Afifah Diens*, Khaerudin, Cecep Kustandi, Imam Fitri Rahmadi

Master Educational Technology, Universitas Negeri Jakarta, Jakarta, 13220, Indonesia

ARTICLE INFO

Article history:

Received: 02 Feb 2026

Accepted: 28 April 2026

Available Online: 05 May 2026

Keywords:

Interactive Learning Media,
Secondary School,
Science Education

* Corresponding author:

E-mail: nur.azmi@mhs.unj.ac.id

Article Doi:

<https://doi.org/10.31258/jes.10.5.p.149-168>

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-nc-sa/4.0/) license.



ABSTRACT

Science education at the secondary level increasingly demands interactive, technology-driven approaches to enhance learning quality. This study aims to identify global trends in the use of interactive learning media in secondary school science education from 2020 to 2024. A Systematic Literature Review (SLR) method following the PRISMA 2020 framework was employed, analyzing 29 peer-reviewed articles selected from the Scopus database using strict inclusion criteria. The results show that web-based media and interactive e-books are the most commonly used types, followed by augmented reality, virtual reality, game-based learning, and simulations. Regarding learning outcomes, cognitive aspects such as conceptual understanding and academic achievement are most frequently reported, followed by critical thinking skills, learning motivation, affective attitudes, creativity, process skills, and scientific literacy. Overall, interactive learning media support not only cognitive development but also motivation and essential 21st-century skills. The findings underscore the importance of integrating interactive media to improve instructional effectiveness and foster comprehensive student competencies in secondary science education.

1. Introduction

Over the past decade, the rapid development of digital technology has brought about profound changes in the global education system. International reports such as OECD Trends Shaping Education (2025) and UNESCO (2024) emphasize that technology has now become a central pillar of educational transformation, particularly through the integration of artificial intelligence, adaptive learning, and interactive digital platforms. Technology-based learning is no longer regarded as a supplementary component, but has become a crucial foundation of contemporary educational practice. This condition demands continuous innovation in instructional design, including the development of interactive digital media capable of meeting twenty-first-century learning needs. Interactive learning media are defined as digital learning resources that enable two-way interaction between

learners and content through automatic feedback, self-directed navigation, simulations, object manipulation, and response-based activities (Mayer, 2020). Recent studies affirm that this medium is specifically designed to deliver an active, personalized, and multimodal learning experience, thereby enhancing student engagement and conceptual understanding (Putri & Fitria, 2021; Krouska et al., 2022). The main characteristics of interactive media encompass interactivity, multimodality, user control, and active engagement, which collectively position the student as an active information processor rather than a passive recipient of knowledge, making it highly relevant to the evolving demands of modern science education.

Despite these technological advances, science education continues to face significant challenges in providing learning experiences that are interactive, meaningful, and aligned with contemporary demands. Ideally, science learning should foster critical thinking, problem-solving, and evidence-based decision-making (Bybee, 2020), yet classroom practice in many contexts remains largely conventional and makes suboptimal use of available technology. A variety of interactive technologies, ranging from augmented reality (AR), virtual reality (VR), and virtual laboratories to AI-based learning systems, have developed rapidly; however, their adoption in secondary school science education remains uneven and exhibits substantial variation across different educational settings (Akçayır & Akçayır, 2020; Ibáñez & Delgado-Kloos, 2023). Interactive features such as adaptive quizzes, animations, and educational games have been proven to reinforce the learning process by increasing motivation, material retention, learning outcomes, problem-solving abilities, and higher-order thinking skills (HOTS), particularly in the context of science education, which demands strong competencies in observation, analysis, and reasoning (Sari et al., 2022; Ahmed & Parsons, 2023). These challenges highlight the urgency of conducting a comprehensive and systematic review of the current landscape of interactive media use in science education globally. Such a review is essential so that more informed and evidence-based instructional decisions can be made by educators and policymakers alike.

Interactive learning media serve as a potential solution to these challenges, as they allow students to interact directly with content through self-directed navigation, dynamic simulations, and real-time feedback (Mayer, 2020). In science education specifically, interactive media play a distinctive role through visualization, virtual simulations, and dynamic animations that help students understand abstract or invisible phenomena, such as photosynthesis processes, chemical reactions, force mechanisms, and microscopic biological structures (Nugroho et al., 2021; Ahmed & Parsons, 2023). Various types of interactive learning media have emerged in recent years, including computer-based interactive multimedia, web-based interactive modules, mobile applications, game-based learning, and advanced technologies such as augmented reality (AR) and virtual reality (VR) (Huang et al., 2022; Lin & Wang, 2023). This diversity enables educators to tailor the media to specific learning needs, the complexity level of the material, and individual student characteristics. However, the implementation of interactive media also encounters several constraints, including infrastructure readiness, teachers' digital competence,

the potential for cognitive overload, and the time and technical expertise required to develop high-quality media (Wijaya et al., 2021; El-Masri & Tarhini, 2023). Recent studies indicate that interactive media can enhance the understanding of abstract concepts, increase learning motivation, and enrich scientific inquiry experiences (García-Bravo et al., 2024; Ibáñez & Delgado-Kloos, 2023), yet international research in this area remains fragmented, as many studies focus on specific technologies without providing a comprehensive overview of global trends in the period 2020 to 2024.

Therefore, this study conducts a Systematic Literature Review (SLR) to identify global trends in the use of interactive learning media in science education for the period 2020–2024. The analysis is guided by three research questions: (1) What are the research trends related to interactive learning media in science education from 2020 to 2024? (2) What types of interactive learning media are most frequently used in science instruction? and (3) What are the implications of implementing interactive learning media in science instruction at the secondary school level? The resulting synthesis is expected to provide a comprehensive mapping that can serve as a foundation for developing more adaptive, interactive, and effective science instruction aligned with the demands of the digital era. This review also aims to guide future research directions and inform instructional policy decisions in the field of science education.

2. Methodology

Research Design

The method used in this study is the Systematic Literature Review (SLR). Paul et al. (2023) define SLR as a research method aimed at synthesizing previous research findings through a structured, transparent, and replicable procedure, thus minimizing bias and enhancing the validity and credibility of the research findings. This approach was chosen because it is particularly appropriate for conceptual research such as this one, where the main focus is to analyze trends in the use of interactive learning media in secondary school science education from 2020 to 2024. The use of this method allows for the synthesis of empirical research findings that meet the established objectives and selection criteria, providing a current overview of the research landscape and identifying potential directions for future research development (Gurevitch et al., 2018; Newman & Gough, 2020).

The literature review procedure follows the framework of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 (Page et al., 2021), which is an updated version of the Quality of Reporting of Meta-Analyses (QUOROM) guidelines from 2009 to improve transparency and consistency in reporting. The review process was carried out step-by-step, starting from identification, selection, eligibility assessment, to the inclusion of relevant literature articles. The stages of the SLR process, including identification, screening, eligibility, and final inclusion of articles, are described in detail in Figure 1.

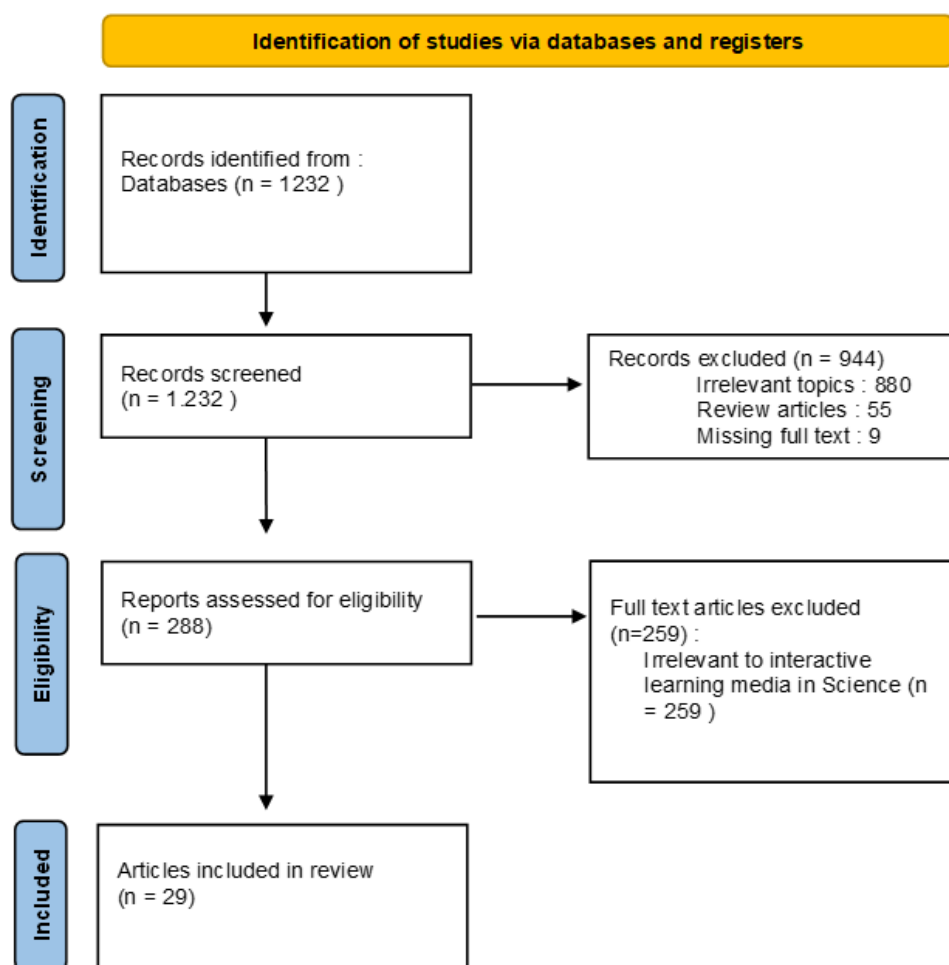


Figure 1. Systematic Literature Review Procedures

Figure 1 illustrates the systematic literature review procedure followed in this study. Referring to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 model, the review procedure includes four main stages: identification, screening, eligibility, and final inclusion of research articles.

Data Collection

The data collection process was conducted by identifying relevant articles from the Scopus database using the specific keyword “Interactive Learning Media.” The search was limited to publications written in English and published between 2020 and 2024. A specific keyword string was applied to ensure that the retrieved articles focused on the development of interactive learning media within the context of education, specifically at the secondary school level, with an emphasis on science subjects.

The search yielded 1,232 articles. In the title and abstract screening stage, 944 articles were eliminated because they were not relevant to the focus on interactive learning media in secondary education for Science/STEM subjects. The remaining 288 articles were then evaluated in the eligibility stage. Of these, 259 articles were

excluded due to content-related reasons, including not discussing interactive or digital media, not being relevant to Science/STEM topics, or focusing on education levels other than secondary school. Finally, 29 articles met the inclusion criteria and were included in the qualitative synthesis. To ensure a systematic and transparent selection process, inclusion and exclusion criteria were applied, as presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Category	Inclusion Criteria	Exclusion Criteria
Publication Type	Peer-reviewed research articles indexed in Scopus	Non-journal publications such as conference proceedings, book chapters, reports, or review papers without empirical data
Publication Year	Published between 2020–2024	Published before 2020 or after 2024
Educational Level	Focused on high school or secondary school	Focused on primary education (elementary school) or higher education
Language	Written in English	Written in other languages without translation or English abstract
Content Focus	Type of SLR or similar discusses. Does not discuss, the development or implementation of interactive learning media in science-related or STEM subjects	Type of SLR or similar discusses. Does not discuss the development or implementation of learning media in science or STEM subjects, or focuses on non-digital media without interactivity,

Table 1 presents the inclusion and exclusion criteria used in this systematic literature review to ensure a consistent and transparent selection process. Articles were included if they met the following criteria: (1) only peer-reviewed, Scopus-indexed articles were included, while non-journal publications such as conference proceedings or reports were excluded; (2) articles must have been published between 2020 and 2024, with publications outside this range not considered; (3) the study must focus on secondary school education, rather than primary or higher education; (4) the articles must be written in English, so publications without English translations or abstracts were excluded; and (5) the content must address the development or implementation of interactive learning media in science/STEM fields. Studies that were irrelevant, used non-digital media without interactivity, or were systematic literature reviews or similar, were excluded. This ensured that only studies directly relevant to the use of interactive learning media in secondary school science education were included for synthesis and analysis.

Data Analysis

Data analysis in this study was carried out using thematic analysis and content analysis techniques to systematically examine the selected articles. Each of the 29 selected articles was coded using the documentation form described in the previous stage, ensuring consistency and traceability throughout the analysis process. The coding process followed an inductive three-stage approach, consisting of open coding, axial coding, and selective coding. In the open coding stage, recurring patterns, themes, and categories were identified across the articles without applying prior assumptions. This was followed by axial coding, in which related themes were

grouped into broader conceptual categories, such as media type and learning outcome domain. Finally, in the selective coding stage, the core patterns most directly relevant to the three research questions were identified, refined, and prioritized for further analysis. The categorization of media types was based on the dominant technological characteristics reported in each study, including web-based platforms, augmented reality (AR) and virtual reality (VR) environments, e-books or e-modules, and game-based learning systems. In addition, the classification of learning outcomes was derived from the outcome variables reported in each article and organized into three main domains, namely cognitive outcomes (such as concept mastery and learning achievement), scientific and 21st-century skills (including critical thinking, collaboration, and scientific literacy), and affective outcomes (such as motivation and engagement). To support the interpretation of patterns across the dataset, frequency counts and percentage distributions were employed to summarize the occurrence of each category. This systematic categorization process ensures the transparency and traceability of the analysis, linking the methodological procedures directly to the findings presented in the Results and Discussion section.

3. Results and Discussion

The synthesis of findings in this study was conducted using thematic analysis and content analysis techniques. Each of the 29 selected articles was systematically coded based on three main categories: (1) publication year and country of origin, (2) type of interactive learning media developed or implemented, and (3) learning outcomes or competencies reported. The coding process was carried out inductively, beginning with open coding to identify recurring patterns and themes across articles, followed by axial coding to group related themes into broader categories, and selective coding to determine the core patterns that directly address the research questions. The categorization of media types was established based on the dominant technological characteristics described in each study, such as web-based platforms, AR/VR environments, e-books or e-modules, and game-based systems. Similarly, the classification of learning outcomes was derived from the outcome variables reported in each article, including cognitive outcomes (concept mastery and learning achievement), scientific and 21st-century skills (critical thinking, collaboration, and science literacy), and affective outcomes (motivation and engagement). This systematic categorization process ensures traceability between the methodological procedures and the findings presented in the following subsections.

The results of the review are presented in this section to provide a comprehensive understanding of the dynamics of research over the past four years. A total of 29 articles that met the inclusion criteria were analysed and synthesized to identify publication patterns, topical trends, and the characteristics of interactive learning media development in the context of secondary school science education. These findings are organized into several subsections in accordance with the focus of the study. The first part presents a descriptive overview of how research on the use of interactive learning media has evolved during the period 2020–2024. The second

part summarizes the variations in the types of interactive media that have been developed and implemented. The final part identifies the learning objectives or student competencies most frequently reported in the implementation of interactive media, including the prevalent competency domains that researchers seek to enhance.

Trends in Interactive Learning Media

The analysis of the 29 selected articles begins with mapping the annual publication trends to understand the dynamics of research interest in the topic of interactive learning media from 2020 to 2024. The distribution of the number of articles and their corresponding countries based on publication year is presented in Table 2.

Table 2. Trends in Interactive Learning Media

Year	Frequency	Percentage (%)	Country
2020	6	20.7%	Indonesia
2021	5	17.2%	Indonesia, Malaysia
2022	8	27.6%	Indonesia, USA, Thailand, Turkey
2023	4	13.8%	Indonesia, Hong Kong, Pakistan
2024	6	20.7%	Indonesia, USA, Taiwan

Table 2 describes the publication trends on interactive learning media in secondary-level science subjects, which exhibit a fluctuating pattern while still reflecting a growing research interest in this topic. The peak of publications occurred in 2022, with eight articles (27.6%) originating from Indonesia, the United States, Thailand, and Turkey. This relatively high number indicates a strong academic response to the urgent need for innovation in learning media driven by digital transformation and reflects increasing global attention to interactive media innovation. The initial period in 2020 recorded six studies (20.7%), all conducted in Indonesia, whereas 2021 showed a slight decline with five publications (17.2%) from Indonesia and Malaysia, marking an expansion of the research context within the Southeast Asian region. Although there was a decrease to four publications (13.8%) in 2023, which nonetheless involved a more diverse set of countries such as Indonesia, Hong Kong, and Pakistan, the trend strengthened again in 2024 with six publications (20.7%) from Indonesia, the United States, and Taiwan. Overall, these findings indicate that research on interactive learning media has undergone progressive development, characterized by an increasing focus on immersive technologies, self-directed learning experiences, and the enhancement of twenty-first-century skills. The fluctuating yet overall stable pattern underscores that interactive media have become one of the key and sustained approaches to addressing the challenges of science learning, which is often abstract in nature and requires a high level of visualization.

Types of Interactive Learning Media

The distribution of types of interactive learning media developed in secondary school science learning across the 29 studies can be grouped into five main

categories: Web-Based Interactive Learning Media, Augmented Reality (AR), Virtual Reality/Simulation, Interactive E-Books and E-Modules, and Game-Based Learning. A more detailed breakdown of the types of interactive learning media most frequently used can be found in Table 3.

Table 3. Types of Interactive Learning Media

Types	Authors	Findings
Web-Based Interactive Learning Media	Sari et al. (2021)	Web/computer-based interactive multimedia "Inquiry Play-Room" as an electronic learning resource on rotation and equilibrium.
	Heliawati et al. (2022)	Adobe Flash-based ethnochemistry learning media that integrates local wisdom to improve students' science literacy.
	Nurkanti & Yasundari (2024)	Multimedia Interactive Visual (MIVI) designed to enhance students' creative thinking and collaboration.
	Yulina et al. (2021)	Interactive HPLC multimedia to improve analytical thinking skills.
	Ristante et al. (2020)	Interactive dichotomous key media about invertebrates to increase student learning motivation.
	Herianto & Wilujeng (2021)	Interactive science learning multimedia designed to enhance the ARCS components (attention, relevance, confidence, satisfaction).
	Wegwerth et al. (2024)	The interactive "Lewis Structure Explorer" website supports accessible learning of Lewis structures.
	Herwinarso et al. (2020)	An Android app to help students learn physics quantities and measurement principles.
	Mufit et al. (2022)	Smartphone-based interactive multimedia combined with cognitive conflict models to develop 21st-century skills.
	Wahyuni et al. (2020)	Edmodo-based interactive teaching materials as an alternative science learning medium to improve critical thinking skills.
Augmented Reality (AR)	Liliana et al. (2020)	Interactive web-based online physics learning media to improve student achievement and interest in learning.
	Adil et al. (2021)	An interactive mobile augmented reality system for learning about the structure of human vision.
	Wibowo et al. (2021)	Interactive Book Augmented Reality (IBAR) to facilitate students' 21st-century skills.
	Habiddin et al. (2022)	AR-based digital comic media for science learning at the secondary level.
Virtual Reality / Simulation	Anil & Batdi (2023)	Testing the effectiveness of AR in science education using a broad Multi-complementary (McA) approach.
	Rahman et al. (2024)	Metaverse-based virtual chemistry classes for chemical bonding topics in distance learning.
	Mead et al. (2022)	Virtual gamification exploration environment covering 350 million years of vertebrate evolution.
	Suwandi et al. (2023)	The "Virtual Garden" simulation media and students' perceptions of its use.

	Fahmi et al. (2024)	Virtual Reality Laboratory for studying the laws of heredity and improving student technology literacy.
	Stiawan et al. (2022)	Virtual simulation of molecular shapes based on VSEPR theory to improve student conceptual mastery.
Interactive E-Book & E-Module	Harjono et al. (2020)	Interactive physics e-book to improve students' conceptual mastery.
	Lestari et al. (2022)	Articulate Storyline 3-based digital teaching materials on atomic structure and the periodic table.
	Herianto, Wilujeng, & Lestari (2022)	Interactive multimedia e-books on science subjects to foster curiosity among junior high school students.
Game-Based Learning	Sulistiyana et al. (2023)	Mosiry e-module based on guided inquiry on the immune system.
	Zi-Ning Huang et al. (2024)	Interactive e-books in science demonstrations to analyze children's viewing behavior.
	Purba et al. (2020)	Educational game about the concept of plant growth.
	Ding & Yu (2024)	Serious game-based learning and learning by creating games to improve student science learning outcomes.

Table 3 describes in detail the distribution of the types of interactive learning media across the five categories. Web-based media occupy the largest proportion, as evidenced by the development of various interactive multimedia and learning applications by Sari et al. (2021), Heliawati et al. (2022), and Nurkanti and Yasundari (2024). The use of AR and VR/Simulation in studies such as Adil et al. (2021), Wibowo et al. (2021), Rahman et al. (2024), and Stiawan et al. (2022) illustrates efforts to create more immersive three-dimensional learning environments. The development of interactive e-books and e-modules is documented in Harjono et al. (2020) and Lestari et al. (2022). The Game-Based Learning category remains the least represented, as in Purba et al. (2020) and Ding and Yu (2024). Overall, this pattern indicates that although the categories of interactive media are fairly diverse, research attention remains largely concentrated on web-based media and interactive digital learning materials, whereas AR, VR, and educational games are developing more selectively and have not yet become mainstream.

Implications of Interactive Learning Media in Science Education

Based on the 29 articles analysed, various types of learning outcomes were reported as the effects of implementing interactive learning media. These outcomes were subsequently classified into three main categories to facilitate interpretation and presentation of the data, as shown in Table 4. Table 4 illustrates that the main focus of the reviewed studies falls within the category of Concept Mastery and Learning Outcomes (13 studies), in which various forms of interactive media have been demonstrated to deepen students' understanding of scientific concepts and improve their academic achievement. This is evident in the studies by Wegwerth et al. (2024), Stiawan et al. (2022), Mead et al. (2022), Sari et al. (2021), and Harjono et al. (2020). The category of Scientific and 21st-Century Skills (10 studies) highlights

the contribution of interactive media to scientific literacy, collaboration, and critical thinking, as demonstrated by Fahmi et al. (2024), Sulistyana et al. (2023), Nurkanti et al. (2024), Wibowo et al. (2021), and Wahyuni et al. (2020).

Table 4. Learning Outcomes of Interactive Learning Media Implementation

Category	Frequency	Outcome	Representative Studies
Concept Mastery & Learning Outcomes	13	Concept Mastery	Sarah E. Wegwerth et al. (2024); Stiawan et al. (2022); Chris Mead et al. (2022); Adil et al. (2021); Sari et al. (2021); Harjono et al. (2020); Herwinarso et al. (2020); Zi-Ning Huang et al. (2024)
		Learning Outcomes	Ai-Chu Elisha Ding et al. (2024); Hameedur Rahman et al. (2024); Ozgur Anil et al. (2022); Liliana et al. (2020); Purba et al. (2020)
Science Literacy & 21st Century Skills	10	Science Literacy	Fahmi et al. (2024); Sulistyana et al. (2023); Heliawati et al. (2022); Suprpto et al. (2022)
		21st Century (4C) / Collaboration Critical Thinking	Mufit et al. (2022); Nurkanti & Yasundari (2024); Wibowo et al. (2021); Indarini Dwi Pursitasari et al. (2022); Yulina et al. (2021); Wahyuni et al. (2020)
Student Affectivity & Engagement	6	Learning Motivation	Lestari et al. (2023); Suwandi et al. (2023); Herianto et al. (2022); Herianto et al. (2021); Ristanto et al. (2020)
		Interest in Learning	Habiddin et al. (2022)

The Affective and Student Engagement category (6 studies) describes how interactive media contribute to students' motivation and interest in learning, as reported by Lestari et al. (2023), Suwandi et al. (2023), Herianto et al. (2022; 2021), Ristanto et al. (2020), and Habiddin et al. (2022). Overall, this pattern indicates that interactive media not only enhance concept mastery and learning outcomes but also foster the development of scientific and 21st-century skills, while simultaneously strengthening affective dimensions and student engagement in the learning process.

This review aims to provide a comprehensive mapping of global trends in the use of interactive learning media in secondary school science education from 2020 to 2024. A Systematic Literature Review (SLR) was conducted to analyse three main aspects: research trends on interactive learning media, the types of interactive learning media most frequently used in science education, and the implications of their implementation in science teaching. The synthesized results are expected to offer a deeper understanding of the development and implementation of interactive media in science education, serving as a foundation for more adaptive, interactive, and digitally relevant innovations in science teaching.

The analysis of 29 articles reveals that research interest in interactive learning media tends to increase, albeit with a fluctuating pattern, with a publication peak in 2022 and a dominance of research conducted in the Indonesian context, followed by

contributions from the United States, Thailand, Turkey, Hong Kong, Pakistan, Malaysia, and Taiwan. However, this geographic distribution warrants critical attention. The strong dominance of Indonesian studies across all five years of the review period suggests that research activity in this area may reflect national-level educational policy priorities, institutional research agendas, or funding patterns, rather than a truly global consensus on effective practice. This observation is consistent with a broader pattern of rapid growth in educational technology research in Indonesia, where government initiatives to accelerate digital transformation in schools have stimulated substantial scholarly output in media development and implementation.

For instance, Septiani et al. (2025), publishing in the *Journal of Educational Sciences*, demonstrated the practicality and effectiveness of augmented reality integrated learning media in improving the learning outcomes of Phase E senior secondary students in Indonesia, reflecting how national curriculum reforms have created new opportunities and demands for innovative interactive media development. Studies from high-income countries such as the United States and Taiwan are comparatively fewer in number, raising important questions about whether findings on media effectiveness are generalizable across educational systems that differ substantially in infrastructure, curriculum design, and pedagogical traditions. Future research should therefore prioritize cross-national comparative studies to better understand how contextual factors mediate the effectiveness of interactive media in science education.

One of the key findings of this review concerns the dominance of web-based interactive learning media, which constitute the largest portion of interactive media development across the 29 articles. This finding is consistent with prior reviews indicating that web-based technologies are generally more accessible, more readily integrated with existing school infrastructure, and do not require specialized hardware as AR and VR technologies do (Heliawati et al., 2022; Mufit et al., 2022). However, the dominance of web-based media should not be interpreted solely as a result of cost or accessibility constraints. It also reflects deeper pedagogical and curricular considerations: web-based media tend to align more naturally with existing lesson structures, assessment practices, and current teacher competencies, thereby requiring less extensive instructional redesign for classroom integration. In contrast, augmented reality and virtual reality technologies, despite their well-documented potential for creating immersive learning environments, require not only adequate device availability but also substantial pedagogical adaptation, including the redesign of learning sequences, assessment tasks, and classroom management strategies.

This pedagogical readiness gap is reflected in recent research published in the *Journal of Educational Sciences*: Ryni and Sukarmin (2025) found that augmented reality-assisted student worksheets on chemical bonding materials could significantly improve student learning outcomes, but noted that the successful implementation required carefully designed instructional scaffolding to support students' interaction with the AR environment. Similarly, Julkifli et al. (2025) demonstrated that AR media positively influenced learning outcomes in ICT

subjects at the junior secondary level, yet highlighted that teacher facilitation and digital readiness remained critical mediating factors. These findings suggest that the limited mainstream adoption of AR and VR in secondary science education reflects not only an infrastructure gap, but also a significant gap in teachers' professional preparedness to design pedagogically sound instruction around these technologies. Professional development programs for science teachers must therefore address both the technical operation of immersive media and the instructional design principles required to use them effectively within curriculum frameworks. Furthermore, the near-absence of game-based learning in this corpus with only 2 studies raises questions about whether the existing research base overrepresents media that are easier to develop and evaluate, potentially creating a skewed understanding of the full landscape of effective interactive media in science education.

With regard to learning outcomes, the synthesis indicates that the most frequently reported impact focuses on Concept Mastery and Learning Outcomes (13 studies), followed by Scientific and 21st-Century Skills (10 studies) and Affective and Student Engagement domains (6 studies). This concentration on cognitive outcomes aligns with the general characteristics of interactive media, which are particularly suited to visualizing abstract phenomena and providing simulations that approximate real conditions capabilities that are especially valuable in science education, where concepts such as molecular structures, genetic inheritance, and physical forces are inherently difficult to observe directly. However, the overwhelming dominance of cognitive outcomes in this corpus raises an important concern about potential publication bias. Studies reporting significant improvements in test scores or conceptual mastery are likely more publishable than those reporting null or mixed results, which may mean that the current evidence base overestimates the effectiveness of interactive media for cognitive outcomes while underrepresenting contexts where implementation challenges such as cognitive overload, poor curriculum alignment, or insufficient instructional scaffolding yield less positive results.

This concern is particularly relevant for e-module-based interactive media: Hasibuan et al. (2025), in a study published in the *Journal of Educational Sciences*, found that interactive e-modules based on the Kvisoft Flipbook platform with a discovery learning model effectively improved student learning outcomes on arthropod content, but also highlighted that the quality of the guided discovery process embedded within the module was a decisive factor in determining whether the cognitive benefits were realized. This finding underscores the point that the same category of interactive media can produce highly variable outcomes depending on the pedagogical framework within which it is embedded. Similarly, the relatively smaller number of studies addressing affective outcomes and 21st-century skills may not indicate an absence of impact in these domains, but rather a measurement challenge, as constructs such as motivation, engagement, and collaborative skills are considerably more difficult to quantify and assess reliably than performance on knowledge tests. Future research should therefore employ more mixed-methods and longitudinal designs to capture the full spectrum of learning impacts across cognitive, affective, and competency-based dimensions.

A further critical observation concerns the gap between the types of media studied and the pedagogical frameworks within which they are embedded. Across the 29 articles reviewed, relatively few studies provide explicit descriptions of the instructional design principles or pedagogical models used alongside the interactive media. While some studies mention inquiry-based learning, cognitive conflict, or guided discovery as their pedagogical approach, the majority focus primarily on the technical features of the media itself. This tendency reflects a risk of technological determinism in the field the assumption that the technology itself will produce learning gains regardless of how it is embedded in instruction. Evidence from educational technology research more broadly consistently demonstrates that the pedagogical context in which media are used is at least as important as the technical sophistication of the media (Mayer, 2020).

This gap is further evident when examining e-module development research in the JES context: Wahyuni et al. (2025) found that an e-module integrating project-based learning with green pedagogy principles was effective not primarily because of its digital format, but because it embedded structured opportunities for students to develop creative thinking and digital literacy through authentic tasks. In a parallel vein, Rosiana et al. (2023) demonstrated that an e-module for the circulatory system, designed around the 8E learning cycle, significantly enhanced students' critical thinking abilities, illustrating how the instructional model embedded within the media rather than the media itself was the primary driver of learning. These findings strongly suggest that future systematic reviews in this domain should systematically code for the pedagogical frameworks accompanying interactive media use, and that primary research should more explicitly investigate the interaction between media type and instructional design in determining learning outcomes.

In addition, the review findings reinforce the benefits of interactive media for the affective domain and students' learning engagement. A number of studies report increased motivation, interest in science, and student engagement when interactivity, appealing visuals, or gamification elements are integrated into learning activities. These outcomes are particularly relevant in the context of secondary-level science learning, which is often perceived by students as difficult, abstract, and disconnected from everyday experience. By providing more engaging representations and interactive learning activities, media such as digital comics, virtual environments, and interactive web-based modules can help reduce learning anxiety, sustain students' attention, and foster more positive orientations toward science. Nevertheless, a critical observation is that motivation and engagement are frequently measured as short-term responses to the novelty of a new technology rather than as sustained dispositions toward science learning. Studies in this review that report improved motivation rarely include delayed post-tests or follow-up assessments to determine whether the motivational benefits persist beyond the initial period of media use. This limitation calls for longitudinal research designs that track affective outcomes over extended periods of implementation, enabling researchers to distinguish genuine motivational gains from transient novelty effects.

Several important implications can be drawn from these findings. First, there is a need to reframe the role of interactive media from tools for content delivery to integral components of inquiry-based, problem-solving-oriented, and collaborative instructional designs. Studies that combined interactive media with structured pedagogical strategies consistently report more comprehensive and sustained learning impacts across cognitive, affective, and skills-based domains. Second, the limited number of studies exploring AR, VR, and game-based learning indicates a need for more systematic research examining how these technologies can be aligned with curriculum goals, assessment practices, and classroom realities, rather than being evaluated solely as technological innovations in isolation. Third, the geographic concentration of studies in Indonesia underscores the need for more internationally diverse research to validate the generalizability of current findings across different educational systems, resource contexts, and pedagogical cultures.

This review has several inherent limitations. The corpus of articles is restricted to the period 2020–2024 and focuses solely on secondary school science education, which limits the generalizability of findings to other educational levels or subject areas. Additionally, the selection of articles was confined to Scopus-indexed publications in English, meaning that relevant research published in other languages or in non-indexed journals may have been excluded. Publication bias, particularly the under-reporting of interventions that did not yield statistically significant results, cannot be entirely ruled out. Nonetheless, this systematic literature review provides a temporally relevant and methodologically transparent synthesis that can serve as an initial foundation for further investigations. Subsequent studies should extend the examination to more diverse educational contexts and student populations, develop classroom-based longitudinal research designs capable of capturing long-term impacts, and conduct more rigorous comparative analyses across different media types under comparable pedagogical conditions.

4. Conclusion

This systematic literature review confirms that interactive learning media make a strategic contribution to enhancing the quality of science education at the secondary level by providing richer, more visual, and learner-centred learning experiences. In response to the three research questions guiding this study, the findings demonstrate that: (1) research on interactive learning media in secondary science education has grown progressively from 2020 to 2024, with a concentration in Indonesia and a peak in 2022; (2) web-based media and interactive e-books are the most widely developed types, while augmented reality, virtual reality, simulations, and game-based learning remain less prevalent; and (3) the implementation of interactive learning media consistently yields positive implications across cognitive, scientific literacy, and affective domains, supporting both conceptual mastery and the development of 21st-century skills.

Overall, the review affirms that interactive media represent not merely a technological innovation, but a pedagogical approach with the potential to strengthen scientific literacy, enrich learning interactions, and support students'

preparation for challenges in the digital era. Future research should prioritize cross-national comparative studies, longitudinal designs to capture sustained learning effects, and more systematic examination of the pedagogical frameworks accompanying interactive media use, in order to advance a more comprehensive and evidence-based understanding of effective interactive media integration in science education.

References

- Abdusselam, M. S., & Karal, H. (2020). The effect of using augmented reality and sensing technology to teach magnetism in high school physics. *Technology, Pedagogy and Education*, 29(4), 407–424. <https://doi.org/10.1080/1475939X.2020.1766550>
- Adil, A., Zhao, L., Ahmad, N., Arif, M., Jan, A. U., & Liu, X. (2021). An interactive mobile augmented reality for learning the structure of the human visual sense organ. *Applied Sciences*, 11(16), 7419. <https://doi.org/10.3390/app11167419>
- Akçayır, M., & Akçayır, G. (2020). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, 126, 334–345. <https://doi.org/10.1016/j.compedu.2018.07.021>
- Aliasin, S., & Mohammadi, M. (2022). Trends in digital learning media: A systematic review. *Education and Information Technologies*, 27(4), 5231–5254. <https://doi.org/10.1007/s10639-021-10804-5>
- Anil, Ö., & Batdı, V. (2023). Use of augmented reality in science education: A mixed-methods research with the multi-complementary approach. *Education and Information Technologies*, 28, 16041–16064. <https://doi.org/10.1007/s10639-023-11614-5>
- Bybee, R. (2020). *STEM education now more than ever*. NSTA Press.
- Chang, C. Y., & Hsu, T. Y. (2024). Interactive digital simulations for science learning: A meta-analysis. *Journal of Computer Assisted Learning*, 40(1), 112–130. <https://doi.org/10.1111/jcal.12887>
- Chen, Y., Chou, H. W., & Huang, T. C. (2020). Effects of interactive e-books on learning achievement. *Interactive Learning Environments*, 28(5), 684–700. <https://doi.org/10.1080/10494820.2018.1552843>
- Chen, Y., So, W. W. M., Zhu, J., & Chiu, S. W. K. (2024). STEM learning opportunities and career aspirations: The interactive effect of students' self-concept and perceptions of STEM professionals. *International Journal of STEM Education*, 11(1), 1. <https://doi.org/10.1186/s40594-023-00454-3>
- Chu, W. W., Ong, E. T., Ayop, S. K., Mohd Azmi, M. S., Abdullah, A. S., Abd Karim, N. S., & Tho, S. W. (2023). The innovative use of smartphone for sound STEM practical kit: A pilot implementation for secondary classroom. *Research in Science & Technological Education*, 41(3), 1008–1030. <https://doi.org/10.1080/02635143.2021.1978431>
- Ding, A. E., & Yu, C. H. (2024). Serious game-based learning and learning by making games: Types of game-based pedagogies and student gaming hours impact on students' science learning outcomes. *Computers & Education*, 203, 105075. <https://doi.org/10.1016/j.compedu.2023.105075>
-

-
- El-Masri, M., & Tarhini, A. (2023). Factors affecting the adoption of e-learning systems in Qatar and USA. *Educational Technology Research and Development*, 65(5), 1–24. <https://doi.org/10.1007/s11423-016-9508-8>
- Fahmi, F., Rahmawati, Y., & Erdawati, E. (2024). Virtual reality laboratory for studying the laws of heredity and improving student technology literacy. *Journal of Science Education and Technology*, 33, 45–58. <https://doi.org/10.1007/s10956-023-10067-y>
- García-Bravo, J., Chacon, A., & Romero, M. (2024). Interactive learning technologies in science education: A systematic mapping review. *Education and Information Technologies*, 29(3), 5123–5150. <https://doi.org/10.1007/s10639-023-12073-8>
- Gurevitch, J., Koricheva, J., Nakagawa, S., & Stewart, G. (2018). Meta-analysis and the science of research synthesis. *Nature*, 555(7695), 175–182. <https://doi.org/10.1038/nature25753>
- Habiddin, H., Ashar, M., Hamdan, A., & Nasir, K. R. (2022). Digital comic media for teaching secondary school science. *International Journal of Interactive Mobile Technologies*, 16(3), 159–166. <https://doi.org/10.3991/ijim.v16i03.27180>
- Harjono, A., Gunawan, G., Adawiyah, R., & Herayanti, L. (2020). An interactive e-book for physics to improve students' conceptual mastery. *International Journal of Emerging Technologies in Learning*, 15(5), 40–49. <https://doi.org/10.3991/ijet.v15i05.11870>
- Hasibuan, S. H., Zulfarina, Z., & Putra, R. A. (2025). Development of interactive e-modules based on Kvisoft Flipbook with discovery learning models on arthropod material to improve student learning outcomes. *Journal of Educational Sciences*, 7(3), 452–464. <https://doi.org/10.31258/jes.7.3.p.452-464>
- Heliawati, L., Lidiawati, L., & Hendri, S. (2022). Adobe Flash-based ethnochemistry learning media integrating local wisdom to improve students' science literacy. *Jurnal Pendidikan IPA Indonesia*, 11(2), 231–241. <https://doi.org/10.15294/jpii.v11i2.35678>
- Herianto, H., & Wilujeng, I. (2021). Increasing the attention, relevance, confidence and satisfaction (ARCS) of students through interactive science learning multimedia. *Research in Learning Technology*, 29. <https://doi.org/10.25304/rlt.v29.2538>
- Herianto, Wilujeng, I., & Lestari, D. P. (2022). Effect of interactive multimedia e-books on lower-secondary school students' curiosity in a Science course. *Education and Information Technologies*, 27(7), 9619-9639. <https://doi.org/10.1007/s10639-022-11005-8>
- Herwinarso, H., Untung, J. V., & Pratidhina, E. (2020). Development of Android app to assist high school students in learning physics quantities and measurement principles. *Jurnal Pendidikan Fisika Indonesia*, 9(1), 292–295. <https://doi.org/10.15294/jpfi.v9i1.3581>
- Huang, Z. N., Chen, H. W., & Lai, C. L. (2024). Analyzing Children's Viewing Behaviors in Science Demonstrations with and Without Interactive E-Book Support. *Journal of Science Education and Technology*, 33(5), 779-795. <https://doi.org/10.1007/s10956-023-10081-0>
-

- Ibáñez, M. B., & Delgado-Kloos, C. (2023). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109–123. <https://doi.org/10.1016/j.compedu.2018.05.002>
- Ilahi, D. P. (2024). Analysing the impact of augmented reality on student learning outcome in K-12 science education: A meta-analysis study. *EASE Letters*, 3(1), 260–282. <https://doi.org/10.58905/easeletters.v3i1.110>
- Julkifli, F., Hardiansyah, H., & Hakim, A. R. (2025). The influence of augmented reality (AR) media on the learning outcomes of SMP Negeri 2 Woha students in ICT subjects. *Journal of Educational Sciences*, 9(5), 4594–4607. <https://doi.org/10.31258/jes.9.5.p.4594-4607>
- Kim, S., & Bryan, L. (2024). Inquiry-based interactive media in secondary science education: A review. *Journal of Science Education and Technology*, 33, 1–18. <https://doi.org/10.1007/s10956-023-10059-y>
- Koç, A., & Kanadlı, S. (2025). Effect of interactive learning environments on learning outcomes in science education: A network meta-analysis. *Journal of Science Education and Technology*, 34(4), 681-703. <https://doi.org/10.1007/s10956-025-10202-7>
- Krouska, A., Troussas, C., & Sgouropoulou, C. (2022). Mobile game-based learning as a solution in COVID-19 era: Modeling the pedagogical affordance and student interactions. *Education and information technologies*, 27(1), 229-241. <https://doi.org/10.1007/s10639-021-10738-y>
- Lestarani, D., Lalang, A. C., Manggi, I. (2023). Development of Articulate Storyline 3-Based Digital Teaching Materials on the Subject of Atomic Structure and Periodic Elements System for SMA MA Students in Class X. *Orbital: The Electronic Journal of Chemistry*, 15 (2), 127-132. <https://doi.org/10.17807/orbital.v15i2.17959>
- Liliana, L., Kusairi, S., & Wartono, W. (2020). Interactive web-based online physics learning media to improve student achievement and interest in learning. *Jurnal Pendidikan Fisika Indonesia*, 16(2), 89–97. <https://doi.org/10.15294/jpfi.v16i2.24109>
- Lin, C. J., & Wang, C. H. (2023). A systematic review of game-based learning in science education. *Journal of Educational Technology & Society*, 26(1), 45–62. [https://doi.org/10.30191/ETS.202301_26\(1\).0004](https://doi.org/10.30191/ETS.202301_26(1).0004)
- Low, B., Balamuralithara, B., & Yaacob, W. F. W. (2023). Game-based learning: Current practices and perceptions of secondary school physics teachers in Malaysia. *International Journal of Science, Mathematics and Technology Learning*, 31(1), 1–21. <https://doi.org/10.18848/2327-7971/CGP/v31i01/1-21>
- Mayer, R. E. (2020). *Multimedia learning (3rd ed.)*. Cambridge University Press.
- Mead, C., Bruce, G., Taylor, W., Buxner, S., & Anbar, A. D. (2022). Gamifying virtual exploration of the past 350 million years of vertebrate evolution. *Frontiers in Education*, 7, 836783. <https://doi.org/10.3389/educ.2022.836783>
- Mufit, F., Asrizal, A., & Kunsuci, N. (2022). Smartphone-based interactive multimedia combined with cognitive conflict models to develop 21st-century skills. *Journal of Physics: Conference Series*, 2309(1), 012051. <https://doi.org/10.1088/1742-6596/2309/1/012051>
-

-
- Newman, M., & Gough, D. (2020). Systematic reviews in educational research: Methodology, perspectives and application. In O. Zawacki-Richter, M. Kerres, S. Bedenlier, M. Bond, & K. Buntins (Eds.) *Systematic reviews in educational research* (pp. 3–22). Springer VS, Wiesbaden. https://doi.org/10.1007/978-3-658-27602-7_1
- Nugroho, A., Rahayu, S., & Arief, M. (2021). Interactive media for visualizing abstract science concepts in secondary education. *Jurnal Pendidikan IPA Indonesia*, 10(3), 345–357. <https://doi.org/10.15294/jpii.v10i3.30052>
- Nurkanti, M., & Yasundari, Y. (2024). Multimedia Interactive Visual (MIVI) to enhance students' creative thinking and collaboration in biology. *Jurnal Pendidikan Biologi Indonesia*, 10(1), 78–90. <https://doi.org/10.22219/jpbi.v10i1.28901>
- OECD (2025), *Trends Shaping Education 2025*, OECD Publishing, Paris, <https://doi.org/10.1787/ee6587fd-en>.
- Osborne, J. (2022). Science education for the 21st century. *Studies in Science Education*, 58(1), 1–44. <https://doi.org/10.1080/03057267.2020.1802792>
- Paul, J., & Menzies, J. (2023). Developing classic systematic literature reviews to advance knowledge: Dos and don'ts. *European Management Journal*, 41(6), 815–820. <https://doi.org/10.1016/j.emj.2023.11.006>
- Prasetya, S. P., Hidayati, A., Farid, J. A., Listari, T., Ardiansyah, R., & Chanthoeurn, D. (2024). Development of augmented reality atlas volcano series media in social sciences learning. *TEM Journal*, 13(4). <https://doi.org/10.18421/TEM134-36>
- Purba, L., Sormin, E., Rajagukguk, J., & Tambunan, H. (2020). Educational game about the concept of plant growth for secondary school students. *Journal of Physics: Conference Series*, 1471(1), 012038. <https://doi.org/10.1088/1742-6596/1471/1/012038>
- Pursitasari, I. D., Rubini, B., & Firdaus, F. Z. (2022). Feasibility of eco-literacy-based interactive teaching material to promote critical thinking skills. *Cypriot Journal of Educational Sciences*, 17(6), 2105–2116. <https://doi.org/10.18844/cjes.v17i6.7483>
- Putri, R. S., & Fitria, Y. (2021). Interactive multimedia in elementary science learning: A literature review. *Jurnal Basicedu*, 5(3), 1683–1691. <https://doi.org/10.31004/basicedu.v5i3.1010>
- Rahman, H., Wahid, S. A., Ahmad, F., & Ali, N. (2024). Game-based learning in metaverse: Virtual chemistry classroom for chemical bonding for remote education. *Education and Information Technologies*, 29(15), 19595–19619. <https://doi.org/10.1007/s10639-024-12583-5>
- Rejekiningsih, T., Maulana, I., Budiarto, M. K., & Qodr, T. S. (2023). Android-based augmented reality in science learning for junior high schools: Preliminary study. *International Journal of Evaluation and Research in Education*, 12(2), 8822. <https://doi.org/10.11591/ijere.v12i2.24109>
- Ristante, R. H., Rusdi, R., Mahardika, A. I., & Astuti, Y. (2020). Interactive dichotomous key media about invertebrates to increase student learning motivation. *Biosfer: Jurnal Pendidikan Biologi*, 13(2), 199–213. <https://doi.org/10.21009/biosferjpb.v13n2.199-213>
- Rosiana, Y., Syafii, W., Putra, R. A., & Futra, D. (2023). Effectiveness of e-module circulation system based on 8E learning cycle on high school student's
-

- critical thinking ability. *Journal of Educational Sciences*, 7(3), 434–441. <https://doi.org/10.31258/jes.7.3.p.434-441>
- Ryni, A. P., & Sukarmin, S. (2025). Development of LKPD assisted by augmented reality (AR) media on chemical bonding materials to improve student learning outcomes. *Journal of Educational Sciences*, 9(4), 2937–2949. <https://doi.org/10.31258/jes.9.4.p.2937-2949>
- Sari, M., Mawardi, M., & Astuti, S. (2021). Web/computer-based interactive multimedia "Inquiry Play-Room" as an electronic learning resource on rotation and equilibrium. *Jurnal Pendidikan Fisika Indonesia*, 17(1), 45–55. <https://doi.org/10.15294/jpfi.v17i1.26341>
- Sari, M., Suhendi, H., & Winarno, N. (2022). Interactive multimedia and higher-order thinking skills in science education: A review. *Jurnal Pendidikan IPA Indonesia*, 11(4), 567–578. <https://doi.org/10.15294/jpii.v11i4.38091>
- Septiani, U., Guspatni, G., Yerimadesi, Y., & Yusmaita, E. (2025). Practicality and effectiveness of augmented reality integrated learning media on the material of atomic theory development on the learning outcomes of Phase E SMA/MA students. *Journal of Educational Sciences*, 9(1), 90–102. <https://doi.org/10.31258/jes.9.1.p.90-102>
- Stiawan, R., Jumadi, J., & Kuswanto, H. (2022). Virtual simulation of molecular shapes based on VSEPR theory to improve student conceptual mastery. *Jurnal Pendidikan IPA Indonesia*, 11(1), 110–121. <https://doi.org/10.15294/jpii.v11i1.34109>
- Sulistiyana, M., Rahayu, S., & Parno, P. (2023). Mosiry e-module based on guided inquiry on the immune system for senior high school students. *Jurnal Pendidikan Biologi Indonesia*, 9(2), 134–145. <https://doi.org/10.22219/jpbi.v9i2.25109>
- Suwandi, T., Nugroho, S., & Purnomo, A. (2023). The "Virtual Garden" simulation media and students' perceptions of its use in biology learning. *Journal of Science Education and Technology*, 32, 789–801. <https://doi.org/10.1007/s10956-023-10041-8>
- UNESCO. (2024). Technology and education: Global monitoring report. *UNESCO Publishing*. <https://doi.org/10.54675/MJND2049>
- Voogt, J., & Knezek, G. (2020). *Teaching and learning in the digital age*. Springer. <https://doi.org/10.1007/978-1-4614-4538-8>
- Wahyuni, R., Firdaus LN, F. L., Putra, R. A., Linggasari, M. N., Wulandari, P. A., & Fadilah, M. (2025). Project-based learning (PjBL) green pedagogy e-module in improving creative thinking and digital literacy. *Journal of Educational Sciences*, 9(2), 876–885. <https://doi.org/10.31258/jes.9.2.p.876-885>
- Wahyuni, S., Erman, E., Sudikan, S., & Jatmiko, B. (2020). Edmodo-based interactive teaching materials as an alternative media for science learning to improve critical thinking skills of junior high school students. *Jurnal Pendidikan IPA Indonesia*, 9(4), 521–531. <https://doi.org/10.15294/jpii.v9i4.26170>
- Wegwerth, S. E., Urrea, A., Nischik, D. R., Kada, N. N., Manchester, G. J., & Winter, J. E. (2024). The Lewis Structure Explorer: Accessible by design. *Journal of Chemical Education*, 101(3), 987–995. <https://doi.org/10.1021/acs.jchemed.3c00857>

- Wibowo, F. C., Nasbey, H., Sanjaya, L. A., Darman, D. R., Ahmad, N. J., & Ismail, H. N. (2021). The technology of interactive book augmented reality (IBAR) for facilitating student 21st-century skills. *Journal of Theoretical and Applied Information Technology*, 99(22), 5276–5286. <https://doi.org/10.1088/1742-6596/2019/1/012039>
- Wijaya, T. T., Ying, Z., & Suan, L. (2021). Teacher and student response towards the use of HAWGENT dynamic mathematics software. *Journal of Physics: Conference Series*, 1764(1), 012078. <https://doi.org/10.1088/1742-6596/1764/1/012078>
- Yulina, I. K., Rahayu, S., Sunyono, S., & Rudibyani, R. B. (2021). Interactive HPLC multimedia to improve analytical thinking skills of chemistry students. *Jurnal Pendidikan IPA Indonesia*, 10(2), 289–299. <https://doi.org/10.15294/jpii.v10i2.29881>
- Zhao, H., Zhang, X., & Wang, L. (2021). Interactive technologies in science education: A review. *Journal of Science Education and Technology*, 30, 123–140. <https://doi.org/10.1007/s10956-020-09868-y>

How to cite this article:

Diens, N. A. A., Khaerudin., Kustandi, C., & Rahmadi, I. F. (2026). Trends in Interactive Learning Media for Science Education in Secondary Schools: A Systematic Literature Review. *Journal of Educational Sciences*, 10(5), 149-168.
