2026 Volume: 02 Issue: 06 www.ijrpa.com ISSN 2456-9995 Research Article

International Journal Research Publication Analysis

Page: 01-13

VALIDATING AN INTERACTIVE BLOG-BASED PHYSICS LEARNING MEDIUM TO ENHANCE STUDENTS' SCIENTIFIC LITERACY

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Article Received: 28 April 2026
Article Revised: 18 May 2026
Published on: 08 June 2026

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DOI: https://doi-doi.org/101555/ijrpa.5878

ABSTRACT

This study aimed to determine the validity of an interactive blog-based physics learning medium designed to enhance students' scientific literacy. The research was motivated by the persistent challenge of low scientific literacy among students and the lack of interactive, inquiry-oriented learning tools in physics education. The study sought to develop and validate a digital learning medium that integrates conceptual accuracy, pedagogical coherence, and accessibility to support inquiry-based learning.Using a Research and Development approach with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), the medium was constructed, refined, and validated by experts in physics education. The validation focused on four dimensions—content accuracy, construct alignment, readability, and visual design—to ensure the medium's suitability for fostering scientific reasoning and conceptual understanding.The results demonstrated that the interactive blog-based medium achieved a high level of validity across all dimensions. Experts confirmed that the content was scientifically accurate, aligned with curricular goals, and effectively facilitated inquiry and problem-based learning. The language and visual design enhanced conceptual accessibility, while the blog's interactive features encouraged exploration and reflection. These findings indicate that valid instructional design plays a crucial role in linking abstract physics concepts to real-world applications and developing students' ability to think scientifically.In conclusion, the study provides empirical evidence that a validated interactive blog-based learning medium serves as a pedagogically sound and scientifically reliable tool for improving students' scientific literacy. Its validated structure contributes to the

advancement of digital science education and offers a foundation for further exploration of technology-integrated learning in physics classrooms.

KEYWORDS: interactive learning media, blog-based physics learning, scientific literacy, validity, inquiry-based education.

INTRODUCTION

Education plays a fundamental role in shaping the intellectual and technological advancement of a nation. Among the various dimensions of education, scientific literacy has emerged as a crucial competency in the 21st century, as it equips individuals with the ability to understand, apply, and evaluate scientific information in their daily lives. According to the Programme for International Student Assessment (PISA), scientific literacy refers to an individual's capacity to engage with science-related issues and ideas as a reflective citizen (OECD, 2019). In an increasingly technology-driven world, scientific literacy not only enables individuals to comprehend scientific phenomena but also supports evidence-based decision-making and problem-solving within social and environmental contexts. However, global assessments have consistently shown that Indonesia's performance in scientific literacy remains below the international average. The PISA 2022 results placed Indonesia at the 72nd position out of 79 participating countries, with an average science score of 396, considerably lower than the OECD average of 487. This gap highlights persistent challenges in developing students' understanding of scientific concepts and their ability to apply them to real-world problems.

At the classroom level, several systemic and pedagogical factors contribute to this problem. Traditional teaching approaches in Indonesian schools are predominantly teacher-centered, relying heavily on lectures and rote memorization (Widodo &Wahyudin, 2021). Such methods often position students as passive recipients of information, limiting opportunities for active engagement, critical thinking, and conceptual understanding. Moreover, limited access to laboratories, inadequate instructional resources, and insufficient integration of technology further constrain science learning experiences (Rahmawati&Suryadi, 2022). Many teachers also face difficulties in designing or implementing innovative learning media that cater to diverse learning styles and encourage student participation. Consequently, science education often fails to connect with students' everyday experiences, making scientific concepts appear abstract and detached from reality.

Addressing this pedagogical gap requires a transformation in instructional design, emphasizing interactive and student-centered learning approaches that foster scientific

inquiry and literacy. One effective solution involves the development and integration of innovative learning media. Learning media serve as tools or materials that facilitate the communication of educational content, enabling students to comprehend complex scientific ideas more effectively. As Djuanda (2018) notes, well-designed instructional media can bridge the gap between abstract theory and tangible understanding by providing visualizations, simulations, and contextualized experiences. Additionally, media-based learning supports differentiated instruction by accommodating various learning modalities—visual, auditory, and kinesthetic—thereby promoting inclusivity and engagement across diverse student populations. In line with the Merdeka Curriculum, which emphasizes student autonomy and project-based learning, the integration of contextual, technology-based media can cultivate both scientific understanding and problem-solving competence.

Previous research has demonstrated the potential of interactive media in enhancing scientific literacy. Widodo and Wahyudin (2021) found that interactive digital media not only increased students' comprehension of scientific concepts but also stimulated intrinsic motivation and interest in learning science. Kusumawati (2020) reported that project-based digital modules fostered critical thinking by situating learning within authentic contexts, while Rahmawati and Suryadi (2022) showed that the use of animations and simulations simplified abstract concepts, making science learning more accessible and enjoyable. These studies collectively affirm that technology-enhanced learning media, when appropriately designed, can bridge the gap between scientific theory and practical application. Yet, despite the growing body of research, the implementation of such media in Indonesian classrooms remains limited and inconsistent, indicating a need for more structured and validated development efforts.

Recent advances in educational technology have made digital platforms—such as blogs, e-modules, and learning management systems—powerful tools for interactive learning. Blogs, in particular, offer an accessible and versatile platform that supports various media formats, including text, images, videos, and hyperlinks. According to Sutrisno et al. (2021), educational blogs serve as dynamic repositories where teachers can organize content, and students can interact through comments, reflections, and discussions. This interactivity promotes dialogic learning and continuous feedback between teachers and students. Moreover, Fauzi and Ramdhani (2022) argue that digital interactive media enhance both the attractiveness and effectiveness of learning by allowing learners to personalize their experiences, access materials anytime and anywhere, and engage with content that responds

to their input in real time. Such affordances make blog-based learning media particularly suitable for science education, where abstract phenomena can be visualized and explored through multimedia integration.

The integration of blogs into science education has been supported by empirical evidence. For instance, Ridwan (2020) developed a Google Sites–based physics learning platform that significantly improved undergraduate students' scientific literacy in fundamental physics courses. Similarly, Nurul Hidayah et al. (2021) designed a Problem-Based Learning (PBL) website to enhance students' scientific reasoning and engagement, reporting a marked increase in literacy scores. Zubaidah et al. (2020) also emphasized that digital learning environments built upon PBL frameworks effectively nurture inquiry, reasoning, and collaboration—skills that are essential for scientific literacy. These studies underscore the effectiveness of combining digital interactivity with inquiry-oriented pedagogies in fostering meaningful science learning. However, many of these innovations remain confined to higher education or specialized contexts, with limited application at the secondary level, particularly in physics instruction where abstractness and mathematical reasoning often hinder comprehension.

Within this context, physics education presents a critical area for the development of interactive learning tools. Physics concepts—such as vibration and wave phenomena—are inherently abstract, requiring visualization and experimentation for deep understanding. Conventional teaching methods that rely solely on verbal explanation and textbook exercises are insufficient to facilitate students' conceptualization of these topics. The incorporation of an interactive physics learning blog provides a potential solution by integrating textual explanations, visual aids, simulations, and collaborative discussion spaces. As proposed by Putri and Suryani (2021), digital platforms can simultaneously deliver content and foster communication, thus creating a blended environment where learners actively construct knowledge through exploration and reflection. The presence of features such as live chat, comment sections, and embedded videos allows for two-way interaction, promoting continuous engagement and feedback between teachers and students.

A number of relevant studies have further explored how the Problem-Based Learning (PBL) model enhances students' scientific literacy when supported by digital tools. For example, Erayani and Jampel (2020) demonstrated that PBL combined with interactive media improved both metacognitive skills and literacy among elementary students. Kurniawati and Hidayah (2020) found that PBL integrated with blended learning strategies effectively

developed students' ability to analyze, evaluate, and interpret scientific data. Fathiah and Fauziah (2019) also revealed that the implementation of PBL on the topic of global warming led to significant gains in literacy and environmental awareness. Collectively, these findings highlight the synergy between problem-oriented pedagogy and digital media in facilitating deep scientific understanding. Nonetheless, the literature still lacks comprehensive studies focusing on the design, validation, and empirical evaluation of blog-based physics learning tools aimed specifically at improving scientific literacy among junior high school students.

Building upon this research gap, the present study seeks to develop and validate an interactive blog-based physics learning medium designed to enhance students' scientific literacy. This research employs the ADDIE development model, encompassing five systematic stages: analysis, design, development, implementation, and evaluation (Alessi & Trollip, 2018; Agustina & Sutrisno, 2019; Riyanto, 2020). The focus is to ensure that the developed medium meets the criteria of validity, practicality, and effectiveness. The validity of the media is assessed through expert evaluation, practicality through classroom implementation, and effectiveness through the measurement of students' scientific literacy improvement. The novelty of this research lies in its integration of blog technology with the PBL framework to create a learning environment that is not only accessible and engaging but also empirically proven to enhance literacy outcomes. Unlike many existing digital platforms, the proposed medium is designed to align with the Indonesian secondary science curriculum and to address the contextual challenges faced by both teachers and students in rural schools with limited resources.

Therefore, the primary objective of this study is to examine how the validity and application of an interactive physics learning blog can contribute to improving students' scientific literacy. This research is justified by the urgent need to provide innovative, technology-based learning solutions that bridge the gap between abstract physics concepts and students' real-world experiences. By developing a valid, practical, and effective instructional medium grounded in the ADDIE framework, this study aims to advance pedagogical practices in science education and provide empirical evidence supporting the use of blogs as an alternative medium for enhancing literacy and engagement in physics learning. Ultimately, the study aspires to contribute to a broader understanding of how digital interactivity and contextual learning design can transform science education in Indonesia, empowering students to become scientifically literate, critical thinkers equipped for the demands of the modern world.

METHODOLOGY

This study adopted a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to develop and validate an interactive blog-based physics learning medium designed to enhance students' scientific literacy (Alessi & Trollip, 2018; Agustina & Sutrisno, 2019; Riyanto, 2020). The research utilized a One-Group Pretest–Posttest design, in which students completed a pretest, engaged in learning activities using the developed blog, and then took a posttest to measure improvement in their scientific literacy (Sugiyono, 2017).

The study was conducted at SMP Negeri 2 Kwandang, North Gorontalo Regency, with a group of eighth-grade students during the 2024/2025 academic year. Data collection took place over a two-month period through observations, interviews, questionnaires, and tests. The Analysis phase identified that students had limited scientific literacy skills and that learning was still dominated by traditional, teacher-centered methods. Teachers and students expressed a strong need for more engaging and technology-based learning media.

In the Design phase, the blog was conceptualized to include structured learning materials, interactive worksheets, instructional videos, PhET simulations, and communication features such as comment sections and live chat. The learning design applied the Problem-Based Learning (PBL) model, emphasizing inquiry, collaboration, and reflection to build students' understanding of scientific concepts (Hidayat et al., 2019; Mulyasa, 2018).

The Development phase involved creating the prototype of the blog and validating its content, structure, and readability through expert review from the Physics Education Department at Universitas Negeri Gorontalo. The experts confirmed that the media met the standards of validity and was appropriate for classroom use (Utomo, 2018).

During the Implementation phase, the blog was integrated into classroom instruction over several sessions. Observations and feedback indicated that the medium supported active learning, increased student engagement, and facilitated collaboration. Students found the blog easy to use and reported that it helped them better understand physics concepts and relate them to real-life contexts.

The Evaluation phase focused on assessing the validity, practicality, and effectiveness of the developed media using both qualitative and quantitative analyses. Results from expert validation, classroom observation, student questionnaires, and literacy-based assessments consistently showed that the blog-based learning medium was feasible, user-friendly, and beneficial for improving scientific literacy.

RESULTS AND DISCUSSION

Overview of the Media Development and Validation Process

The primary objective of this study was to determine the validity of an interactive blog-based physics learning medium developed to enhance students' scientific literacy. Validity in this context refers to the degree to which the learning medium accurately represents the intended content, aligns with learning objectives, and supports the cognitive and literacy skills it aims to develop. Following the ADDIE model (Alessi & Trollip, 2018; Agustina & Sutrisno, 2019; Riyanto, 2020), the research progressed through systematic phases—analysis, design, development, implementation, and evaluation—to ensure a rigorous validation process. The development process involved collaboration between the researcher, subject matter experts, and physics educators to guarantee the pedagogical and conceptual accuracy of the media content.

The validation of the interactive blog was conducted by three expert validators from the Physics Education Department at Universitas Negeri Gorontalo, who assessed the medium across four key dimensions: (1) content validity, which evaluates the accuracy and completeness of the scientific concepts; (2) construct validity, which assesses the alignment between learning objectives and instructional strategies; (3) readability, which examines clarity and coherence of language; and (4) visual and interactive design, which evaluates usability and aesthetic appeal. These dimensions were adapted from the criteria for instructional media validation as proposed by Utomo (2018), emphasizing that valid media must integrate both scientific accuracy and pedagogical suitability.

The validation process revealed that the blog-based learning medium met the criteria of high validity. The evaluators confirmed that the instructional content was accurate, consistent with the secondary school physics curriculum, and effectively communicated scientific concepts in an accessible way. The materials presented within the blog—particularly the sections on vibration and wave phenomena—were aligned with the scientific literacy framework defined by OECD (2019), which includes understanding scientific concepts, applying scientific methods, and interpreting data and evidence in a scientific context. Moreover, the validators agreed that the medium reflected the pedagogical principles of Problem-Based Learning (PBL) (Hidayat et al., 2019; Mulyasa, 2018), which is recognized for promoting inquiry and conceptual understanding in science education.

Content Validity and Alignment with Scientific Literacy

Content validity refers to the extent to which the learning material accurately represents the domain of knowledge it seeks to teach. The experts found that the interactive blog's content was conceptually precise, relevant, and pedagogically sound. The material on vibration and wave phenomena was presented through a progressive structure—from basic definitions and conceptual explanations to real-world applications—ensuring that students could construct understanding through both theoretical and contextual lenses.

The blog's design facilitated the development of key competencies in scientific literacy, as defined by Oktaviani and Yuliani (2017) and Fadilah (2021), which include the ability to comprehend, apply, and evaluate scientific information to make evidence-based decisions. Through the inclusion of text-based explanations, visual animations, and interactive simulations, the blog helped learners bridge the gap between abstract physics concepts and tangible phenomena. The integration of simulation-based learning tools, such as PhET interactive simulations, further allowed students to explore cause-and-effect relationships in a controlled environment, enhancing their ability to reason scientifically.

In addition, the learning materials within the blog adhered closely to the curriculum standards of the Indonesian Ministry of Education (Kemendikbud, 2017), ensuring that all scientific principles and examples were appropriate for the cognitive level of junior secondary students. Each section of the blog included explicit learning objectives, conceptual summaries, and problem-solving activities that required students to apply their understanding in new contexts—an approach consistent with the inquiry-based nature of scientific literacy development (Bybee, 2020; National Research Council, 2021).

Construct Validity: Pedagogical Coherence and Theoretical Consistency

Construct validity in instructional media refers to the internal consistency between the learning objectives, instructional strategies, and assessment components. In this study, the experts affirmed that the blog demonstrated a coherent pedagogical structure aligned with the Problem-Based Learning (PBL) framework. The instructional design guided students through a systematic learning process involving problem orientation, exploration, data interpretation, and reflection.

This approach aligns with the model proposed by Eggen and Kauchak (2020), who argue that effective learning design should engage learners in constructing knowledge through exploration and discussion rather than rote memorization. Within the blog, each learning module began with a contextual problem or real-world phenomenon—such as oscillating

pendulums, wave propagation in water, or sound vibration—which students were required to investigate using available tools and resources. The inclusion of multimedia elements (e.g., videos and visualizations) supported conceptual understanding by illustrating phenomena that would otherwise be challenging to observe directly.

Furthermore, the assessment components embedded in the blog—such as reflection prompts, comprehension questions, and inquiry-based tasks—encouraged learners to engage in higher-order thinking, including analysis, synthesis, and evaluation. This structure reflected the principles outlined by Smaldino, Lowther, and Russell (2019), who emphasize that valid instructional media must facilitate cognitive engagement and self-directed inquiry. The validators highlighted that the consistency between the learning activities and intended outcomes strengthened the construct validity of the blog, confirming that it was theoretically and pedagogically aligned with the development of scientific literacy.

Readability and Conceptual Accessibility

Another crucial aspect of validation concerned the readability and conceptual accessibility of the instructional materials. According to Arifin (2018) and Yaumi (2018), readability in educational media affects not only students' comprehension but also their motivation and engagement with the content. The experts assessed that the language used in the blog was appropriate for junior high school students—clear, concise, and free of excessive technical jargon. Explanations were written in a sequential manner, linking prior knowledge with new concepts, thus enabling students to follow the logical progression of scientific reasoning.

The integration of multimodal elements, including diagrams, simulations, and illustrative videos, was noted as an effective strategy for improving conceptual accessibility. These components provided alternative representations of scientific phenomena, allowing students to visualize and manipulate abstract concepts. The validators emphasized that such visual scaffolding was particularly beneficial for topics like vibration and wave motion, which often require an understanding of motion dynamics and spatial relationships. Moreover, the inclusion of interactive features such as comment sections and live chat functionalities promoted communication and collaborative learning, aligning with Sutrisno et al. (2021), who underscore the pedagogical value of blogs as interactive learning environments.

Overall, the readability analysis confirmed that the blog's design and content were developmentally appropriate and accessible to its target audience. This aligns with Putri and Suryani (2021), who argue that digital learning environments should combine clarity of explanation with visual interactivity to sustain learners' interest and support comprehension.

Visual and Interface Design Validity

In addition to content and language, the visual and interface design of the blog played a critical role in determining its validity as an instructional medium. According to Fauzi and Ramdhani (2022), the integration of design principles such as consistency, simplicity, and responsiveness enhances user experience and learning efficiency. The validators observed that the blog's layout was intuitive, enabling users to navigate seamlessly between sections without confusion. The use of color schemes, icons, and interactive buttons followed ergonomic standards and digital learning principles, contributing to an engaging and non-distracting interface.

Furthermore, the blog demonstrated effective multimedia integration, allowing simultaneous presentation of text, visuals, and video content. This multimodal approach aligns with Mayer's Cognitive Theory of Multimedia Learning, which posits that learning is optimized when information is presented through both visual and auditory channels in a complementary manner. The validators emphasized that this design encouraged active engagement and improved retention of scientific concepts, particularly for visual learners. Additionally, the inclusion of features such as PhET simulations and embedded quizzes transformed the blog from a static information source into a dynamic learning platform, promoting exploratory learning and reinforcing conceptual understanding.

Validation Results and Interpretation

The combined results of the validation process confirmed that the interactive blog-based physics learning medium possessed a high degree of validity across all evaluated dimensions. The validation findings demonstrated that the medium was scientifically accurate, pedagogically coherent, linguistically clear, and visually well-structured. The evaluators collectively agreed that the blog was ready for classroom implementation and capable of supporting inquiry-based science learning.

From a theoretical perspective, the strong validation results can be attributed to the alignment between the design of the medium and established frameworks of scientific literacy development. As noted by Bybee (2020) and Harlen (2019), scientific literacy encompasses the ability to reason scientifically, apply scientific methods, and communicate ideas effectively. The blog's design successfully integrated these dimensions by combining conceptual explanation, simulation-based exploration, and opportunities for reflective discussion. Students were guided to observe, hypothesize, and analyze scientific phenomena through authentic inquiry, which is central to literacy-based science education.

Moreover, the validators emphasized that the blog's emphasis on contextual learning—relating scientific principles to everyday experiences—enhanced its pedagogical relevance. This contextualization is crucial for developing functional scientific literacy, as it enables students to connect theoretical understanding with practical applications (Purwati, 2019; Windyariani, 2017). For example, lessons on wave motion were linked to real-life phenomena such as sound, light, and earthquake waves, encouraging students to recognize science as a dynamic and applicable discipline.

The validation findings also align with the argument of **Branch (2018)** and **Smaldino et al. (2019)** that instructional design models like ADDIE ensure systematic development and continuous improvement through expert feedback. In this study, iterative revisions were made after each validation round based on expert suggestions, resulting in refined materials that adhered more closely to both scientific and pedagogical standards.

Implications of Validity for Scientific Literacy Development

The high validity of the interactive blog carries significant implications for the enhancement of students' scientific literacy. First, valid instructional media ensure that learners are exposed to accurate scientific knowledge and reasoning processes, minimizing misconceptions and reinforcing conceptual integrity (Osborne, 2018). Second, a valid design fosters meaningful learning experiences by integrating inquiry, problem-solving, and reflection, all of which are essential for developing critical thinking and evidence-based reasoning (National Research Council, 2021).

The blog's validated structure supports active engagement and self-directed learning, key components of literacy development. As Lederman and Lederman (2020) note, scientific literacy thrives in environments where learners are encouraged to question, investigate, and construct meaning from evidence. The interactive elements of the blog—such as simulations and open-ended reflection prompts—enable this process by immersing students in authentic scientific inquiry. In addition, the validated visual and linguistic components reduce cognitive load, allowing students to focus on conceptual understanding rather than struggling with interface or language barriers.

Overall, the validation results demonstrate that the interactive blog-based physics learning medium is a scientifically and pedagogically sound tool for developing scientific literacy among secondary students. Its validated design ensures that it effectively conveys accurate concepts, promotes inquiry, and aligns with both national curriculum standards and

international frameworks for science education. The combination of scientific rigor, instructional coherence, and accessibility positions the medium as a reliable and innovative resource for teachers seeking to integrate technology into physics education and foster a generation of scientifically literate learners.

CONCLUSION

This study established that the interactive blog-based physics learning medium developed through the ADDIE model demonstrates a high degree of validity as an instructional tool for enhancing students' scientific literacy. Expert evaluations confirmed that the medium aligns strongly with curricular goals, pedagogical frameworks, and the conceptual demands of physics learning. The content accurately represents scientific principles, the design supports inquiry-oriented learning, and the presentation ensures accessibility through clear language and visual interactivity. These attributes collectively validate the medium as a reliable platform for promoting scientific literacy, which involves understanding, applying, and evaluating scientific concepts within real-world contexts.

The findings contribute to the growing body of literature on digital and inquiry-based science education by providing empirical evidence that validated instructional media, particularly those utilizing blog technology, can effectively bridge the gap between abstract scientific ideas and meaningful learning experiences. This research reinforces the importance of integrating technological and pedagogical validity in media design to ensure conceptual accuracy and engagement. Future studies are encouraged to expand this line of inquiry by examining how validated blog-based learning environments influence different dimensions of scientific literacy, such as reasoning, argumentation, and data interpretation, across diverse student populations and educational settings.

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