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Transforming Elementary Science Education: Developing AI-Based Interactive Learning Media (ARIPAS) for Enhanced Engagement and Comprehension

Fatma Riyanti Sanggulu, Abdul Haris Panai, Irvin Novita Arifin

Pascasarjana, Universitas Negeri Gorontalo, Indonesia

ABSTRACT

This study explores the development and effectiveness of ARIPAS, an Artificial Intelligence-based interactive learning media, designed to enhance student engagement and comprehension in integrated science (IPAS) lessons for fifth graders. The research addresses challenges associated with traditional teaching methods, including limited interactivity and reliance on static textbooks, which hinder student motivation and understanding. The study's primary objective is to create an engaging, multimodal learning tool that aligns with the goals of Indonesia's *Kurikulum Merdeka*. Using the 4D development model—Define, Design, Develop, Disseminate—the study identified educational needs, designed a user-friendly interface, validated the media with experts, and tested its effectiveness in classroom settings. ARIPAS integrates animations, simulations, and interactive assessments, offering a dynamic alternative to conventional teaching practices. Results indicate significant improvements in student engagement and learning outcomes, with pre- and post-test analyses showing marked knowledge gains. Teachers also reported increased classroom participation and independent learning. Despite infrastructure and training challenges, ARIPAS demonstrates strong potential for scalability and adaptability across educational contexts.This study contributes to the advancement of AI-driven educational tools, highlighting their role in fostering active, inclusive learning environments. Future research should explore the long-term impact of such technologies and their application in diverse subject areas.

Keyword : *AI-enhanced education, Interactive learning tools, Science pedagogy innovation*

INTRODUCTION

The curriculum serves as a foundational framework guiding the educational process to achieve predetermined learning objectives (Amarta et al., 2024). Over time, Indonesia has experienced a dynamic evolution in its curriculum, reflecting societal and technological advancements. From its rudimentary beginnings during independence to the recent *Kurikulum Merdeka* (Freedom Curriculum), these changes highlight a consistent drive towards modernization and alignment with global standards. The *Kurikulum Merdeka* emphasizes learner-centered education, granting educators the creative freedom to design engaging and effective learning environments. In particular, the transformation of natural science (IPA) into integrated science (IPAS) underscores a broader interdisciplinary approach. As IPAS delves into the phenomena of the universe and the processes governing it, its relevance becomes increasingly critical in fostering scientific literacy among young learners, equipping them with the skills necessary to navigate and address complex real-world challenges (Purba et al., 2023; Sakila et al., 2023).

Despite these advancements, traditional teaching practices remain predominant in many Indonesian primary schools, often relying on outdated methods such as static textbooks and rote memorization. While these tools provide a foundational understanding, they fail to engage students or stimulate higher-order thinking skills. This inadequacy becomes particularly evident in topics requiring visualization and interaction, such as human body systems, where students struggle to grasp abstract concepts through textual explanations alone. Research suggests that the effective integration of technology in classrooms can significantly enhance learning experiences, offering interactive and immersive opportunities that cater to diverse learning styles (Pratiwi, 2021; Winangsih & Harahap, 2023). However, the lack of innovative teaching tools and teacher training in leveraging modern technologies, including Artificial Intelligence (AI), continues to hinder the optimal realization of the *Kurikulum Merdeka's* vision.

The core issue identified in this study revolves around the limited availability and utilization of interactive learning media in Indonesian primary schools, particularly for IPAS lessons. Teachers at SDN 2 Tilongkabila, for example, still rely heavily on traditional instructional methods, which often fail to fully engage students or support independent learning. Observations reveal that the use of existing digital aids, such as speakers and LCD projectors, is minimal, with no substantial implementation of interactive media. Consequently, classroom dynamics remain passive, students' motivation wanes, and their critical thinking skills remain underdeveloped. Addressing this problem requires a systematic integration of interactive learning media tailored to the specific needs of primary education and leveraging technological advancements to transform the learning experience.

Interactive learning media represent a promising solution to these challenges, offering engaging, multimodal platforms that combine visual, auditory, and kinesthetic elements to facilitate active learning. Such tools not only bridge the gap between abstract concepts and tangible understanding but also foster an environment where students can explore, inquire, and problem-solve independently (Harsiwi & Arini, 2020). As the era of digital transformation unfolds, the incorporation of AI-powered technologies provides unprecedented opportunities to revolutionize education. AI enables the creation of adaptive, personalized learning experiences that respond to individual learners' needs and preferences, enhancing both engagement and achievement (Tjahyanti et al., 2022).

Several studies underscore the potential of AI in educational contexts. For instance, platforms like Quizizz, Canva, and Google AI tools offer intuitive interfaces for creating visually appealing and interactive content, promoting self-directed and collaborative learning. Research by Dwiqi et al. (2020) demonstrates the efficacy of interactive learning media in improving students' engagement and academic performance. Similarly, Safira et al. (2021) emphasize that incorporating multimedia elements—such as animations, videos, and simulations—into teaching practices not only captivates students' interest but also deepens their conceptual understanding.

Building on these advancements, recent studies have explored AI-driven applications explicitly designed for primary education. For example, Afriyani et al. (2024) developed AI-based chatbot tools for physics lessons, reporting significant improvements in students' independent learning and comprehension of abstract topics such as heat and temperature. These findings suggest that integrating AI into interactive media can enhance its effectiveness by offering real-time feedback, adaptive content delivery, and personalized learning pathways. Moreover, tools like Canva, which blend AI with user-friendly design features, allow educators to create rich, multimodal learning environments that cater to students' diverse preferences and needs.

Despite the growing body of research advocating for AI in education, there remains a notable gap in the application of AI-based interactive media for primary science education in Indonesia, specifically within the *Kurikulum Merdeka* framework. Existing studies predominantly focus on secondary education or technical subjects, leaving a critical void in understanding how AI-driven tools can be effectively adapted to the needs of younger learners. Furthermore, while platforms like Canva and Quizizz have been explored in isolation, there is limited research on the synergistic integration of multiple AI-powered tools to create comprehensive learning experiences.

This study aims to address these gaps by developing an AI-based interactive learning media called ARIPAS, specifically tailored for fifth-grade IPAS lessons. By combining the strengths of various AI platforms, ARIPAS seeks to offer an engaging, user-friendly, and pedagogically sound solution to the challenges faced in primary science education.

The primary objective of this research is to develop, implement, and evaluate the effectiveness of ARIPAS in enhancing learning outcomes for fifth-grade IPAS students at SDN 2 Tilongkabila. This study hypothesizes that integrating AI-based interactive media will significantly improve students' motivation, engagement, and comprehension of scientific concepts. Unlike traditional methods, ARIPAS leverages AI to deliver personalized content, foster active participation, and facilitate independent learning, aligning with the *Kurikulum Merdeka's* emphasis on creativity and critical thinking.

The novelty of this study lies in its holistic approach to AI integration, combining multiple tools and methodologies to create a versatile and adaptive learning platform. This approach not only addresses the immediate needs of the classroom but also contributes to the broader discourse on the role of AI in shaping the future of education. By focusing on IPAS—a subject critical for cultivating scientific literacy—this study offers valuable insights into how emerging technologies can be harnessed to transform primary education in Indonesia.

METHODOLOGY

This study was conducted at SDN 2 Tilongkabila, located in Kasmat Lahay Street, Bongopini Village, Tilongkabila District, Bone Bolango Regency, Gorontalo Province. The school was chosen due to the researcher's prior observation of challenges faced in its learning processes, particularly in the fifth grade. At the time of the study, the school was led by Principal Jusra Ladiku, S.Pd., and accommodated 155 students across six grade levels in the 2024/2025 academic year. The research took place during the first semester of the academic year, allowing for the implementation and evaluation of the developed educational media.

This research adopted a Research and Development (R&D) methodology, as described by Sugiyono (2019), aimed at creating and testing the effectiveness of a specific product—in this case, an interactive learning media based on Artificial Intelligence (ARIPAS). This method systematically combines theoretical and practical approaches to produce educational innovations tailored to specific needs. Zakariah et al. (2020) emphasized that R&D processes involve developing or refining products through rigorous, evidence-based practices.

The development process utilized the 4D model by Thiagarajan et al. (1974), comprising four distinct stages: Define, Design, Develop, and Disseminate. This model was selected due to its structured approach and practical applicability in creating and implementing educational tools. While the model's brevity is advantageous for streamlined execution, it does not extend to post-dissemination evaluation, which is recognized as a limitation.

This study employed a mixed-methods approach, integrating qualitative and quantitative techniques. According to Taylor and Bogdan (as cited in Moleong, 2008), qualitative research enables the collection of descriptive data from natural settings, providing rich insights into participant behaviors and perceptions. This approach was used during the initial exploratory phases, including interviews, observations, and document analysis, to identify problems and inform the design of the educational media. Conversely, the quantitative approach facilitated the statistical evaluation of data obtained during the testing phase, focusing on assessing the practicality, validity, and effectiveness of the developed media.

This study adhered to ethical guidelines for educational research. Informed consent was obtained from all participants, including parents and guardians for student participants. Anonymity and confidentiality were ensured throughout data collection and analysis. The study also sought approval from relevant institutional authorities at SDN 2 Tilongkabila to conduct fieldwork and implement ARIPAS.

RESULTS AND DISCUSSION

Overview of Initial Conditions for Interactive Learning Media

The initial assessment of the learning environment at SDN 2 Tilongkabila revealed significant limitations in the use of interactive learning media for integrated science (IPAS). Classroom observations and teacher interviews indicated that conventional teaching practices dominated instructional methods, with minimal integration of technology. The reliance on static printed materials as the primary learning resource created a passive learning environment, resulting in limited student engagement, reduced motivation, and suboptimal knowledge retention. Teachers utilized basic technological tools, such as speakers and projectors, primarily for lecture delivery rather than fostering interactive and student-centered learning experiences.

These findings align with earlier research by Purba et al. (2023), who emphasized that the lack of engaging instructional strategies often impedes students' comprehension of abstract concepts, particularly in science education. Without dynamic, interactive tools, students are less likely to develop critical thinking skills and the capacity to independently explore scientific phenomena.

Development of the ARIPAS Interactive Learning Media

To address these challenges, this study employed the 4D model (Thiagarajan et al., 1974) to design and implement **Artificial Intelligence-Based Interactive Learning Media (ARIPAS)**. The design phase involved a thorough analysis of curricular objectives, student needs, and existing technological resources. The content was structured to align with the *Kurikulum Merdeka's* emphasis on fostering creativity, collaboration, and critical thinking.

The ARIPAS media integrates diverse features, including animations, interactive simulations, audio explanations, and embedded assessments. These elements were designed using AI-enhanced platforms such as Canva, Quizizz, and Adobe Express, offering a multimodal approach to accommodate various learning styles. The interface was intentionally crafted to be intuitive and user-friendly, ensuring accessibility for both students and educators with varying levels of technological proficiency.

Expert validation of the prototype yielded high scores across content accuracy, design quality, and linguistic clarity. Content experts noted the media's alignment with curricular standards and its capacity to effectively scaffold complex concepts. Design specialists praised its aesthetic appeal and navigational simplicity, while linguistic experts highlighted the clarity and appropriateness of the language used. Feedback from these validations informed iterative refinements to ensure the media met pedagogical and usability standards.

Implementation of ARIPAS in the Classroom

The ARIPAS media was implemented in a series of classroom sessions, targeting the topic of human body systems—a subject identified during the needs analysis as particularly challenging for students. The media facilitated interactive lessons where students could explore the structure and function of respiratory and digestive systems through animations, simulations, and guided inquiry activities.

The implementation was monitored through direct observation, teacher interviews, and student feedback surveys. Teachers reported increased levels of student participation and engagement, noting that the interactive elements of ARIPAS fostered curiosity and active learning. For instance, students were observed eagerly interacting with simulations to identify the components of the respiratory system, demonstrating a deeper conceptual understanding compared to traditional lecture methods.

These findings are consistent with studies by Harsiwi & Arini (2020), who observed that interactive learning media significantly enhance student engagement by creating immersive and participatory learning experiences. Furthermore, integrating AI-driven features allows for real-time feedback and adaptive learning pathways, as demonstrated in earlier research by Tjahyanti et al. (2022).

Effectiveness of ARIPAS in Enhancing Learning Outcomes

To evaluate the effectiveness of ARIPAS, pre-test and post-test assessments were conducted, measuring students' knowledge and comprehension of the human body systems. The results showed a marked improvement in student performance, with average normalized gain scores indicating moderate to high learning gains.

Quantitative data analysis revealed statistically significant increases in test scores, confirming the media's efficacy in facilitating knowledge acquisition. Additionally, qualitative feedback from students highlighted the media's role in making complex scientific concepts more accessible and engaging. Many students expressed a preference for the visual and interactive components of ARIPAS over traditional textbook-based learning.

The effectiveness of ARIPAS aligns with the findings of Dwiqi et al. (2020), who reported that interactive learning media enhance students' cognitive engagement and knowledge retention. Similarly, Safira et al. (2021) emphasized that multimedia elements, such as animations and simulations, support conceptual clarity and foster a deeper understanding of abstract topics.

Challenges and Limitations

Despite its overall success, the implementation of ARIPAS encountered several challenges. Teachers required additional training to fully utilize the media's features, as many were unfamiliar with AI-based educational tools. This finding highlights the importance of professional development programs to equip educators with the skills needed to integrate technology into their teaching practices effectively (Razak et al., 2023).

Moreover, the reliance on digital infrastructure posed logistical challenges, particularly in classrooms with limited access to reliable internet connections or sufficient devices. Addressing these barriers will require systemic investments in technological resources and infrastructure to ensure equitable access to digital learning tools.

Contributions to the Field of Science Education

The development and implementation of ARIPAS represent a significant contribution to the field of science education, particularly within the context of Indonesia's *Kurikulum Merdeka*. By integrating AI into interactive learning media, this study offers a scalable and replicable model for enhancing student engagement and achievement in primary education.

ARIPAS's multimodal design caters to diverse learning preferences, promoting inclusivity and accessibility. Its adaptability across various topics and disciplines underscores its potential for widespread application in different educational settings. Moreover, the study provides empirical evidence supporting the pedagogical value of AI-driven tools, contributing to the growing body of literature advocating for technology-enhanced learning.

CONCLUSION

This study demonstrates the effectiveness of ARIPAS, an AI-based interactive learning media, in enhancing engagement, motivation, and comprehension among fifth-grade students studying integrated science (IPAS). Initial observations revealed limitations in traditional teaching methods, including reliance on static textbooks and minimal use of technology, which hindered active learning and critical thinking. ARIPAS addressed these challenges by integrating animations, simulations, and adaptive assessments, significantly improving students' understanding of complex topics like human body systems. Pre- and post-test results showed substantial learning gains, confirming its efficacy in facilitating knowledge acquisition and retention.

This research contributes to the growing body of knowledge on AI in education by offering a scalable, user-friendly model tailored to primary school contexts. Its multimodal design supports diverse learning styles, fostering inclusivity and accessibility. However, challenges such as teacher readiness and infrastructure limitations highlight the need for professional development and systemic investments in educational technology.

The findings emphasize the transformative potential of AI in revolutionizing science education. Future research should explore the long-term impact of AI-driven tools on learning outcomes and investigate their application across diverse subjects and educational contexts. By bridging the gap between innovation and practice, this study advances the integration of technology in achieving inclusive, high-quality education.

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