

Developing Local Wisdom-Based Augmented Reality Modules for Science and Social Studies Learning in Elementary Schools

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ABSTRACT

This study aims to develop and evaluate a local wisdom-based science learning module integrated with augmented reality (AR) for Grade V elementary school students. The module incorporates elements of Bojonegoro's natural and social environment to enhance contextual learning. The research employed the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) with a sample of 100 students from three elementary schools in Bojonegoro. The development process included analyzing student needs, designing, validating, and revising the module before implementation and evaluation. Validation involved assessments from IT learning method experts, science education experts, and practitioners. Validation results indicated the module was highly suitable for use: 95% were from IT experts, 90% were from science education experts, and 94% were from practitioners. Implementation demonstrated significant improvements in students' science learning outcomes, with an average score increase from 56 to 88. Additionally, the module enhanced student motivation (92%) and participation (96%) during the learning process. The integration of augmented reality in the module effectively addressed limitations in real-world observation, engaging students and diversifying science learning media. The module's emphasis on local wisdom further enriched students' understanding of their cultural and environmental context. The developed AR-based local wisdom science module is an effective and engaging tool for improving learning outcomes and fostering motivation among elementary school students.

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1. INTRODUCTION

The Independent Curriculum emphasizes the integration of science and social studies concepts closely aligned with students' natural and social environments (Yulia et al., 2024). This alignment highlights the need for contextual learning strategies that connect material to students' lived experiences, optimizing engagement and comprehension. Consequently, developing learning modules that incorporate local content has become increasingly important.

Local wisdom-based learning in science and social studies is vital for strengthening students' cultural identity while enhancing their understanding of scientific concepts relevant to their environment (Ayu et al., 2019). By exploring elements of local wisdom—such as social traditions, natural resource management, and cultural practices—students gain insight into the interconnection between science, society, and everyday life (Y. Wang & Wu, 2023). This approach also supports the preservation of cultural heritage and fosters critical thinking and problem-solving skills, particularly in addressing environmental challenges. Integrating local wisdom into learning materials not only broadens students' perspectives but also cultivates values of cultural respect and environmental stewardship. Therefore, the development of modules that leverage augmented reality (AR) to bring local wisdom to life offers a promising solution to enhance student engagement and learning outcomes in elementary education.

Local wisdom-based learning in science and natural sciences integrated with Augmented Reality (AR) technology provides a new dimension to interactive and contextual education (Indarta et al., 2022). This approach allows students to explore local cultural heritage and natural wealth through immersive digital simulations, such as viewing 3D models of local ecosystems, local icons of the region, local wealth in terms of culture and natural resources (Indarta et al., 2022). AR integration makes it easier for students to understand abstract concepts in science and natural sciences, such as energy cycles or ecosystem management, through realistic and fun visualizations (M. Wang et al., 2018). By combining modern technology and local wisdom, learning becomes more relevant and interesting, and it fosters a sense of pride in local culture amidst the development of the times. In addition, the use of AR in local wisdom learning improves 21st-century skills such as digital literacy, creativity, and collaboration. Students not only learn about local cultural values but also develop the ability to utilize technology to solve problems and convey their ideas (Reilly & Dede, 2019). This approach also opens up opportunities to involve local communities in creating AR-based educational content, thereby strengthening the relationship between schools and communities. Thus, science learning integrated with local wisdom and AR technology not only supports students' understanding of science but also builds cultural awareness that is adaptive to the digital era.

One of the essential aspects of the Merdeka Curriculum is the integration of Science (IPA) and Social Studies (IPS) into a single subject, Science and Social Studies (IPAS) (Iskandar et al., 2023). The purpose of this integration is to manage the natural and social environments as a unified whole (SRR et al., n.d.). The concepts presented in this subject are closely related to the students' lives within their natural and social environments. Therefore, presenting material through contextual strategies is considered more optimal. This phenomenon underscores the importance of developing learning based on local content (Rachmadyanti, 2017). In addition, classroom learning can be developed by focusing on the strengths and uniqueness of a particular region (Ramdani, 2018).

One of the regions that has a unique character is the Bojonegoro region. The physical (natural) environment as well as the social and cultural environment of the Bojonegoro community can be explored and developed to support learning in schools, enabling students to appreciate and preserve the local wisdom of their surrounding area (Ni'mah, 2018). However, several studies mention that students' knowledge and interest in culture are low (S Sutrisno & Rofi'ah, 2023). Based on the results of observations and initial studies, the factor influencing the low level of students' knowledge of local wisdom in the Bojonegoro region is the suboptimal implementation of education. More than 80% of students tend to prefer foreign cultures over their own (Narimo et al., 2019). The suboptimal state of education is demonstrated by the lack of innovation by teachers in the learning process (Yulia et al., 2022). Based on an initial study of the textbooks available to Bojonegoro students on cultural diversity, the focus was on the Minang tribe, a group living far from the students' environment (Sutrisno Sutrisno et al., 2020). In fact, appropriate learning for elementary-level students should begin with the immediate environment of the learners (Sutrisno Sutrisno et al., 2024). In this context, the local culture of Bojonegoro should be the material focus.

Schools must consider all aspects that can engage students' interest in learning about their local culture (Ardiansyah & Yulia, 2022). The teaching materials typically available at schools include

textbooks, modules, and worksheets (Amalia et al., 2022), focusing on physical, social, and cultural environments (Pornpimon et al., 2014). However, the content is dominated by national-level physical and cultural wealth, rather than the students' local environment. This is a major factor in students' limited knowledge, particularly regarding the local wisdom of Bojonegoro.

Therefore, research is needed to discuss the process and outcomes of developing local wisdom modules based on augmented reality in elementary schools, to describe the validity and effectiveness of these learning modules. Furthermore, this research is important for introducing local wisdom education that aligns with technological advancements. As a result, students can develop a stronger connection to and love for their own cultural identity.

To address this problem, a solution to improve students' knowledge and skills regarding local cultural wisdom in Bojonegoro is to develop a module that reflects the unique wisdom and characteristics of the region. This module should also be enhanced with realistic visualizations so students can engage more closely with the material (Akçayır & Akçayır, 2017). The module will include Augmented Reality tools that allow 2D images to appear realistic and match their actual conditions (Ichsan, 2023).

The development of teaching materials based on local culture has been previously conducted, producing books that support thematic learning (Wijiningsih et al., 2017). However, these books support the 2013 curriculum, not the *Merdeka* curriculum (Lawe, 2019). Other teaching material developments have aimed to enhance nationalism by using historical stories from Bojonegoro (Suttriso Suttriso et al., 2024). Additionally, other studies have focused on local wisdom by highlighting batik arts, though based on student worksheets (Irawan et al., 2022). These studies aim to create meaningful learning by integrating education with everyday life and introducing local culture.

However, there is a significant difference between this research and previous studies. This study focuses on developing a learning module tailored to the *Merdeka* curriculum for Grade 4 with the theme *My Regional Culture*. Furthermore, the module to be developed includes digital tools such as Augmented Reality, providing a realistic learning experience related to the unique natural, social, and cultural wealth of Bojonegoro. Therefore, this research aims to develop an Augmented Reality-based local wisdom learning module for Science and Social Studies in elementary schools.

2. METHODS

The development of the Augmented Reality-based Local Wisdom Module for Science and Social Studies (IPAS) in Elementary Schools is also expected to allow students to experience firsthand the richness of nature and socio-cultural aspects presented in the Grade 4 material. This development is conducted by considering the needs of students and the available school facilities. The development follows the Research and Development method with the ADDIE Model.

In product development, maintaining the quality of the product remains the primary objective. This quality is ensured through expert validation activities. After the product is developed, an analysis of student responses and capabilities is carried out. Previous development of teaching materials based on local culture has resulted in a book that can support thematic learning (Sugiyono, 2017). However, this book supports learning in the 2013 curriculum, not the *Merdeka* curriculum (Suryaman, 2020). Other teaching material developments have aimed to foster nationalism by incorporating historical stories from Bojonegoro (Romadhan & Suttriso, 2021). Additionally, other developments have focused on the value of local wisdom by highlighting batik arts, but in the form of student worksheets (Nofiana & Julianto, 2018). These studies aim to create meaningful learning experiences by integrating education with everyday life and introducing local culture.

However, there are significant differences between this research and previous studies. The focus of this research is on developing a learning module adapted to the *Merdeka* curriculum for Grade 4 with the theme *My Regional Culture*. Moreover, the module developed by the researcher will be equipped with digital tools, namely Augmented Reality, which can provide a realistic impression of the learning process related to the uniqueness and wealth of nature, as well as the socio-cultural aspects of Bojonegoro.

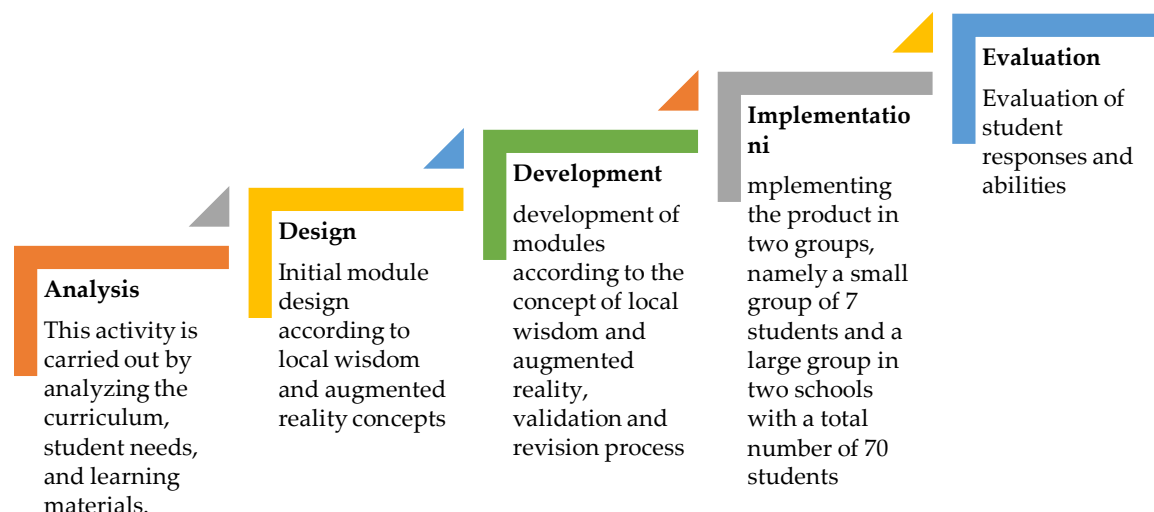


Figure 1. Stages of Development Media

2.1 Analysis

This analysis stage was conducted during the initial observations in the pre-research phase. The activities included analyzing the curriculum, students' needs, and the learning material. This analysis was carried out by analyzing findings based on the results of interviews, observations and documentation. The key points analyzed in this phase are as follows:

1. Curriculum Analysis

This analysis includes assessing the competencies in Science and Social Studies (IPAS) learning and local wisdom that can be integrated. The main focus in this needs analysis is the learning objectives of Grade 5 IPAS.

2. Student Needs Analysis

Besides analyzing the learning objectives in the IPAS material, the researcher also conducted an analysis of student needs. The result of this analysis was determining the appropriate learning technology, particularly for students in phase C. The researcher also considered various aspects of student development, such as language, physical, and cognitive development, to ensure that the model meets students' needs.

3. Material Analysis

In this phase, the researcher identified the theme for the module development, focusing on the topic *Harmony of My Living Environment*. The next step was to analyze and adapt the topic to be presented with a digital approach, specifically Augmented Reality (AR).

2.2 Design

The next stage involves designing the development process during the research. This phase includes designing an AR-based module, with the following steps:

1. Formulating Learning Objectives

The first step was designing by establishing the learning objectives. These objectives then serve as a reference for selecting content, determining relevant social phenomena topics, and formulating assessment tools like test questions.

2. Creating a Product Outline

This involves creating the outline design for the Augmented Reality-based Local Wisdom Module in Science and Social Studies for elementary schools.

2.3 Development

The third stage is developing the Augmented Reality-based Local Wisdom Module for Science and Social Studies in elementary schools. This development includes:

1. Developing the content for the IPAS material on *My Living Environment*.
2. After the material is structured, the next step is integrating local wisdom learning into the content.
3. Developing AR components to support the module.
4. Designing the module's appearance to suit students' characteristics.
5. Validating the module with three experts: a learning media expert, a learning technology expert, and a teaching practitioner.
6. Revising the product based on feedback and suggestions from the experts.

2.4 Implementation

The implementation phase involves applying the product to two groups: a small group of 7 students and a large group in two schools with a total of 100 students. At the implementation stage, the researcher will apply the revised module and declare it feasible. The data sought at this stage is focused on student participation and response in learning.

2.5 Evaluation

1. Evaluating Student Responses
After implementing the product, the results are analyzed based on student feedback. Student responses were measured through a questionnaire on module interest and the learning process.
2. Effectiveness of the Module on Students' Abilities
The next step is analyzing the module's effectiveness in improving students' abilities. The effectiveness of module use is measured by comparing student abilities before and after learning.
3. Final Product Revision
This includes making final revisions to the product.

3. FINDINGS AND DISCUSSION

3.1 Findings

This research aims to develop an Augmented Reality (AR)-based learning module that integrates local wisdom into the Science and Social Studies (IPAS) subject for elementary schools. The study uses a Research and Development (R&D) method with the ADDIE model approach (Analysis, Design, Development, Implementation, Evaluation). The stages in the ADDIE model include needs analysis, module design, prototype development, field implementation, and evaluation of the effectiveness of the learning media.

In the analysis stage, it was found that elementary school students tend to be less interested in local wisdom content because it is delivered in a conventional manner. Therefore, an AR-based module was developed to present local wisdom content in a more interactive and engaging way. This module is designed to visualize local culture, such as traditional dances, customary ceremonies, and folklore, using AR technology that allows students to interact with cultural objects directly through digital devices.

At this stage, the researcher conducted an initial analysis to prepare for development. This analysis covered curriculum analysis, material analysis, and student analysis. The results of these needs analyses have been reviewed and integrated with field findings. The detailed results of the analysis in the ADDIE stage can be seen in Table 1.

Table 1. Initial Needs Analysis

Curriculum	Material	Student
Students understand the natural wealth around them by reading texts and viewing images in textbooks	focusing on the local flora, fauna, and ecosystems near their homes.	However, they tend to lose interest in readings longer than three paragraphs. Additionally, students are generally passive during learning sessions, only becoming active when engaging with topics they are already familiar with.
The images in the textbooks do not effectively support the achievement of learning objectives.	The material in the textbooks has minimal visualization.	Students need learning experiences that enhance their participation and engagement.

Tables processed by researchers, 2024

In the topic of biodiversity, students face difficulties in understanding the concepts of species diversity and ecosystems, particularly in identifying and relating various types of flora and fauna to their habitats. The theoretical nature of the learning materials and the lack of concrete visualization make it challenging for students to grasp the importance of biodiversity in their environment. Additionally, the material is often delivered through conventional approaches that lack interactivity, leading to reduced motivation and engagement in the learning process. Therefore, there is a need for more engaging and interactive learning media, such as Augmented Reality technology, which allows students to interact virtually with objects related to biodiversity (Sutrisno & Yulia, 2023).

The Design phase involved creating the structure and content of the module to align with the learning material and to be appealing to students. The first step was to establish specific learning objectives, namely integrating local wisdom concepts with AR technology to help students better understand and appreciate their local culture. The module was designed to include various elements of local wisdom implemented through interactive AR visualizations. The design process included developing storyboards, concept maps, and detailed lesson scenarios outlining the teaching and learning activities.

The design phase also encompassed the selection of appropriate media, tools, and technology to support the use of AR in learning. AR applications and supporting devices such as tablets or smartphones were chosen to facilitate direct student interaction with digital content. Engaging visual and audio content was prepared to enhance interactive and enjoyable learning experiences. Additionally, the user interface and user experience (UI/UX) of the AR application were considered to ensure accessibility and ease of use for Grade 5 students. All these elements were designed to create a holistic learning experience that motivates students to understand and appreciate their local cultural heritage. The specific activities in the design phase are detailed in Table 2.

Table 2. Design Modules

Material	Content	Learning Scenario	Media
My Living Environment	Characteristic Ecosystems of Bojonegoro	Analysis of Flora and Fauna in the Content	Visualization of Cepu Block and its surroundings, Sosrodilogo River and Bridge, and Hutan Kayangan Forest
Environmental Changes	Water Hyacinth Phenomenon in Bengawan Solo River	Analysis of Issues and their Impact on the Ecosystem	Conversation and Role-playing
Food Web in the Surroundings	Local Flora and Fauna	Creating a Food Web Diagram	Worksheet in Diagram Form

Ecosystem Changes			Crop Failure Phenomenon in Bojonegoro		Problem Analysis and Identification of Root Causes		Worksheet with Group-Based Problem Solving	
Natural Bojonegoro	Potential of		Natural Phenomenon in Bojonegoro	Wealth	Analysis of Bojonegoro's Potential and Improvement of Potential		Visualization of Bojonegoro's Natural Wealth	
Potential Bojonegoro	Problems in		Natural Phenomenon in Bojonegoro	Damage	Analysis of Bojonegoro's Problems		Visualization of the Impacts of Development and Human Actions in Bojonegoro	
Social Bojonegoro	Potential in		Social Phenomenon in Bojonegoro	Celebration	Analysis of Social Celebrations in Bojonegoro		Video of Celebrations in Bojonegoro	Various in

Tables processed by researchers, 2024

The implementation results indicate that the AR-based local wisdom module received a positive response from students. About 90% of students found the media engaging and motivating, which encouraged them to learn more about local culture. They reported that the interactive visualizations and use of AR technology made the learning process more enjoyable and meaningful. Furthermore, the module significantly improved students' understanding of local culture, as evidenced by their enhanced ability to identify and explain various aspects of the local wisdom taught.

The final evaluation demonstrated that the AR-based module is effective for use in IPAS learning at the elementary level. The module not only increased student interest and involvement in the learning process but also strengthened their understanding of material related to local wisdom. The findings suggest that AR technology in education can be further developed, especially in efforts to preserve and introduce local culture to younger generations.

During the Development phase, additional content and learning media were incorporated into the module. AR content was developed by adding virtual objects representing elements of local wisdom, such as 3D images, videos, and animations that visualize the material. To enhance interactivity, each module section included QR codes that students could scan to access AR content through digital devices like tablets or smartphones. The AR content development process utilized specialized applications and software to ensure optimal visual and audio quality, making the content more engaging and easier for students to understand.

Subsequently, the developed module was validated by several experts to ensure its effectiveness and suitability for learning. The first validation was conducted by a content expert who evaluated the accuracy and relevance of the local wisdom presented in the module in relation to the IPAS curriculum. The second validation was carried out by an IT learning expert, who assessed the technical quality of the AR application, including usability, navigation, and performance when projecting AR content. Finally, the module was also validated by educational practitioners, such as elementary school teachers, to gather feedback on the module's alignment with the characteristics and needs of Grade 5 students. Feedback from these experts was used for revisions and improvements, ensuring that the final module is of high quality and ready for use in teaching activities. The suggestions provided by the experts are detailed in Table 3.

Table 3. Development Modules

No.	Expert	Comment	Improvement
1	Material	90% of the material validation results in the module are appropriate for the characteristics of the students. However, the reading needs to be simplified according to the context.	<input type="checkbox"/> Simplify the reading on Bojonegoro's social wealth <input type="checkbox"/> Remove complex compound sentences <input type="checkbox"/> Ensure readings are no more than 3 paragraphs, with each paragraph consisting of 3 simple or compound-simple sentences
2	IT Learning	87% of the media is suitable for AR-based IT learning development, but visibility of the media needs to be ensured.	<input type="checkbox"/> Use barcodes for each visual object <input type="checkbox"/> Focus AR media on occurring phenomena <input type="checkbox"/> Ensure media is easily accessible
3	Practitioner	95% of the module can be used in the learning process and supports the learning process. However, some animations need to be added to the module.	<input type="checkbox"/> Add animations to the module <input type="checkbox"/> Include additional student activities

Tables processed by researchers, 2024

This module was validated by IT learning method experts by 95%, science learning experts by 90%, and practitioners by 94% so that the results were suitable for use. The use of this module has been proven to increase the average science ability from 56 to 88, as well as student motivation and participation by 92% and 96% in the learning process. This module is equipped with Augmented Reality, which makes students interested and curious.

3.2 Discussion

The module that has been validated was tested in two elementary schools (SD) in Bojonegoro. The implementation involved fifth-grade students as participants, who used the module in the Science and Social Studies (IPAS) lessons over several sessions. The teacher provided a brief introduction on how to use the Augmented Reality (AR)-based module and the devices used, such as tablets or smartphones equipped with AR applications. After that, students were asked to scan QR codes on the module to access interactive AR content presenting information about local wisdom, such as traditional dances, ceremonies, and local folklore.

During the implementation process, it was observed that students were very enthusiastic and showed active participation in learning. They quickly adapted to AR technology and directly engaged with the displayed digital content. The use of the AR-based module successfully captured students' attention, making them more motivated and interested in learning. They actively asked questions and discussed the displayed material, as well as showing greater enthusiasm to explore additional information related to local wisdom in their environment. The involved teachers also stated that this method provided a different and more interactive learning experience compared to conventional teaching methods.

The results of this implementation were then evaluated, and a positive change was observed in students' ability to understand IPAS material, particularly related to local cultural diversity. Students appeared more capable of identifying and explaining various aspects of local wisdom, such as types of natural and social wealth in Bojonegoro that are part of local culture. Additionally, the evaluation of students' learning outcomes showed an improved understanding of concepts related to biodiversity and culture, as measured through pre- and post-learning tests. Thus, this implementation phase demonstrated that the AR-based local wisdom module not only increased students' learning interest but also had a significant impact on their academic ability in IPAS subjects.

According to constructivist theory, learning involving active interaction between students and learning materials will enhance understanding and information retention (Nurdyansyah & Fahyuni, 2016). In the context of this research, the use of an AR-based local wisdom module in two elementary schools in Bojonegoro provided students with the opportunity to learn in a more interactive and contextual manner. AR technology allows students to interact directly with digital representations of local cultural objects, facilitating multisensory learning and enriching learning experiences (Saputra et al., 2020).

The discussion of implementation results shows that this module successfully increased students' enthusiasm and participation during the learning process. Theoretically, learning motivation increases when students feel actively engaged and find real relevance between learning material and their daily lives (Khasanah & Rigianti, 2023; Yulia et al., 2023). This aligns with intrinsic motivation theory, which states that students' interest and involvement increase when learning is designed with relevant and engaging elements. In these two schools, students appeared more motivated to learn because they were not only passively receiving information but also actively participating by scanning QR codes and exploring AR-based digital content. This active participation encouraged them to discuss, ask questions, and seek additional information related to local wisdom.

Furthermore, the discussion of implementation results shows a significant change in students' ability to understand IPAS learning material related to local wisdom (Yulia et al., 2024). According to experiential learning theory, when students learn through active exploration and interaction with real or digital objects, they tend to understand concepts better and more thoroughly (Indarta et al., 2022). Evaluation results showed improved student understanding in identifying and explaining aspects of local wisdom after using the AR-based module (Gestiardi et al., 2022). This confirms that the use of AR technology in learning not only motivates students but also effectively enhances learning outcomes, especially in educational contexts that require a deep understanding of local culture. This implementation demonstrates that integrating digital technology with local content can be a powerful strategy for enriching the teaching and learning process in elementary schools.

Elementary school students are at the concrete operational stage, where they more easily understand concepts through direct experiences and visual media. According to Mayer, learning is more effective when information is delivered through a combination of images, text, and audio (Putri & Muhtadi, 2018). Therefore, this module development was designed by combining strong visual elements, such as animations, 3D images, and AR videos, allowing students to interact directly with learning objects (Wati & Kamila, 2019). This interactive visualization not only makes the material more engaging but also helps students build a more concrete and in-depth understanding of local wisdom, which is the focus of the learning (Rukayah et al, 2021).

Furthermore, the theory of active learning emphasizes the importance of students' role as active participants in the learning process (Narut & Supradi, 2019). By integrating AR technology into the learning module, students are not just passively receiving information but are also engaged in exploration and direct interaction with digital content. Through the use of QR codes and AR devices, students are encouraged to scan, observe, and interact with elements of local wisdom presented in visually appealing formats (Nuralita & Reffiane, 2020). This approach aligns with the active learning principle, which states that students' direct involvement in the learning process enhances their motivation, interest, and understanding of the material. Thus, this module is designed to facilitate student activity, increase their engagement in learning, and strengthen the learning experience in a fun and meaningful way.

Further discussion shows that combining visual elements and emphasizing student activity in this learning module can enhance teaching effectiveness in Grade 5 classrooms. The use of visual elements such as images and animations can facilitate information processing in students' brains by utilizing dual cognitive channels: verbal and visual (Howard et al., 2022). In the context of this module, interactive AR visualizations that display local wisdom not only enrich the content but also stimulate students to think critically, observe, and build knowledge independently (Garzón, 2021). Thus, the

development of this AR-based module not only meets the characteristics of elementary school students but also optimizes their potential through a more innovative and effective learning approach.

4. CONCLUSION

The development of local wisdom-based modules utilizing augmented reality (AR) in science learning for elementary schools has proven to be an engaging and effective educational tool. This study demonstrated that AR technology enhances interactivity, making learning more captivating and contextual. Validation results from IT learning method experts (95%), science learning experts (90%), and practitioners (94%) confirmed the module's suitability for use. The module significantly improved students' average science scores, from 56 to 88, while boosting their motivation (92%) and participation (96%) in the learning process. Students found the AR-enhanced module enjoyable and acknowledged its ability to deliver a novel, engaging experience compared to traditional methods. Moreover, it effectively deepened their understanding of local culture, fostering appreciation and awareness of cultural heritage.

Despite its positive outcomes, the research faced limitations, including a narrow focus on a specific geographic and cultural context, which may restrict the generalizability of findings. Additionally, the study did not explore long-term impacts on learning retention or cultural attitudes. Future research should address these limitations by expanding the module's application across diverse regions and investigating its long-term educational effects. Further studies could also explore integrating AR technology into other subjects to broaden its impact on holistic learning. This research underscores the potential of AR as a transformative tool for education, particularly in preserving and promoting local cultural heritage while enhancing the learning experience.

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