



Development of Science and Social Studies Module Integrating Augmented Reality to Improve Elementary School Student Literacy and Numeracy Skills

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Abstract: Indonesia faces ongoing challenges in literacy and numeracy skills, as highlighted by low PISA scores. This research aims to develop an innovative learning module that integrates Natural and Social Sciences (IPAS) with augmented reality (AR) technology for primary school students. Utilizing a Research and Development (R&D) methodology, this study followed the 4D model. In the Define stage, a needs analysis through literature review and field study identified gaps in current IPAS learning and limited technology integration. The Design and Development stages focused on creating an IPAS module incorporating AR, validated by experts in science, social studies, and technology, which demonstrated its validity. During the dissemination stage, the module was tested for compatibility on various Android devices and was 100% successful in both installation and uninstallation. In addition, a feasibility test was conducted using a User Experience Questionnaire (UEQ) with 24 students, showing very positive results, with scores of Attractiveness (2.63), Clarity (2.13), Efficiency (2.38), Accuracy (2.25), Stimulation (2.38), and Novelty (2.56). All scores were above the positive threshold (>0.8). These findings show that the integration of AR in the IPAS module not only increases student engagement but also supports literacy, numeracy, and independent learning.

Keywords: Augmented Reality; IPAS module; Literacy and numeracy

Introduction

Indonesia still faces several complex issues related to literacy and numeracy skills. Research by the OECD through PISA shows that Indonesia ranks as one of the countries with the lowest literacy and numeracy levels (OECD, 2019). This condition is also evident in Natural and Social Sciences (IPAS) learning in primary schools, where many students have difficulty understanding concepts, interpreting data, and relating knowledge to everyday life. Among all reasons for such low attainment is that few mainstream sources of learning for schools exist, particularly mainstream learning modules, which remain uninteresting in character to date. Modules most likely just present plain text and

pictures, without facilitating in-depth literacy and numeracy activities

To overcome these problems, it is necessary to develop IPAS modules that are specifically designed to foster students' literacy and numeracy skills. These modules not only serve as material guides, but also include activities such as reading, writing, calculating, and reasoning with data that are contextualised to students' daily lives. Thus, the modules can be a strategic tool for improving the quality of science understanding while honing students' basic skills. Several previous studies have also shown that the development of literacy- and numeracy-based modules has a positive impact on learning outcomes. The use of science literacy-based modules has been proven effective in improving students' analytical and scientific process skills (Aris et

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al., 2024; Yosa et al., 2025). Meanwhile, numeracy-based modules, both through the development of e-modules supported by edugames and numeracy modules based on local culture, have also been proven to be valid, practical, and effective in improving numeracy skills while fostering an appreciation of local wisdom (Meira Sagita & Petra Kristi Mulyani, 2023; Muliana et al., 2023). These findings reinforce the urgency of developing IPAS modules that integrate literacy and numeracy in an integrated manner, so that they can contribute more comprehensively to improving the quality of science learning in primary schools.

In addition to the integration of literacy and numeracy, the modules also need to be enriched with digital technology. Augmented Reality (AR) is one innovation that can provide an interactive, engaging, and multimodal learning experience. Through AR, students can observe IPAS phenomena directly through digital devices, for example, seeing the movement of planets, the structure of the earth, or changes in the form of objects. Although research on the integration of Augmented Reality (AR) in learning already exists, its application in learning modules specifically designed with a literacy and numeracy framework is still very rare. Most previous studies have only focused on the development of AR-based modules in general without emphasising the integration of literacy and numeracy skills (Aththibby et al., 2024; Bakri et al., 2021). Similarly, in countries such as Turkey, China, and Mexico, AR technology has been applied in education, but it is still limited to learning media (Chang & Hwang, 2018; Fidan & Tuncel, 2019; Ibáñez et al., 2020). In fact, modules that are the main source of learning for students can be further optimised by incorporating AR as a technology-based modality and as a means to strengthen students' literacy and numeracy skills.

There are several reasons why integrating AR into learning modules is essential. First, it enhances multimodality in representing concepts (Wu et al., 2013). By incorporating AR, students can directly access interactive phenomena from the learning module using technology. For example, students can observe the movement of planets in the solar system when AR is provided in the learning module. Second, integrating AR into learning modules makes them more appealing to students due to the dynamic visualizations. This, in turn, can encourage literacy and numeracy activities through the narrative arguments presented. Third, AR offers a unique experience by immersing students in an environment that blends the real and virtual worlds (Arvanitis et al., 2009).

The aim of this project is to develop an IPAS learning module for elementary school students that integrates Augmented Reality (AR) technology and is designed based on a literacy and numeracy framework.

Beyond serving as an interactive learning tool, the module is expected to enhance students' reading and numeracy skills while fostering independent learning, especially in the aftermath of the COVID-19 pandemic. The research questions in this study are: What is the validity of the IPAS learning module designed with a literacy and numeracy framework and integrated with AR technology? and What are students' perceptions of using the IPAS learning module based on literacy, numeracy, and AR integration?

Method

Research design and method should be clearly defined the research method used in this research is Research and Development (R&D) (Branch, 2009). The research design chosen was the Define, Design, Development, and Disseminate (4D) research design, which was developed by (Thiagarajan, 1974). The first stage of this research is the define stage, which includes needs analysis through interviews with teachers and a literature review on IPAS learning and the application of augmented reality technology. Data from the interviews were analysed using thematic analysis (Gumilar & Ismail, 2023), while the literature study was conducted through a systematic review to map trends and findings from previous relevant studies. The second stage is the Design stage, which includes the preparation of an augmented reality-integrated IPAS module design based on the results of the needs analysis, including material structure, AR integration, and learning support instruments. The next stage is the Develop stage, which is carried out through expert validation (expert judgment) involving three experts, namely information technology experts, science experts, and social studies experts. Validation was carried out using the Content Validity Index (CVI) instrument (Shrotryia & Dhanda, 2019) to assess the aspects of content suitability, clarity, and relevance of the module and AR media. The final stage is the Disseminate stage, which includes two activities: (1) testing device compatibility on five smartphones with different Android operating systems (Android 10, 11, 12, 13, and 14), and (2) a limited trial involving 24 primary school students using the User Experience Questionnaire (UEQ) instrument, which assessed six aspects, namely attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty (Bangor et al., 2008; Hinderks et al., 2019).

Sample

The research sample was determined using purposive sampling (Barratt & Lenton, 2015). The sample in this study consisted of 24 fifth-grade students from MI Insan Cendekia Garut. In addition, three

Based on the define stage, both through literature studies and field studies, it can be concluded that IPAS is a new type of learning, and teachers in the field are struggling to implement it ideally. This is because there are still few references regarding IPAS learning, and no research has linked IPAS learning, specifically with Augmented reality. Therefore, further development is needed regarding IPAS learning integrated with augmented reality.

Design and development Stage

Design and development IPAS Module At this stage, the initial design for IPAS module integrated with literacy and numeracy at the elementary school level is carried out, as shown in Table 2.

In addition to designing IPAS module integrated with literacy and numeracy, this stage also includes the design of learning outcome instruments. The instruments used in this research consist of two questions.

Table 2. Initial Design of IPAS Module Integrated with Literacy and Numeracy

Stages	Sub-Stages
Literacy	Morning Message
	Let's Read (integrating AR)
	Let's Write
	New Words
	Let's Practice
	Reading Journal
Numeracy	Reflection
	Reading (integrating AR)
	Let's Compare
	Let's Observe
	Let's Try
	Let's Practice
	Reflection

Development IPAS module

At this stage, the IPAS module design integrated with literacy and numeracy, which has been developed, is validated by three experts, namely experts in IPA (Science) and IPS (Social Studies). The results of the expert validation are shown in Table 3.

Table 3. Expert Validation of the Initial Design of IPAS module Integrated with Literacy and Numeracy

Stages	Sub-Stages	Judgment result			Total	Score
		expert 1	Expert 2	Expert 3		
Literacy	Morning Message	√	√	√	3	1
	Let's Read	√	√	√	3	1
	Let's Write	√	√	√	3	1
	New Words	√	√	√	3	1
	Let's Practice	√	√	√	3	1
	Reading Journal	√			1	0.33
Numeracy	Reflection	√	√	√	3	1
	Reading	√	√	√	3	1
	Let's Compare	√	√	√	3	1
	Let's Observe	√	√	√	3	1
	Let's Try	√	√	√	3	1
	Let's Practice	√	√	√	3	1
	Reflection	√	√	√	3	1

Table 4. Final Design of IPAS Learning Integrated with Literacy and Numeracy

Stages	Sub-Stages
Literacy	Morning Message
	Let's Read (integrating AR)
	Let's Write
Numeracy	Let's Practice
	Reading (integrating AR)
	Let's Compare
	Let's Observe
	Let's Try
	Let's Practice
	Reflection

From the Table 3, it can be seen that there have been revisions to the design of IPAS module integrated with literacy and numeracy. The "Reading Journal" step was removed because two experts disagreed with this stage. Additionally, the "Let's Write" and "New Words" stages were combined into one stage, and the "Reflection" stage was merged. As a result, the final design of IPAS module integrated with literacy and numeracy is shown in Table 4.

Design and development augmented reality application

The IPAS-AR Module in this study is developed with the integration of AR technology. The purpose of

this integration is to combine the real world with the virtual world in the form of video. The integration of AR in the practical model is applied during the measurement stage using a markerless marker in the

IPAS module. The design process for the integrated AR technology begins with creating a storyboard and the user interface (UI) of the application, as shown in Table 5.

Table 5. Storyboard and User Interface (UI) of the Application

Feature	Story board	User interface	Information
Loading Screen			The AR application's splash/loading screen appears before entering the main menu.
Main Menu			The main menu contains several menu buttons: Augmented Reality Menu: To enter the AR camera view. Instructions Menu: To view the application's user guide. Profile Menu: For viewing the profile information. Exit Button: To close the application if the user wants to exit.
Menu Augmented Reality			This menu contains a button to start the video. It also includes a Back button to return to the main menu.
Menu Kamera AR			This menu displays the phone's camera view, with 3 buttons: Play Button: To start the video. Pause Button: To pause the video. Stop Button: To stop the video. Back Button: To return to the main menu
Video			This screen shows the animated video being displayed in the AR view.
Menu Petunjuk Penggunaan			This menu provides information on how to use the application, with step-by-step instructions. It also includes a Back button to return to the main menu.
Menu Profil			This menu displays information about the developer of the IPAS-AR module.

Implementation Stage

In this stage, the implementation is carried out in two ways: testing the developed application on various devices and conducting usability tests with the users or application participants.

Testing on Various Devices

For the testing on various devices, portability is evaluated based on aspects such as adaptability and installability (Supriyono, 2019). The adaptability and installability are tested by installing, running, and uninstalling the application on different devices and OS versions. The results of the testing on 5 different devices and Android OS versions are shown in Table 6.

Table 6. Results of Application Testing on Various Devices and OS Versions

Device	Android version	Install	Uninstall
Vivo Y17S	14	Successful	Successful
Vivo Y22	13	Successful	Successful
Vivo Y21	12	Successful	Successful
Redmi 9 T	11	Successful	Successful
Redmi Note 9	10	Successful	Successful

Based on Table 6, it can be concluded that the MODUL IPAS-AR application was successfully installed and uninstalled on the sample of 5 different devices. This indicates that the application meets the standards for adaptability and installability with a 100% success rate, or is valid.

Usability Testing

The usability test is conducted to assess user feedback on the software's ability to be understood, learned, used, and attractive to users. This testing used the UEQ questionnaire, consisting of 26 questions, and was distributed to 24 students. The data obtained from the dissemination are shown in Table 7. Based on the user feedback, it was found that all aspects scored above 0.8, meaning that the application received positive evaluations from both teachers and students. Among the six aspects assessed, the Attractiveness aspect received the highest score (2.625) according to the students. One of the aspects rated in the stimulus was that the application is interesting to use. This aligns with previous studies, which stated that when AR technology is applied in learning, it can increase students' interest and motivation (Hanafi et al., 2021; Roumba & Nicolaidou, 2022). On the other hand, the Clarity aspect received the lowest score (2.125), but the lowest score is still well above 0.8. This means that overall, the developed application received a positive evaluation and is deemed suitable for further use and implementation.

Table 7. UEQ Analysis

Aspects	Score
Attractiveness Aspect	2.63
Clarity Aspect	2.13
Efficiency Aspect	2.38
Accuracy Aspect	2.25
Stimulation Aspect	2.38
Novelty Aspect	2.56

Discussion

The results of the study indicate that the developed IPAS-AR module has met the validity criteria based on expert assessment. This is in line with previous studies that emphasize the importance of expert validation in ensuring the quality of content, construct, and suitability of learning media before being tested extensively (Beck, 2020; Firman et al., 2024). The design revision process based on expert input is also in line with the instructional development model approach, which emphasizes the importance of the validation and revision stages to refine the product for better usability. Testing the application's compatibility on five Android devices also resulted in a 100% success rate in both installation and uninstallation. These results show that the application is adaptive to various device specifications. This fact is consistent with previous studies that emphasise that technical success is a key prerequisite before digital media can be widely implemented (Alzahrani, 2020; Dutta et al., 2022; Gill et al., 2024). From the author's experience during the trial, students were able to access the module without significant technical obstacles, making it a portable and practical medium.

A feasibility test using the UEQ involving 24 students produced very positive responses. High scores in the aspects of Attractiveness (2.63), Novelty (2.56), and Stimulation (2.38) indicate that students felt engaged and enjoyed the learning experience with AR. This is in line with other studies that show the effectiveness of UEQ as an instrument for evaluating user experience in a learning context (Saleh et al., 2022; Sugianto & Suyoto, 2023). Furthermore, these results are also consistent with findings that AR is capable of creating interactive and enjoyable learning experiences (Heydemans & Elmunsyah, 2024; Ibáñez & Delgado-Kloos, 2018; Singh & Ahmad, 2024; Zuo et al., 2025). Although the Clarity aspect received the lowest score (2.13), the value was still positive. This condition is also reflected in the literature, which emphasises that the clarity of instructions and application navigation are often challenges in AR implementation. The latest guidelines on the use and interpretation of the UEQ even confirm that this instrument is still highly relevant in educational research (Kollmorgen et al., 2025).

Thus, these findings reinforce the evidence that integrating AR into learning modules not only enhances the appeal of the media but also strengthens student engagement and is positively received in primary schools. However, the limitations of this study are clear, namely that the new measurements cover validity, compatibility, and student perceptions. Therefore, conclusions about improvements in student literacy and numeracy cannot yet be drawn directly. Further studies are needed to assess the effectiveness of the module in improving these skills. In line with this, previous research has also emphasized the importance of evaluating the long-term impact of AR and the need for valid analysis as an initial stage in media development (Govindasamy et al., 2024).

Conclusion

The development of the IPAS-AR module for elementary students has successfully incorporated augmented reality (AR) technology into an interactive learning experience that combines literacy and numeracy content in an integrated Natural and Social Sciences (IPAS) curriculum. Based on the development stages defined by the 4D model (Define, Design, Develop, Disseminate), several important findings and conclusions can be drawn from this study. First, the validity of the IPAS-AR Module Framework: The design and development of the IPAS-AR module have been validated by experts in science, social studies, and technology. The validation results show that the module meets the criteria for content and construct validity, with several design revisions that strengthen the quality and integration of the module. Second, Device Compatibility: The application shows full compatibility across various devices and versions of the Android operating system, with a 100% success rate in installation and uninstallation tests. This indicates that the AR application in the module can be used without significant technical obstacles. Finally, Student Feasibility and Perception Test: A feasibility test using the UEQ questionnaire, which was completed by 24 students, showed very positive perceptions. All aspects evaluated (Attractiveness = 2.63; Clarity = 2.13; Efficiency = 2.38; Accuracy = 2.25; Stimulation = 2.38; Novelty = 2.56) far exceeded the positive threshold (>0.8). This indicates that students found the module attractive, clear, effective, accurate, stimulating, and provided a positive new experience.

In conclusion, the IPAS-AR module developed in this study was declared valid by experts, compatible with various devices, and received very positive responses from students in terms of user experience. However, this study did not directly measure improvements in literacy and numeracy, nor the long-

term impact on learning outcomes. Therefore, further studies are recommended to test the effectiveness of the module in improving student learning outcomes and literacy and numeracy skills.

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Author Contributions

All authors contributed to the writing and revision of the article. the tasks of individual authors. e.g., A Ismail contributed to data collection by conducting research; Isrok'atun contributed to data analysis and interpretation; DD Bahkti contributed to AR product development; all authors have approved the final version.

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Conflicts of Interest

The authors declare no conflict of interest. in the publication of this scientific article.

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