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Virtual Reality Media in IPAS: A Problem-Based Learning Development Study for Grade 5 Students' Critical Thinking

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Abstract: This study aimed to develop Virtual Reality (VR)-based learning media integrated with the Problem-Based Learning (PBL) model for fifth-grade IPAS learning. VR was used to present contextual problems at the problem orientation stage, allowing students to explore phenomena immersively before engaging in inquiry and problem-solving activities. This study employed a Research and Development (R&D) approach using the ADDIE model and involved 56 teachers and students from four elementary schools in Padang Ganting and Atar. Data were collected through expert validation, practicality questionnaires, and effectiveness tests. Validation by three experts resulted in an average score of 91%, consisting of content validity (85%), media validity (97%), and language validity (92%), all categorized as highly valid. Practicality tests yielded teacher scores of 93–94% and student scores of 97%, indicating a highly practical category. Furthermore, the effectiveness analysis produced an average N-Gain score of 0.8 (high category). These findings indicate that integrating immersive VR visualization with the PBL model provides meaningful learning experiences and supports the development of students' critical thinking skills. Therefore, the developed media is feasible, practical, and effective for elementary IPAS learning.

Keywords: IPAS; Learning media development; Practicality; Problem-based learning; Validity; Virtual reality

Introduction

Education, as an investment in the future, will be meaningless unless it is accompanied by continuous improvement, development, and innovation in learning that influences the instillation of character values and the culture of the Indonesian nation (Desyandri et al., 2019). Education today demands the use of technology in the learning process, with the aim of enabling students to thrive in contemporary learning environments, thereby shifting the focus from teacher-centered to student-centered learning (Anita et al., 2022). Efforts to improve the quality of education are carried out through budget increases, problem-solving at various levels, and the implementation of policies, including curriculum updates (Azis & Lubis, 2023).

The curriculum is a crucial element in the implementation of education, serving as a foundational reference, tool, and guide for the learning process (Salsabilla et al., 2023). The curriculum currently in use is the Merdeka Curriculum. The Merdeka Curriculum is a curriculum that instills the concept of "Merdeka Belajar" (independent learning), granting "freedom" to educational practitioners—particularly teachers and school principals—to design, develop, and implement the curriculum based on the potential and needs of students and the school (Rahmadayanti & Hartoyo, 2022). One form of innovation within the Merdeka Curriculum is the emergence of IPAS learning.

IPAS education is a scientific discipline that explores living organisms and their interactions with the environment and the universe (Donna & Julianto, 2023). In short, IPAS education is a combination of natural science (IPA) and social science (IPS) lessons. The integration of IPA and IPS aims, among other things, to encourage children to manage their natural and social environments as a unified whole, a process that requires critical thinking skills.

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Critical thinking is a complex cognitive ability that involves analyzing and evaluating information received, as well as solving problems (Nadhiroh & Anshori, 2023; Ningsih & Rizki, 2021). Critical thinking is a fundamental competency that must be developed starting in elementary school as the foundation for fostering rational, logical, and reflective thinking. Critical thinking is one of the higher-order thinking skills that must be applied in students' thinking processes. Critical thinking falls under the cognitive domains C4, C5, and C6, which are essential components of higher-order thinking skills (Sumargono et al., 2022).

Based on a preliminary study conducted at four elementary schools in Padang Ganting and Atar, the analysis revealed that the use of instructional media is not yet optimal. Preliminary observations showed that most students were unable to independently identify problems or draw evidence-based conclusions during IPAS lessons, indicating low critical thinking skills. The media currently used are not yet effective enough to develop critical thinking skills such as identifying problems, analyzing information, drawing conclusions, and evaluating. This occurs because, first, most teachers still rely on lecture-based methods and simple media such as blackboards or textbooks, resulting in students tending to be passive participants. Second, the use of technology-based media is still limited to PowerPoint presentations and videos from external sources such as YouTube, without independent development by teachers, so it does not sufficiently support students' specific needs. Regarding the choice of VR as a solution, although VR requires more sophisticated hardware, the researchers deliberately developed VR content that teachers can operate independently using affordable smartphone-based headsets already available at the schools, making it a viable and pedagogically purposeful step up from conventional media. Additionally, while some schools in the preliminary study have supporting facilities, the limited ability of teachers to develop and utilize learning media remains a major obstacle to achieving maximum critical thinking skills.

Instructional media refers to the various tools or materials used in the teaching-learning process with the aim of providing assistance or support in the form of conveying information, concepts, or subject matter to students in a more effective and engaging manner (Titin et al., 2023; Yuniarti et al., 2023). Ideally, the use of instructional media in the modern educational era should not only focus on conveying information but also encourage students' active engagement in the learning process through technology- and digital-based innovations as an effort to strengthen digital literacy and critical thinking skills (Hadi & Hermawan, 2024).

Media plays a crucial role in helping students understand material in a more concrete and engaging manner while fostering the development of critical thinking skills. Learning media should be able to simplify abstract concepts, increase learning motivation, and facilitate active interaction between teachers and students, which ultimately contributes to the development of critical thinking skills (Azi & Gündüz, 2020; Zahwa & Syafi'i, 2022). However, the reality on the ground shows that the use of media remains very limited, particularly in the form of innovative technologies.

One potential solution is the use of Virtual Reality technology in education. Virtual Reality is a computer-based technology that allows users to enter an artificial three-dimensional (3D) environment, interact with objects and scenarios within it, and experience a lifelike sensation through specialized devices such as headsets, data gloves, and motion sensors (Pramesti et al., 2022; Tiwari et al., 2022). The use of Virtual Reality in learning can enhance learning motivation, conceptual understanding, and encourage students to think critically when analyzing phenomena they experience virtually (Aini et al., 2023; Kavanagh et al., 2017).

The use of Virtual Reality will be more effective when combined with the PBL model in enhancing critical thinking skills. PBL is a student-centered learning model in which the learning process begins with the presentation of a real-world problem relevant to daily life (Indriani et al., 2022; Faresta et al., 2024; (Khairani & Aloysius, 2023)) The advantage of the Problem-Based Learning model is that it not only focuses on understanding the subject matter but also develops critical thinking, problem-solving, communication, collaboration, and independent learning skills (Putri & Hamimah, 2023). The ultimate goal is to enable students to find solutions to their problems, to approach the discussed problems critically and systematically, and to draw on their understanding to draw conclusions (Amris & Desyandri, 2021).

The novelty of this research lies in the development of VR media specifically designed for IPAS learning in elementary schools in rural areas of West Sumatra, where VR-based learning media of this type has not been previously developed. Unlike prior studies by Yolantia et al. (2021) and Aprilianto et al. (2025), which examined VR and AR in general learning contexts, this study integrates VR directly into each stage of PBL syntax: at the problem orientation stage, VR presents concrete 3D simulations of natural phenomena (e.g., the water cycle and ecosystems) to engage students with authentic problems; at the problem analysis stage, students use VR to investigate and collect virtual evidence; and at the solution presentation stage, VR provides a shared experiential context for discussion and reflection.

Furthermore, this study deliberately developed VR content that teachers themselves can operate and deploy independently, addressing the barrier of limited teacher technological capability identified in the field. Fifth-grade students were selected because this developmental stage (ages 10–11) aligns with the concrete-to-formal operational transition, during which VR's immersive 3D environment provides appropriate cognitive scaffolding for abstract science concepts. Research suggests that brief and well-supervised VR sessions of 10–15 minutes do not pose significant health risks for this age group. Thus, Virtual Reality and PBL are closely linked in developing students' critical thinking skills (Yolantia et al., 2021; Yu & Zin, 2023). When Virtual Reality is used in Problem-Based Learning, students do not merely receive information but are actively engaged in the thinking and decision-making processes. Thus, Virtual Reality-based Problem-Based Learning is theoretically capable of supporting the development of students' critical thinking skills because it combines hands-on learning experiences with a structured problem-solving process (Aprilianto & Rahmawati, 2025; Erita et al., 2024).

Method

The type of research used is research and development (R&D). Research and development (R&D) is a method and set of steps for creating new products or developing and refining existing products to test their effectiveness, thereby ensuring their reliability (Okpatrioka, 2023). The ADDIE model is the model used in this research and development process. The ADDIE model was chosen because it is specific in planning development at each stage and is sufficiently tailored to produce a successful product. (Nadiyah & Faaizah, 2015) state the advantages of the ADDIE model: "it has flexible guidelines that help instructional designers in building effective support tools across five (5) phases: Analysis, Design, Development, Implementation, and Evaluation." The development stages of the ADDIE model are outlined as follows.

First, analysis: analytical activities covering several areas, namely curriculum analysis, media needs analysis, and facilities and infrastructure analysis. This analysis aims to assess the readiness of the learning environment to support the development and implementation of Virtual Reality-based learning media. Second, design: at this stage, the design of Virtual Reality learning media is carried out using the Problem-Based Learning model, along with the design of instructional modules and research instruments. Third, Development: the stage for developing the previously designed learning media. It is then developed based on input from experts (validators). Once the media is deemed valid by the experts, a Focus Group Discussion (FGD) is conducted. The FGD is held to introduce the product and test the initial feasibility of the design prior to the field trial. Finally, a small-scale trial assesses the practicality of the media that has been used.

Fourth, Implementation: In this stage, the developed product is implemented in a real-world classroom setting. This stage begins with preparing the equipment and the learning environment. Once everything is ready, the teacher can use Virtual Reality (VR) learning media in the lesson. Afterward, a post-implementation questionnaire is administered to both teachers and students. Finally, Evaluation: This stage aims to determine the quality of the product. It is conducted to determine both qualitative and quantitative evaluation results. Qualitative results are derived from comments and improvement suggestions provided by experts (validators). Quantitative results, meanwhile, are derived from validation questionnaire scores (media, content/materials, and language) and practicality questionnaire scores from teachers and students.

This study will be conducted at four elementary schools. The research subjects are fifth-grade teachers and students. One of the schools, UPT SDN 03 Padang Ganting, will serve as a small-scale pilot to gather initial feedback on the feasibility, practicality, and suitability of implementing PBL-based Virtual Reality learning media in the early stages. In addition, the other three schools will serve as locations for a large-scale pilot study: UPT SDN 05 Padang Ganting, UPT SDN 06 Padang Ganting, and UPT SDN 07 Atar. The details are as follows.

Table 1. Research Subject

School name	Number of Students	Description
UPT SDN 03 Padang Ganting	12	Small-scale trial
UPT SDN 05 Padang Ganting	17	
UPT SDN 06 Padang Ganting	11	Large-scale trial
UPT SDN 07 Atar	16	

The instrument used in this study is a questionnaire. A questionnaire is a data collection technique that involves distributing a list of questions to respondents so they can provide answers to those questions (Noor, 2010). The questionnaires used consist of a content validity questionnaire and a practicality questionnaire. The validation questionnaire was used to collect data and measure the validity of the developed learning media, specifically regarding content/material, language, and media. Meanwhile, the practicality questionnaire was used to collect data regarding the practicality of the developed learning media from the perspectives of both teachers and students.

The data analysis technique was derived from the validity and practicality data. The data obtained from the validation and practicality assessment of the Virtual Reality learning media were analyzed using a 1–5 Likert scale. The Likert scale is a scale used to measure the perceptions, attitudes, or opinions of an individual or group regarding an event or social phenomenon (Pranatawijaya et al., 2019). Next, the total scores obtained from the validity and practicality questionnaires will be converted into percentage scores using the formula.

$$P\ (\%) = \frac{\sum x}{n} \text{ x } 100\% \quad (1)$$

Description
P = Percentage
$\sum x$ = Total score
n = Ideal score

Table 2. Categories of Validity for Virtual Reality Learning Media

Percentage (%)	Criteria
81-100	Very Valid
61-80	Valid
41-60	Quite Valid
21-40	Less Valid
0-20	Invalid

Table 3. Categories of Practicality for Virtual Reality Learning Media

Percentage (%)	Criteria
81-100	Very Practical
61-80	Practical
41-60	Quite Practical
21-40	Less Practical
0-20	Not Practical

The effectiveness was tested using the N-Gain Score, calculated using the following formula:

$$N\ Gain\ = \frac{(Spost - Spre)}{(Ideal\ score - Spost)} \quad (2)$$

Table 4. N-Gain Category

N-Gain Value	Criteria
G > 0.7	High
0.3 ≤ G ≤ 0.7	Medium
G < 0.3	Low

Result and Discussion

Researchers have developed a clear narrative for elementary school students about Indonesia's geographical features. The virtual reality narrative created by the researchers offers several advantages. In practice, this virtual reality medium has been integrated with the PBL model. It includes a more comprehensive set of features, such as images, narration, and background music, making it more engaging.

Figure 1. User guide page

Figure 2. Narration feature

Once the product has been fully developed, the next step is validation by experts to assess its suitability before implementation. Validation is conducted by three validators: a content validator, a media validator, and a language validator. The product is deemed valid if the experts determine that it is suitable for use based on its content, structure, and presentation (Siahaan et al., 2023).

The material was validated against 12 evaluation criteria covering three main aspects: content and learning objectives, presentation of the material, and the learning process. The validation results yielded a total score of 51 out of an ideal score of 60, resulting in a validity percentage of 85%, which falls into the "highly valid" category. These results indicate that the developed materials meet the standards of suitability in terms of content—including alignment with Learning Outcomes, presentation of the material, and their ability to support the learning process and the development of students' critical thinking skills (Nabila et al., 2025; Ikhsan et al., 2020).

Next, media validation. The evaluation was conducted on 15 assessment items covering four main aspects: appearance, graphics, alignment with the PBL model, and usability and smoothness of the media. The

media validation results showed that 13 out of 15 evaluation items received a perfect score of 5 (Excellent), while 2 items—namely, the appropriateness of the background and the layout of objects supporting learning focus—each received a score of 4 (Good). The total score obtained was 73 out of an ideal score of 75, resulting in a media aspect validity percentage of 97.33%, categorized as highly valid. Finally, language validation. The assessment was conducted on 5 evaluation items covering two main aspects: linguistic aspects and readability. A total score of 23 out of an ideal score of 25 was obtained, resulting in a validity percentage of 92%, categorized as highly valid.

Table 5. Summary of Validation Results

Validation Aspects	Score	Ideal Score	Percentage	Qualifications
Content	51	60	85%	Very valid
Media	73	75	97%	Very valid
Language	23	25	92%	Very valid
Average			91%	Very valid

Based on the summary of validation results from the three validators, an average validity percentage of 91% was obtained. This percentage falls within the 81–100% range, which qualifies as "highly valid" with a determination of "highly suitable" and requiring no revisions (Pranatawijaya et al., 2019). These results indicate that the Virtual Reality learning media using the developed PBL model has met the feasibility standards in terms of content, media, and language, so the product is deemed suitable for implementation in the next phase.

The product, which had been validated by the validators, revised, and tested through focus group discussions (FGD), was then pilot-tested in a school on a small scale. The subjects of the small-scale product trial were 12 fifth-grade students from UPT SDN 03 Padang Ganting. The fifth-grade teacher from that school acted as the instructor who implemented the teaching media and modules directly in front of the students, as will be done during the full implementation phase.

Based on a small-scale pilot study of Virtual Reality learning media using the PBL model to improve students' critical thinking skills in science education in Grade 5 at UPT SDN 03 Padang Ganting, the teacher practicality questionnaire yielded a 94% rating. The evaluation considered aspects of media, time, presentation, and usefulness. Furthermore, the results of the student practicality questionnaire at UPT SDN 03 Padang Ganting yielded a percentage of 97%. Both results refer to the established practicality criteria; these percentages fall within the 81–100% range, which is classified as "very practical".

Next, a large-scale pilot study was conducted at three schools. The teacher practicality score was 92%, and the student practicality score was 98% at UPT SDN 05 Padang Ganting. At UPT SDN 06 Padang Ganting, the teacher practicality score was 94%, and the student practicality score was 97%. Finally, the teacher practicality questionnaire score was 94% and the student practicality score was 95% at UPT SDN 07 Atar. These results align with the established practicality criteria; these percentages fall within the 81–100% range, which qualifies as "highly practical".

Table 6. Summary of the Results of the Large-Scale Practical Trial

School name	Percentage	
	Teacher	Students
UPT SDN 05 Padang Ganting	92%	98%
UPT SDN 06 Padang Ganting	94%	97%
UPT SDN 07 Atar	94%	95%
Average	93%	97%

Practicality is a crucial aspect in assessing the suitability of a learning medium. The practicality of a medium relates to students' enjoyment and ease of use, as determined by student feedback questionnaires regarding the medium (Istyadji et al., 2022). Based on the table above, it is evident that the overall average practicality score for teachers in the large-scale pilot schools was 93%, indicating the "very practical" category. Similarly, the practicality of students in the large-scale pilot schools showed an average score of 97%, indicating the "very practical" category. This confirms that the use of virtual reality learning media employing the PBL model to enhance students' critical thinking skills in fifth-grade IPAS instruction is highly practical and suitable for implementation. Learning media, particularly mobile and online-based platforms, enable students to learn anytime and anywhere. This expands learning opportunities without being constrained by time or location (Budiarto et al., 2025).

The results of the effectiveness analysis using the N-Gain Score test are shown in the following table.

Table 7. N-Gain Score Results

School name	N-Gain Score
UPT SDN 03 Padang Ganting	0.8
UPT SDN 05 Padang Ganting	0.8
UPT SDN 06 Padang Ganting	0.8
UPT SDN 07 Atar	0.8
Average	0.8

Based on the data analysis results, the N-gain Score for the small-scale pilot school was 0.8. Meanwhile, the N-gain Score for the three large-scale pilot schools averaged 0.8. The N-gain Scores obtained fall into the "high" category, interpreted as "effective." This indicates that the use of Virtual Reality-based learning

media employing the PBL model is effective in enhancing students' critical thinking skills. This finding aligns with the statement by Erita et al. (2024) that Virtual Reality has a positive impact on improving motivation, understanding, and the effectiveness of learning activities.

Research findings also indicate that Virtual Reality learning media not only serve as visual aids but are also capable of fostering students' critical thinking skills. Virtual Reality media can provide an immersive (realistic) learning experience, allowing students to observe and understand objects directly. This aligns with constructivist learning theory, which emphasizes that direct and contextual learning experiences can enhance higher-order thinking processes (Mallek et al., 2024; Sakr & Abdullah, 2024).

Furthermore, the effectiveness of Virtual Reality is further enhanced by the PBL model, which has been proven to improve students' thinking skills. Virtual Reality provides a concrete and immersive learning experience, while the PBL model provides a framework for thinking through problem-solving. This aligns with the research by Astra et al. (2024), which found that the integration of technology and the PBL model creates a more meaningful learning environment. This combination encourages students not only to understand concepts but also to apply them in real-world situations (Liu et al., 2024; Mørk et al., 2024).

Conclusion

The development of Virtual Reality (VR)-based learning media integrated with the Problem-Based Learning (PBL) model has demonstrated feasibility, practicality, and effectiveness in supporting fifth-grade students' critical thinking skills in IPAS learning. The findings indicate that the integration of immersive VR visualization with a structured PBL process creates a complementary learning environment in which students are not only exposed to information but are actively engaged in identifying problems, analyzing evidence, discussing solutions, and drawing conclusions from contextual situations. These findings imply that the educational value of VR does not solely lie in its technological sophistication, but in its ability to transform abstract concepts into meaningful learning experiences when integrated with an appropriate pedagogical model. The PBL syntax embedded within VR enables students to construct knowledge through direct exploration and collaborative inquiry, thereby fostering deeper conceptual understanding and more active cognitive engagement. Therefore, VR-based PBL media can serve as an alternative technology-enhanced instructional innovation for elementary IPAS learning, particularly in facilitating the development of higher-order thinking skills. Future studies are recommended to expand the implementation to broader educational contexts, involve larger and more diverse samples, and compare the effectiveness of VR-based PBL media with other digital learning media to further examine its long-term impact on students' critical thinking development.

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Conceptualization, Lailatuz Zahra, Desyandri; Data curation, Lailatuz Zahra; Formal analysis, Lailatuz Zahra; Investigation, Lailatuz Zahra, Desyandri, Ardipal, Yeni Erita; Writing–original draft, Lailatuz Zahra; Writing–review & editing, Lailatuz Zahra, Desyandri, Ardipal, Yeni Erita.

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The authors declare no conflict of interest.

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