

Research Study on the Development of PJBL Teaching Modules Integrated with Augmented Reality to Increase Activity and Learning Outcomes of Grade V Students

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Abstract: This study examines the development of project-based learning (PJBL) modules integrated with Augmented Reality (AR) technology for solar system material for grade V elementary school students. The main objective of the research is to improve learning activities and student learning outcomes through a more interactive learning experience and real visualization. The methodology used is a systematic literature review (SLR) to collect and evaluate related research from various sources from 2015 to 2025. The results show that the application of AR in learning modules can increase motivation, student engagement, and understanding of abstract astronomy concepts. However, there are challenges related to infrastructure and user training that need to be addressed for optimal implementation. The findings support the development of innovation in basic education through the effective and practical use of AR technology.

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Introduction

Learning in today's digital era faces a number of considerable challenges, especially in an effort to improve the quality of learning outcomes obtained by students. One significant problem in this context is the low level of active participation of students during the learning process. Traditional learning methods, such as lectures that are often used, often do not have an effective impact in improving students' academic performance. This is especially evident in subjects that are classified as Natural and Social Sciences (IPAS) (Siregar and Lubis 2024). The phenomenon of using conventional learning methods has also been highlighted due to the decline in students' activities and learning outcomes that are no longer in accordance with the characteristics of current learning methods. The results of research conducted in Bengkulu found that students' learning activities were very low due to the use of the lecture method (Agustini, 2017). Furthermore, Tarigan's research (2014), expressed the same opinion that the low learning activity of students was due to the teacher still using the conventional lecture method.

Learning, in essence, is designed with the aim that students can undergo an effective learning process. The learning process in question is not only focused on developing cognitive abilities, but also includes the development of affective and psychomotor aspects. In this context, it is very important to maximize learning activities carried out by students. Without activity, the learning process itself cannot take place (Widodo & Widayanti, 2013). This statement implies that every learning activity must involve some form of activity. In addition, it should be noted that one of the factors contributing to improved student learning outcomes is an increase in their learning activities (Nurhidayah, 2015).

Learning activities can be defined as a series of activity processes carried out by students that result in changes in their behavior or skills (Putri et al., 2022). This learning activity is a series of activities designed by the teacher with the aim of helping students in the learning process, which is related to their efforts to find and understand knowledge (Sumianto, 2020). Basically, increasing learning activities is very important for students in order to create an atmosphere of interaction in a dynamic and positive teaching and learning process (Kahar, 2022).

Thus, it can be concluded that learning activities are not only an integral part of the learning process, but also a key factor that influences the effectiveness of student learning outcomes. Therefore, it is important for educators to design and implement learning activities that are varied and interesting, so that students can be actively involved in their learning process. Through such an approach, it is expected that students will not only be able to master knowledge, but also be able to develop the attitudes and skills needed in everyday life.

In this situation, it is important to explore a variety of more innovative and interactive learning approaches and strategies, which can encourage students to be more involved and actively participate in their learning process. By utilizing more modern technology and learning methods, it is expected that the quality of student learning outcomes can be significantly improved. In addition, students' active involvement in learning will not only help them understand the material better, but can also increase their motivation and interest in the lessons taught. For this reason, more serious efforts are needed to design and implement learning methods that can meet the needs and characteristics of students in this digital era.

Facing significant challenges in improving the quality of learning. One approach that is starting to be widely applied is Project-Based Learning (PjBL), which emphasizes project-based learning to increase student involvement. Research conducted by Kahar (2022), revealed that the project-based learning model is able to increase student learning activities, the activities contained in the PjBL implementation procedure have strong potential to increase student learning activities. Project-based learning (PjBL) is a form of student-centered active learning characterized by student autonomy, constructive inquiry, goal setting, collaboration, communication, and reflection in real-world practice. It has been explored in a variety of contexts and in different phases of schooling, from primary education to higher education (Menzies, 2016).

Thomas (2000). in *A Review Of Research On Project Based Learning*, suggests project-based learning is a model that organizes learning around projects. According to the definition contained in the PBL guidebook for teachers, projects are complex tasks, based on challenging questions or problems, which involve students in design, problem solving decision making, or investigative activities; provide students with opportunities to work relatively independently over a long period of time; and culminate in a realistic product or presentation (Jones, Rasmussen, & Moffitt, 1997; Thomas, Mergendoller, & Michaelson, 1999).

PJBL allows students to learn actively through hands-on experience and collaboration in completing projects. By integrating the latest technology such as Augmented Reality (AR), the potential for learning can be significantly enhanced. Research shows that the use of AR in education can increase students' motivation and understanding of the material taught (Yuen et al., 2011). Other research conducted by Waruwu (2023), shows that augmented reality-based chemistry e-modules are one of the relevant learning resources implemented in the digital era, through augmented reality-based chemistry e-modules, the need for digital-based learning content can be accommodated in the learning process.

According to Azuma (1997), AR is a technology that combines virtual objects with the real world, providing a more immersive experience for users. In the field of education, the application of AR can help students understand complex concepts in a more visual and interactive way. One of the materials that students often find difficult is the solar system, which involves understanding planets, orbits, and other astronomical phenomena. Grade V students, who are at an important stage of cognitive development, often have difficulty in understanding abstract concepts such as the solar system. Data from the Ministry of Education and Culture of the Republic of Indonesia shows that the average national exam scores for science subjects at the primary level are still below the expected standard. This suggests challenges in the teaching methods used today. Therefore, innovation is needed in the development of teaching modules that can improve student activity and learning outcomes.

Currently, the teaching module contained in the Merdeka Curriculum is seen as a very important tool and has a crucial role in supporting the smooth implementation of the learning process with a new approach or paradigm. This becomes even more relevant when we consider the transformation that has occurred due to the industrial revolution and the rapid development of digital technology. Thus, this teaching module not only functions as a guide, but also as a means of supporting adaptation and innovation in the evolving world of education. The Merdeka Curriculum, through its teaching modules, provides opportunities for educators to implement learning methods that are more flexible and responsive to the needs of students in the digital era. In this context, it is important for educators to understand and optimally utilize these teaching modules in order to create a more interesting and meaningful learning experience for students.

In addition, with the changes brought by the industrial and digital revolution, this teaching module is also expected to help students develop the skills needed to face future challenges, such as critical thinking, collaboration, and creativity. Therefore, the role of teaching modules in the Merdeka Curriculum is very strategic, because it does not only focus on delivering material, but also on building student character and competencies that are relevant to the demands of the times.

21st century education requires a transformation in the learning process to be more contextual, active, and relevant to technological advances. In the context of science learning at the elementary school level, especially on solar system material, there are still various obstacles that hinder the achievement of optimal learning objectives. This material is abstract and difficult to understand only through verbal explanations or two-dimensional images in textbooks. As a result, students tend to be passive, lack interest, and have difficulty in understanding concepts such as the rotation and revolution of the earth, the position of the planets, and the relationship between celestial bodies.

Project-based learning (PJBL) is one approach that is believed to be able to increase active student involvement and activity. PJBL encourages students to build knowledge

through exploration, problem solving and collaboration. However, this approach is rarely integrated with innovative technology that suits the characteristics of today's learners who are familiar with digital devices.

One technology that has the potential to be integrated in learning is Augmented Reality (AR). AR is able to visualize three-dimensional objects in a real and interactive way, so it can help students understand abstract material better. The integration of AR in the PPA teaching module allows for a more interesting, realistic and meaningful learning experience.

However, until now, PPA teaching modules integrated with AR developed specifically for solar system material in grade V SD are still very limited. This shows a gap between the potential of technology and its application in learning at the primary level. Therefore, it is necessary to develop PPABL teaching modules integrated with AR as an innovative solution to improve student learning activities and outcomes, as well as answering challenges in abstract science learning by exploring research literature related to the development of PPABL teaching modules integrated with augmented reality, which will be developed by researchers.

Research Method

This study uses the Systematic Literature Review (SLR) method, which is used to refer to research and development research that will be carried out by collecting and evaluating research related to this study (Suryani, 2014). This research also aims to identify, review, evaluate and interpret all available research with the topic area of the phenomenon that is the topic of research (Tang, 2019). This research will summarize the findings of articles that have similarities with the keywords in this study, through Google Scholar and articles published in the time span 2010 to 2025. Then, the author notes and reviews in depth, especially regarding the research results presented in the discussion and conclusion sections. At the end of the study, the researcher compared the findings presented in the articles and compiled a conclusion.

Result and Discussion

Author and Year	Research Results	Researcher Analysis
Setyawan, B., & Fatirul, A. N. (2019). Augmented reality in science learning for elementary school students.	The results of development research in the form of AR learning media show very good results and are feasible to use as learning media, both in class and independently according to the results of validation of learning design experts, media experts and teacher validation as material experts Students' response to the use of this media in learning is very good. Students are eager to participate in learning and arouse students' curiosity.	In the context of augmented reality (AR) learning media development research that shows positive results, there are some research gaps that still need to be explored further. Although the validation results from learning design experts, media experts, and teachers show that this media is feasible to use, as well as excellent student responses, there are still some aspects that require more attention in further research. One gap that needs to be researched is the long-term effectiveness of using AR

Author and Year	Research Results	Researcher Analysis
		learning media. Most existing studies may only assess the immediate impact after the use of the media, without considering how students' understanding of the material persists over a longer period of time. More in-depth research can be conducted to evaluate students' retention knowledge after the use of AR media in a longer period.
Vari, Y. (2021). Utilization of augmented reality to train 21st century thinking skills in science learning.	Augmented Reality has benefits as an interactive, direct and real learning media for students can invite students to imagine. Augmented Reality Learning Media is able to increase student interest in learning. Augmented Reality Learning Media in training 21st century thinking skills depends on the learning activities that take place.	Augmented reality (AR) has emerged as a promising tool in education, providing a more immersive and interactive learning experience. Although many studies have been conducted to explore the benefits of AR in education, there are still some gaps that need further research. In this analysis, there is still a lack of research that addresses the impact of AR on various learning styles. Further research is needed to explore how AR can be adapted to different learning styles, such as visual, auditory, and kinesthetic. This will help in designing more inclusive AR learning experiences.
Saputri, F. E., Annisa, M., & Kusnandi, D. (2018). Development of ipa learning media using augmented reality (ar) based on android for grade iii students of SDN 015 tarakan.	Based on the results of the study, it can be concluded that Science Learning Media Using Android-Based Augmented Reality (AR) for Students of SDN 015 Tarakan Class III is very feasible to use as a learning media in schools.	Researchers' analysis shows that the use of AR in science learning focuses on the context of education in developed countries. Research conducted in Indonesia, especially in areas such as Tarakan, is still limited. Most studies do not consider local factors such as culture, technology infrastructure and student characteristics in the area.
As'zaroh, U. M., & Arianti, A. (2024). Improving IPAS	The results of the research obtained in this study are with the application of Augmented Reality-	This research has not specifically linked increased motivation with learning outcomes in IPAS

Author and Year	Research Results	Researcher Analysis
Learning Outcomes through Augmented Reality-Based Pop Up Book Media on the Material of Indonesian Cultural Wealth in Class IV SD.	based Pop Up Book learning media on the material of Indonesia's cultural wealth has increased, namely in cycle 1 to 45% of students who have completed and in cycle 2 experienced an increase in learning completeness to 86% in cycle 2 with details of students who have completed 19 students out of 22 students.	materials. The results of this study also show that pop-up book media increases interest in learning, but does not delve deeper into how this media can facilitate better understanding of the material being taught. Influence on Critical Thinking Skills Previous studies have focused more on improving motivation and cognitive learning outcomes, but none have explored how this media can affect students' critical thinking skills. Critical thinking skills are essential in IPAS learning, and further research is needed to assess the impact of this media on these skills.
Marchelina, S., & YERIMADESI, Y. (2024). Validity and Practicality of Molecular Shape Module Based on Project Based Learning Integrated with Augmented Reality for Phase F High School.	From the results of the study, the average Aikens'V value was 0.897 with a valid category and the practicality value by teachers and students was 90% and 96% with a very practical category. The results showed that the PjBL module integrated with AR for high school phase F was valid and practical.	Many studies using PBL and AR-based modules have not tested the validity of the assessment instruments used to measure student learning outcomes. Further research is needed to develop and test valid and reliable instruments in learning contexts that integrate AR. While some studies show that AR can improve concept understanding, no research has systematically explored the implementation practice of AR modules in a real classroom context. Further research is needed to understand the practical challenges faced by teachers and students when using this module.
Indriani, R., Wahidin, W., & Arif, A. G. (2022). Development of Project Based Learning (PjBL) Model Assisted by Augmented Reality (AR) to Improve	The results showed that for KPS the average pretest score of the experimental class was 49.9 and the average posttest score was 80.5 while in the control class the average pretest score was 48.7 and the average posttest score was 60. For scientific attitudes the average	Researchers' analysis shows the integration of AR in PjBL. shows the benefits of PjBL and AR separately, there are still few studies that integrate the two systematically. Existing research tends to focus on one aspect only, without considering how the two

Author and Year	Research Results	Researcher Analysis
Science Process Skills and Scientific Attitudes of Grade XI Learners on Cell Structure Material.	experimental pretest score was 60, posttest was 86.9 while in the control class the average pretest score was 58.9 posttest was 81. Followed by t test analysis and obtained sig (2-tailed) value of 0.000 <0.05, so it is concluded that the development of PjBL model assisted by AR can improve KPS and scientific attitude of students.	can complement each other to improve student learning outcomes. This study also measured science process skills that assessed student learning outcomes only in terms of cognitive knowledge, without measuring science process skills comprehensively, for this reason, a research instrument is needed that can measure science process skills appropriately in the context of AR-assisted PjBL.

Learning the solar system at the elementary school level often faces challenges due to the abstract nature of the material and is difficult to visualize with conventional media such as textbooks and two-dimensional images. This results in low levels of student participation and a lack of understanding of astronomical concepts, such as planetary positions, orbits, and the phenomena of earth rotation and revolution. To overcome this problem, innovation in learning is needed that is able to visualize concepts interactively and realistically. Augmented Reality (AR) is a technology that can integrate virtual objects with the real world, thus providing a more real and interactive visualization experience. When integrated in the learning process, AR can help students understand abstract material in a more interesting and real way. The Project-Based Learning (PJBL) approach encourages students to actively build knowledge through exploration, collaboration, and solving relevant problems, so that the learning process becomes more meaningful and contextual. This research combines the two approaches to improve the effectiveness of solar system learning.

The development of a Project-Based Learning (PJBL) module integrated with Augmented Reality (AR) shows that technology and innovation in education can significantly improve student learning activities and outcomes. The utilization of AR provides a more real and fun learning experience, which in turn has a positive impact on their motivation and understanding of astronomy material. The findings of this study encourage the need for further development and widespread dissemination of this module, while still paying attention to aspects of training and supporting infrastructure.

Based on the literature review, it can be concluded that the integration of Augmented Reality (AR) technology in project-based learning (PJBL) is an innovation that has great potential in increasing student motivation, activity, and learning outcomes, especially in abstract material such as the solar system at the elementary school level. The research shows that the learning module that integrates AR and PJBL is valid and practical from the expert's point of view as well as getting positive responses from teachers and students. The use of AR is able to present interactive and realistic visualizations, thus helping students to understand complex concepts better and interestingly. However, challenges related to the readiness of technological infrastructure and the need to develop comprehensive and systematic evaluation instruments still need to be addressed. In general, the literature indicates that the development of innovative learning modules based on AR and PJBL is very relevant and has

great potential to improve the quality and effectiveness of learning at the primary level, if supported by adequate facilities and proper teacher training.

The study results also show that the learning module designed based on PJBL and AR has a high level of validity and practicality, which is assessed and supported by experts, teachers, and students. Positive responses from all parties indicate that the success of this module development is not only theoretical, but also applicable and feasible in the context of real learning in the classroom. The use of AR is able to facilitate understanding of complex and abstract concepts that are difficult to explain verbally or through simple visuals, so as to reduce boredom and increase student absorption and retention of the material taught.

However, the literature also reveals the existence of obstacles, such as the limitations of adequate technological infrastructure, the need for training for teachers to be able to operate and integrate AR in the learning process, as well as the need to develop comprehensive evaluation instruments to measure the long-term effectiveness of using this media. This condition demands support from policy makers, including facilities, training, and development of relevant assessment tools.

In conclusion, learning innovation by utilizing AR in the framework of PJBL is a strategic step that can answer the challenges of 21st century education development with learning characteristics oriented towards contextualization, activeness, and collaboration. Optimal implementation requires synergy between technology development, teacher training, and adequate resource allocation. If these aspects can be resolved, then the use of AR in PPA will be an important asset in improving the quality of basic education, opening up opportunities for learning that is more meaningful, enjoyable, and relevant to technological advances and the needs of future society.

Conclusion

The use of Augmented Reality (AR) technology in learning, especially through the Project-Based Learning (PJBL) approach, is a pedagogical innovation that has great potential in improving the quality of student learning processes and outcomes, especially on abstract material such as the solar system. Theoretically and empirically, AR integration provides an interactive learning experience, realistic visualization, and significantly stimulates student activity and motivation. This is in line with constructivist learning theory that emphasizes the importance of active involvement and direct experience in the learning process.

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