JPPIPA 11(2) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Effectiveness of Augmented Reality-Assisted Problem-Based Learning Model on Science Learning Outcomes

Muhamad Azril Gibran[1*], Novi Setyasto[1]

[1]Primary teacher education, FIPP, Universitas Negeri Semarang, Semarang, Indonesia

Received: December 05, 2024
Revised: January 10, 2025
Accepted: February 25, 2025
Published: February 28, 2025

Corresponding Author:
Muhamad Azril Gibran
azrilgibran16@students.unnes.ac.id

DOI: 10.29303/jppipa.v11i2.10319

Abstract: The implementation of learning models that are not in accordance with the provisions of the Minister of Education, Culture, Research and Technology Regulation Number 16 of 2022 concerning Process Standards, as well as not maximizing the integration of technology media into learning, has an impact on low student learning outcomes. This study examines the effectiveness of the Problem-Based Learning model assisted by Augmented Reality compared to the Problem-Based Learning model assisted by images on the learning outcomes of Class V Science at SD Negeri Gugus Budi Utomo. This type of research is experimental research with a Quasi-Experimental Design research design in the form of Non-equivalent Control Group Design. Data analysis techniques included initial data analysis with normality and homogeneity tests and final data analysis with independent sample t-test and N-Gain tests. The hypothetical results of the independent sample t-test obtained a Sig. (2-tailed) value of 0.032 and 0.034 (sig. <0.05), so H0 is rejected and Ha is accepted. This is reinforced by the results of the N-Gain test of the experimental class of 0.430 (moderate) and the control class of -.004 (low). It can be concluded that the Problem-Based Learning model assisted by Augmented Reality is more effective than the Problem-Based Learning model assisted by images on the learning outcomes of Science Class V of SD Negeri Gugus Budi Utomo.

Keywords: Augmented reality; IPAS; Learning Outcomes; Problem-Based Learning Model.

Introduction

In the Regulation of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia No. 16 of 2022 concerning Process Standards, that in implementing the learning process there are three aspects including: learning planning; implementation of learning; and assessment of the learning process. First, learning planning is prepared in the form of a flexible, clear, and simple learning planning document. Second, the implementation of learning is carried out with an interactive, fun and meaningful learning atmosphere, so that it can motivate students to participate actively. Third, the assessment of the learning process is related to the implementation of learning that has been carried out, the provision of assessments is carried out to train students to think critically and learn to reflect on what has been learned. The teacher acts as a role model, companion, and facilitator. Teachers are not only limited to transferring knowledge and the only source of learning, but more towards how teachers are able to manage the classroom atmosphere so that students become active (Nurzannah, 2022).

However, sometimes the real conditions in some schools do not match the expected learning, the implementation of learning carried out in the classroom is not in accordance with the process standards set by the government. Not all teachers carry out learning according to the criteria set out in Permendikbudristek number 16 of 2022 concerning Process Standards.

How to Cite:
Gibran, M. A., & Setyasto, N. (2025). Effectiveness of Augmented Reality-Assisted Problem-Based Learning Model on Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 1093–1102. https://doi.org/10.29303/jppipa.v11i2.10319

Teachers do not pay proper attention to management in planning learning in accordance with the provisions, this results in conceptual errors in providing learning to students. The problem that occurs is the lack of variation and innovation in implementing learning models, the model used still uses the lecture method in delivering material without involving students (Lukum, 2015; Prasojo et al., 2018; Hidayat & Kosasih, 2019). The learning model that has been implemented so far is still centered on the teacher, where students receive and listen more to explanations from the teacher without getting direct learning experience. Of course, This results in a lack of interest among students in understanding a material, making students busy playing and chatting by themselves, which also has an impact on low student learning outcomes. In addition to the learning model, the lack of utilization of facilities and infrastructure, especially in the use of learning media, makes learning less effective, learning that does not match the needs of students certainly makes class activities low and boring (Garlinska et al., 2023; Widiasanti et al., 2023).

From various problems, in SD Negeri Gugus Budi Utomo which includes SD Negeri Kemiri 01, SD Negeri Kemiri 03, and SD Negeri Kemiri 06 researchers also found similar problems. From the results of observations, interviews, documentation, and filling out questionnaires that have been carried out, In the application of learning models, it is still not in accordance with process standards and rarely integrates technology into the learning process. In the learning process, teachers have applied the Problem-Based Learning model, only there are still conceptual errors made by teachers so that the learning implemented is still centered on the teacher. This conceptual error occurs in the planning process in compiling the module, where the teacher does not pay proper attention to the syntax in the Problem-Based Learning model that is in accordance with the provisions of the process standards. In addition, they have not maximized the use of facilities and infrastructure available at the school because they are only used when -only at certain times.

Most of the learning resources used during learning are only textbooks and student worksheets. In fact, every school already has an LCD, speakers, internet network, and some already have Chromebooks. From the results of filling out the questionnaire, 90% of students already have their own smartphones, with 33% of students use it for learning, 36% of students use it for YouTube and social media, 41% of students use it for playing games. It can be seen that 77% of students have not used their smartphones properly for learning, so that the use of smartphones is not appropriate can have an impact on the learning outcomes of students at SD Negeri Gugus Budi Utomo. Based on this statement, the application of learning models that are less in accordance with process standards and are not accompanied by the use of technology-assisted media can affect students' ability to understand complex and abstract material, so that it influences students' learning outcomes.

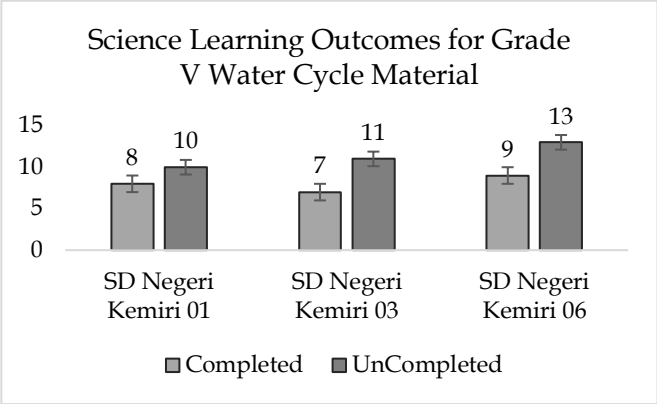

Figure 1. Science Learning Outcomes of Elementary School Students of Gugus Budi Utomo

Based on observations of the cognitive learning outcomes of the science subjects in the Budi Utomo Cluster, it can be seen that the learning outcomes of the science subjects on the Water Cycle material have not achieved maximum results. In SD Negeri Kemiri 01 with 18 students, only 8 students out of 18 (44%) students achieved the KKTP score. SD Negeri Kemiri 03 with 18 students, only 7 out of 18 (39%) have achieved the KKTP. In SD Negeri Kemiri 06 with 22 students, only 9 out of 22 (41%) have achieved the KKTP. Thus, it can be said that the use of learning models that are not in accordance with process standards can affect student learning outcomes in class. From the problems in science learning in Class V of SD Negeri Gugus Budi Utomo, the learning process should be carried out in accordance with the provisions of the process standards, where in the learning process it applies real problem-based material as a context to encourage students to develop critical, creative, and collaborative thinking skills.

The Problem-Based Learning Model is a learning model that begins with a real problem, by solving the problem students can later obtain and build certain knowledge while developing critical thinking skills and problem-solving skills (Sofiani et al., 2024; Fitriyanti et al., 2020). The Problem-Based Learning Model has five syntaxes that better organize students to learn independently, the teacher's task is only to facilitate and guide students (Ngatman et al., 2025). The application of the model begins with problem orientation using media, organizing students in groups, guiding and directing students in conducting investigations, developing and presenting discussion results, and ending with analyzing and evaluating with media. This Problem-

Based Learning Model is in line with the needs of students because it makes students more active and interested during learning, this model is able to place students as the center of learning and allows students to develop the desired learning knowledge (Husna et al., 2024; Sajidan et al., 2022). This is also in line with the results of previous studies which stated that the application of the Problem-Based Learning model can increase student learning activities so that student learning outcomes can increase significantly (Muhayati et al., 2023).

In addition to the application of learning models that are in accordance with the Process Standards, the use of technology media can help teachers create an interesting classroom atmosphere, so that they can increase the involvement of process skills and student learning outcomes (Haleem et al., 2022; Hutahaean et al., 2022). In order for learning to be more optimal, researchers will use Augmented Reality as a learning medium (Amelia & Isdaryanti, 2024). Augmented Reality is a technology that integrates two or three-dimensional virtual objects into the real environment in real time, creating an interactive experience in three-dimensional space (Huang et al., 2022; Aditya & Trisno, 2018). According to Piaget's cognitive development theory, the cognitive development of elementary school students is at the concrete operational stage, where children acquire mental talents that enable them to think logically about concrete events. With this Augmented Reality media, it can help students understand the concept of science material which is still abstract.

Most of the material that is still given tends to use image sources only, making it difficult for students to visualize the concept of the material they are studying (Darling-Hammond et al., 2020). The novelty in this study is the application of the Problem-Based Learning model assisted by Augmented Reality, especially in the subject of Science, water cycle material for grade V of elementary school. Although the Problem-Based Learning model has been widely applied in elementary schools, its application is still lacking and limited to complex Science material (Syahlan et al., 2023; Markula & Aksela, 2022). The application of this Problem-Based Learning model offers an approach based on real problems and student-centered learning, while in most previous studies the application of learning models still tends to use lecture methods and is teacher-centered. In practice, researchers combine the Problem-Based Learning model with Augmented Reality media, the use of technology media in learning is expected to be able to increase active participation of students and help students understand complex Science material.

The Problem-Based Learning model begins with problem orientation using media; organizing students in groups; guiding and directing students in conducting investigations; developing and presenting discussion results; and ending with analyzing and evaluating with media; The application of Augmented Reality media is carried out in syntax 2 and 3, where in this syntax students are asked to find information by working on LKPD in groups. In LKPD, researchers insert a QR code that must be scanned using a smartphone, then a three-dimensional object will appear related to the material being studied. For example, the application of Augmented Reality media is carried out on the Water Cycle material, AR helps to visualize in detail the stages of the water cycle process in three dimensions.

In addition, AR also contains explanations in the form of text and sound that describe in detail the parts of the stages of the water cycle. Students can also rotate 360 °, enlarge, and reduce three-dimensional objects as desired, so that students can more easily observe them from various angles. The use of the Problem-Based Learning model that is in accordance with process standards and uses AR media can encourage students to think critically and collaboratively in solving real problems, which can reduce misconceptions about the material being studied. Based on this background, the researcher conducted a study on the effectiveness of the Problem-Based Learning Model assisted by Augmented Reality on the learning outcomes of fifth grade elementary school students in the Science subject on the Water Cycle material at SD Negeri Kemiri 01. This study also aims to test the effectiveness of the Problem-Based Learning Model assisted by Augmented Reality compared to the Problem Based Learning Model assisted by images in fifth grade at SD Negeri Gugus Budi Utomo, Subah District, Batang Regency.

Method

This type of research is an experimental research with a Quasi-Experimental Design research design in the Non-equivalent Control Group Design model. Quasi-Experimental Design is an experiment in which the placement of the smallest experimental unit into the experimental and control groups is not done randomly [24]. The researcher used the Non-equivalent Control Group Design by giving a pre-test first at the beginning of learning to determine the initial abilities of students. Then, provide different treatments to each class. The treatment given to the experimental class was carried out by applying the Problem-Based Learning model assisted by Augmented Reality, while the experimental class used the Problem-Based Learning model assisted by images. At the end of learning, the researcher gave a post-test to both classes to determine the effectiveness of providing treatment using different learning models for

each class. The following is a form of Quasi Experimental Design research design presented in the following table 1.

The implementation of treatment in the study was carried out in the subject of Science Phase C, grade V, Chapter on the Water Cycle and Efforts to Preserve It. Based on Decree number 032 of 2024 concerning learning outcomes, the learning outcomes in Phase C are that students can understand the water cycle and its relationship to efforts to maintain water availability. The population in the study was 58 students of grade V of SD Negeri Gugus Budi Utomo who were used for the preliminary study. This study used a purposive sampling technique. From the population of grade V students in Gugus Budi Utomo, samples were taken for research purposes, SD Negeri Kemiri 01 as many as 22 students as the experimental class and SD Negeri Kemiri 03 as many as 20 students as the control class. There are two variables used in this study, namely the independent variable (X) and the dependent variable (Y). The independent variable (X) is the Problem-Based Learning Model assisted by Augmented reality while the dependent variable (Y) is the learning outcomes of the Science material on the Water Cycle in grade V of SD Gugus Budi Utomo.

Table 1. Research Design.

Group	*Pre-test*	*Treatment*	*Post-test*
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Information:
O_1 : Experimental Class Pre-test
O_2 : Experimental Class Post-test
O_3 : Control Class Pret-test
O_4 : Control Class Post-test
X_1 : Treatment in the experimental class using the Problem-Based Learning Model assisted by Augmented reality
X_2 : Treatment in the control class using the Problem Based Learning Model assisted by images.

The hypothesis of this study is that the Problem-Based Learning Model assisted by Augmented reality is not effective compared to the Problem-Based Learning Model assisted by images (H_0); The Problem-Based Learning Model assisted by Augmented reality is effective compared to the Problem-Based Learning Model assisted by images (H_a). This study uses data collection techniques in the form of tests and non-tests. The test technique is carried out by giving a pretest and posttest of 30 multiple-choice questions. Before giving the pretest and posttest to the experimental class and control class, the researcher gave 50 multiple-choice questions to the limited class to test validity, reliability, discrimination, and level of difficulty. The following are the test results from the limited class.

Table 2. Test of Validity, Reliability, Differentiation Power, and Level of Difficulty

	Test		Different Power					Difficulty Level			
Information	Valid	Reliability	Very good	Good	Enough	Bad	Too Difficult	Difficult	Currently	Easy	Too Easy
Amount	30	0.946	8	22	0	0	0	1	19	10	0

While non-test techniques are carried out by conducting interviews, observations, documentation, and distributing questionnaires. This study uses initial data analysis and final data analysis. Initial analysis is a prerequisite test that includes normality test and homogeneity test. While the final data analysis uses independent sample t-test and N-Gain test.

Result and Discussion

From the results of the research that has been conducted at SD Negeri Kemiri 01 as an experimental class and SD Negeri Kemiri 03 as a control class in the Budi Utomo Cluster, Subah District, Batang Regency. There are several things related to the effectiveness of the Problem-Based Learning Model that must be studied in the results and discussion, namely: students' science learning outcomes; pretest data normality test for experimental and control class; posttest data normality test for experimental and control class; paired sample t test for experimental and control class; pretest data homogeneity test for experimental and control class; posttest data homogeneity test for experimental and control class; independent sample t test; N-Gain test for experimental and control class.

Based on table 3, it can be seen that the pretest and posttest learning outcomes of students using the Problem-Based Learning model assisted by Augmented reality are higher than those of the control class using the Problem-Based Learning model assisted by images. In

the next stage, the normality test in this study was processed using the SPSS 25 application. Before giving treatment to the experimental class and the control class, the researcher first gave a pretest to both classes. After receiving treatment, the next step was to give a posttest to the experimental class and control class. This method is carried out to determine whether the initial and final data in this study are normally distributed or not by conducting a normality test on the results of learning science on the Water Cycle material for grade V students of SD Negeri Gugus Budi Utomo. The following are the results of the normality test of the pretest and posttest data attached in Table 4.

Table 3. Science Learning Outcomes

Description	Pre-test		Post-test	
	Control	Experiment	Control	Experiment
Number of Students				
Average	20	22	20	22
Highest Score	64.20	62.36	70.80	80.09
Lowest Score	84	84	92	100
Number of Students Completed	36	40	36	56
Learning Completeness	5	6	11	18
Description	25%	27.27%	55%	81.81%

Table 4. Output of Pretest and Posttest Data Normality Test Results

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning outcomes	Pre-test Experiment	.180	22	.062	.912	22	.053
	Post-test Experiment	.183	22	.052	.945	22	.255
	Pre-test Control	.110	20	.200*	.964	20	.620
	Post-test Control	.232	20	.062	.875	20	.143

Based on the Kolmogorov-Smirnov output, it can be seen that in the experimental class the significance value (Sig) of the pretest is 0.062 and the posttest is 0.052. While in the control class the significance value (Sig) of the pretest is 0.200 and the posttest is 0.062. In the Shapiro-Wilk output, it can be seen that in the experimental class the significance value (Sig) of the pretest is 0.053 and the posttest is 0.255. While in the control class the significance value (Sig) of the pretest is 0.620 and the posttest is 0.143. Thus, for all Kolmogorov-Smirnov and Shapiro-Wilk test data > 0.05. It can be concluded that the research data is normally distributed.

Table 5. Paired Sample T-Test

		Paired Samples Test							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Experimental Pretest – Experimental Posttest	-17.727	14.662	3.126	-24.228	-11.227	-5.671	21	.000
Pair 2	Control Pretest – Control Posttest	-6.600	23.798	5.321	-17.738	4.538	-1.240	19	.230

Based on Table 5, the significance value (Sig) in the experimental class is 0.000, so the significance value of 0.000 <0.05 then H0 is rejected and Ha is accepted. While the significance value (Sig) in the control class is 0.230, so the significance value of 0.230> 0.05 then H0 is accepted and Ha is rejected. So there is a difference in the average value of student learning outcomes for the pretest and posttest in the experimental class using the Problem Based Learning model. In the experimental class, there was a significant influence before (pretest) the AR-assisted Problem-Based Learning model was carried out and after (posttest) the AR-assisted Problem-Based Learning model was carried out on the learning outcomes of the Science subject of the Water Cycle. Thus, there is an influence of the use of the Augmented Reality-assisted Problem-Based Learning model on the learning outcomes of class V Science subject of the Water Cycle.

Homogeneity test is an important step in data analysis that aims to determine whether two or more groups come from the same population, especially in the context of educational research. In this case, the researcher uses the pretest and posttest scores of students as data to conduct a homogeneity test. The results of this homogeneity test will provide information about the similarity of variance between the two classes being compared, so that we can find out whether the possible differences in learning outcomes can be considered significant or not. The following are the results of the homogeneity test of pretest and posttest data attached in Table 6.

Table 6. Homogeneity Test of Pretest and Posttest Data.

		Test of Homogeneity of Variance			
		Levene Statistic	df1	df2	Sig.
Learning outcomes	Pre-test	.490	1	40	.488
	Post-test	.731	1	40	.398

Based on Table 6, the significance value (Sig) of the pretest of both classes is 0.488 and the significance value (Sig) of the posttest of both classes is 0.398. So it can be concluded that the significance value of the results of the homogeneity test of the pretest and posttest data is greater than 0.05. So H0 is accepted and the data is homogeneous or there is no difference in variance between the two classes. The results of the prerequisite test can be concluded that the data in this study are normally distributed and homogeneous, so that a hypothesis test can be carried out with the Independent Sample T-Test. Hypothesis testing in this study uses students' posttest scores to determine the effectiveness of the Augmented Reality-assisted Problem-Based Learning model in the experimental class and the effectiveness of the image-assisted Problem-Based Learning model in the control class. The hypothesis tests used in this study are the independent sample t-test and the N-Gain test. The following are the results of the independent sample t-test using SPSS 25 which are attached in Table 7.

Table 7. Independent Sample T-Test

Independent Samples Test										
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Learning outcomes	Equal variances assumed	.731	.398	2.228	40	.032	9.291	4.170	.863	17.719
	Equal variances not assumed			2.203	36.087	.034	9.291	4.218	.737	17.845

Based on Table 7, from the results of the independent sample t-test, the Sig. (2-tailed) values obtained are 0.032 and 0.034. The Sig. value is smaller than 0.05, so H0 is rejected and Ha is accepted. Thus, it can be concluded that the Problem-Based Learning model assisted by Augmented Reality is effective for the learning outcomes of Science on the Water Cycle material in class V of SD Negeri Gugus Budi Utomo. The N-Gain test was conducted to determine the increase in student learning outcomes before and after receiving treatment in the experimental class and also the control class. The N-Gain test in this study was obtained using SPSS 25. The increase in pretest and posttest scores of class V students of SD Negeri Gugus Budi Utomo can be seen in Table 8.

Table 8. Average Increase Test (N-Gain)

Class	Average		N-Gain	Category
	Pretest	Posttest		
Experiment	62.36	80.09	0.430	Medium
Control	64.20	70.80	-.004	Low

Based on Table 8, it can be seen that the n-gain value is 0.430 in the experimental class which is in the medium category, while the N-Gain value is -0.004 in the control class with the low category. This indicates that students in the experimental class who use the Problem-Based Learning model assisted by Augmented reality from the results of research and practice are more

effective than the Problem-Based Learning model assisted by images.

Table 9. Results of Teacher and Student Response Questionnaires

Respondent	Presentation(%)	Criteria
Teacher	93	Very Positive
Students	86	Very Positive

After receiving treatment using the Problem-Based Learning Model assisted by Augmented Reality, teachers and students were given a response questionnaire related to the application of the model and learning media as many as 14 questions. The questionnaire covers three aspects, namely the model, learning media, materials and language. The assessment of this questionnaire uses a Likert scale calculation of 1-4 which must be filled in by teachers and students based on their experiences when observing and receiving treatment. From the data in Table 9, it can be seen that the responses of teachers and students are very positive towards the Problem-Based Learning model assisted by Augmented Reality. Therefore, learning models and media that have very good criteria can help increase the active participation of students. That way, it can facilitate students to think critically in solving real problems and get meaningful learning experiences through the use of interactive learning media. The results of the data analysis show that the Problem-Based Learning model assisted by Augmented Reality is effective in improving the learning outcomes of Class V Science at SD Negeri Gugus Budi Utomo. This is also further strengthened by several factors.

First, the Problem-Based Learning model encourages students to solve real and relevant problems, so that students can see the direct relationship between what they learn and the situations they face in everyday life (Dwindiarti et al., 2021). By using real problems, students are expected to be actively involved in discussions, research, and collaboration to find solutions (Bergmark & Westman, 2018; Li et al., 2023; Zhang et al., 2023). This activity not only increases student engagement but also encourages them to think critically and creatively. Second, the Problem-Based Learning model indirectly develops 21st century skills because students must work together in groups to solve problems, communicate well, and think critically to analyze situations and find solutions (Rehman et al., 2024; Xu et al., 2023). Process-based assessment, assessment does not only focus on the final result but also on the process that students go through in solving problems (Hontvedt et al., 2023; Luo & Chan, 2023; Baker & Mayer, 1999). This allows teachers to evaluate students' critical thinking, collaboration, and problem-solving skills more holistically (Bustanul Arifin & Abdul Mu'id, 2024; Fricticarani et al., 2023). The Problem-Based Learning model places students at the center of the learning process, where they are responsible for finding solutions to the problems they face (Asido, 2022). For students, this can increase their sense of ownership of learning and encourage students to be more active in the learning process.

Third, the Problem-Based Learning model combined with the use of media in learning shows a significant positive effect on improving students' abilities (Asido, 2022). The use of media provides a relevant real context, allowing students to apply the concepts learned in everyday life situations, thus encouraging them to think critically and creatively (Kwangmuang et al., 2021). Fourth, the use of Augmented Reality media in learning has a significant positive impact on the learning process and outcomes of students. Augmented Reality media is able to attract students' attention and increase their interest in the subject matter. By presenting learning content in the form of interactive 3D visuals, Augmented Reality creates a more interesting and enjoyable learning experience, so that students are more involved in the learning process (Mulianti et al., 2023). Augmented Reality helps students understand difficult and abstract concepts in a more concrete way. With clear and interactive visualizations, students can see and interact directly with learning objects, which makes it easier for students to understand complex material (Al-Ansi et al., 2023; Wang et al., 2023).

Students can work together in groups to complete tasks involving Augmented Reality, which increases active student participation (Hafizhah & Setyasto, 2024; Upadhyay et al., 2023). Previous research also shows that the application of Augmented Reality media in learning can significantly improve student learning outcomes. Students who learn using Augmented Reality tend to have better understanding and higher academic results compared to lecture learning methods (Milasari & Setyasto, 2023; Gandasari, 2021). The implication of this study is that the Problem-Based Learning Model assisted by Augmented Reality can improve the learning outcomes of grade V science studies. By adjusting the Regulation of the Minister of Education, Culture, Research and Technology Number 16 of 2022 concerning Process Standards and several previous studies, the researcher applied the Problem-Based Learning model assisted by Augmented Reality to the science subjects of grade V elementary school. Based on the results of the research and discussion that have been explained previously, it is known that the Problem-Based Learning model assisted by Augmented Reality is effective for the learning outcomes of science studies on the Water Cycle material in grade V of SD Negeri Gugus Budi Utomo.

Conclusion

Based on the research results, the Problem-Based Learning Model assisted by Augmented Reality is effective in improving the learning outcomes of Science in Grade V of SD Negeri Gugus Budi Utomo. The effectiveness of the Problem-Based Learning Model assisted by Augmented Reality is based on hypothesis testing by conducting an independent sample t-test. It is known that the Sig. (2-tailed) values obtained are 0.032 and 0.034. The Sig. value is smaller than 0.05, so H0 is rejected and Ha is accepted. Based on the n-gain test in the experimental class and control class, the N-Gain value was 0.430 in the experimental class which was in the medium category, while the N-Gain value was -0.004 in the control class with the low category. Thus, students in the experimental class who use the Problem-Based Learning Model assisted by Augmented Reality from the results of research and practice are more effective than the Problem-Based Learning Model assisted by images.

Acknowledgments
All praise be to Allah SWT for His grace and guidance, so that this final assignment can be completed. My deepest gratitude to both parents, the supervising lecturer, and all parties who have provided support, prayers, and guidance. May the knowledge gained be useful and bring blessings.

Author Contributions
This research article was published through the collaboration of the first author M. A. G and the second author N. S. The authors' contributions in this article are conducting observations, designing learning tools, research, data analysis, and writing the article. N. S., as the supervisor reviewed the results and approved the final results of the article writing.

Funding
This research is a research funded by the researcher's personal funds, and does not receive funding from external parties.

Conflicts of Interest
The author declares that he has no conflict of interest.

Reference

Aditya, F., & Trisno, B. (2018). Learning Media Based on Augmented Reality Applied on the Lesson of Electrical Network Protection System. *IOP Conference Series: Materials Science and Engineering*, *384*(1), 012075. https://doi.org/10.1088/1757-899X/384/1/012075

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences & Humanities Open*, *8*(1), 100532. https://doi.org/10.1016/j.ssaho.2023.100532

Amelia, V., & Isdaryanti, B. (2024). Application of Assemblr Edu Augmented Reality Media in IPAS Learning on Water Cycle Material at Wonosari 01 State Elementary School. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *14*(1). https://doi.org/10.30998/formatif.v14i1.22161

Asido, B. T. (2022). Pengaruh Model Problem Based Learning Berbantuan Media Papan Musi Terhadap Hasil Belajar Pada Materi Faktor Persekutuan Terbesar. *Jurnal Pengajaran Sekolah Dasar*, *1*(1), 87–95. https://doi.org/10.56855/jpsd.v1i1.106

Baker, E. L., & Mayer, R. E. (1999). Computer-based assessment of problem solving. *Computers in Human Behavior*, *15*(3–4), 269–282. https://doi.org/10.1016/S0747-5632(99)00023-0

Bergmark, U., & Westman, S. (2018). Student participation within teacher education: Emphasising democratic values, engagement and learning for a future profession. *Higher Education Research & Development*, *37*(7), 1352–1365. https://doi.org/10.1080/07294360.2018.1484708

Bustanul Arifin & Abdul Mu'id. (2024). Pengembangan Kurikulum Berbasis Keterampilan Dalam Menghadapi Tuntutan Kompetensi Abad 21. *DAARUS TSAQOFAH Jurnal Pendidikan Pascasarjana Universitas Qomaruddin*, *1*(2), 118–128. https://doi.org/10.62740/jppuqg.v1i2.23

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Dwindiarti, R., Arafik, M., & Suprianti, D. (2021). Model Problem Based Learning (PBL) untuk Meningkatkan Hasil Belajar Matematika tentang Pengukuran Waktu di Kelas II SDN Tamanasri. *JISIP (Jurnal Ilmu Sosial Dan Pendidikan)*, *5*(4). https://doi.org/10.58258/jisip.v5i4.2538

Fitriyanti, F., F, F., & Zikri, A. (2020). Peningkatan Sikap dan Kemampuan Berpikir Ilmiah Siswa Melalui Model PBL di Sekolah Dasar. *Jurnal Basicedu*, *4*(2), 491–497. https://doi.org/10.31004/basicedu.v4i2.376

Fricticarani, A., Hayati, A., R, R., Hoirunisa, I., & Rosdalina, G. M. (2023). Strategi Pendidikan Untuk Sukses di Era Teknologi 5.0. *Jurnal Inovasi Pendidikan Dan Teknologi Informasi (JIPTI)*, *4*(1), 56–68. https://doi.org/10.52060/pti.v4i1.1173

Gandasari, N. (2021). Keefektifan Model Problem-Based Learning Berbantuan Microsoft Sway Terhadap Hasil Belajar PPKn. *Joyful Learning Journal*, *10*(1), 37–41. https://doi.org/10.15294/jlj.v10i1.42761

Garlinska, M., Osial, M., Proniewska, K., & Pregowska, A. (2023). The Influence of Emerging Technologies on Distance Education. *Electronics*, *12*(7), 1550. https://doi.org/10.3390/electronics12071550

Hafizhah, F. J., & Setyasto, N. (2024). Augmented Reality-Assisted Scrapbook Media Development in Natural and Social Science Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 4149–4157. https://doi.org/10.29303/jppipa.v10i7.7258

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hidayat, T., & Kosasih, A. (2019). Analisis Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 22 Tahun 2016 Tentang Standar Proses Pendidikan Dasar Dan Menengah Serta Implikasinya Dalam Pembelajaran PAI di Sekolah. *Muróbbî: Jurnal Ilmu Pendidikan*, *3*(1), 45–69. https://doi.org/10.52431/murobbi.v3i1.172

Hontvedt, M., Prøitz, T. S., & Silseth, K. (2023). Collaborative display of competence: A case study of process-oriented video-based assessment in schools. *Teaching and Teacher Education*, *121*, 103948. https://doi.org/10.1016/j.tate.2022.103948

Huang, C.-Y., Chou, Y.-Y., Chen, C.-H., & Tsai, Y.-H. (2022). Applying Activity System-Based Process Model in Augmented Reality-Based Learning for Natural Science Course in Elementary School. *Mobile Information Systems*, *2022*, 1–18. https://doi.org/10.1155/2022/9579766

Husna, M., Sudiyanto, & Rintayati, P. (2024). The influence of project-based learning and problem-based learning models on science learning ability from the perspectives of learning interest: Project Based Learning and Problem Based Learning. *Multidisciplinary Science Journal*, *6*(8), 2024137. https://doi.org/10.31893/multiscience.2024137

Hutahaean, H. D., Muhammad Aulia Rahman, S., & Mendoza, M. D. (2022). Development of interactive learning media in computer network using augmented reality technology. *Journal of Physics: Conference Series*, *2193*(1), 012072. https://doi.org/10.1088/1742-6596/2193/1/012072

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6), e07309. https://doi.org/10.1016/j.heliyon.2021.e07309

Li, S., Pöysä-Tarhonen, J., & Häkkinen, P. (2023). Students' collaboration dispositions across diverse skills of collaborative problem solving in a computer-based assessment environment. *Computers in Human Behavior Reports*, *11*, 100312. https://doi.org/10.1016/j.chbr.2023.100312

Lukum, A. (2015). Evaluasi Program Pembelajaran IPA SMP Menggunakan Model Countenance Stake. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *19*(1), 25–37. https://doi.org/10.21831/pep.v19i1.4552

Luo, J., & Chan, C. K. (2023). Twenty years of assessment policies in China: A focus on assessing students' holistic development. *International Journal of Chinese Education*, *12*(2). https://doi.org/10.1177/2212585X231173135

Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: How teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research*, *4*(1), 2. https://doi.org/10.1186/s43031-021-00042-x

Milasari, D., & Setyasto, N. (2023). Effectiveness of the Microsoft Sway Assisted Problem-Based Learning Model on Science Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7028–7035. https://doi.org/10.29303/jppipa.v9i9.4563

Muhayati, E. I., Trisnawaty, W., & Subaidah, S. (2023). Implementation of Discovery Learning Models to Improve Students Mathematic Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 3975–3980. https://doi.org/10.29303/jppipa.v9i5.2190

Mulianti, S., Susanta, A., Hanifah, H., & Haji, S. (2023). Pengaruh Pendekatan Problem Based Learning (PBL) Berbantuan Augmented Reality (AR) Terhadap Kemampuan Pemecahan Masalah Matematika di SMK Negeri 1 Lebong. *Jurnal Lebesgue : Jurnal Ilmiah Pendidikan Matematika, Matematika Dan Statistika*, *4*(2), 930–939. https://doi.org/10.46306/lb.v4i2.358

Ngatman, N., Salimi, M., Ulfiana, U., Hidayah, R., Wahyudi, A. B. E., Wahyono, W., Zainnuri, H., Wijayanto, S., Fauziah, M., & Astuti, D. (2025). The Implementation of Problem-Based Learning with Multimedia for Improving Scientific Process Skills. *Salud, Ciencia y Tecnología - Serie de Conferencias*, *4*, 1247. https://doi.org/10.56294/sctconf20251247

Nurzannah, S. (2022). Peran Guru Dalam Pembelajaran. *ALACRITY : Journal of Education*, 26–34. https://doi.org/10.52121/alacrity.v2i3.108

Prasojo, L. D., Kande, F. A., & Mukminin, A. (2018). Evaluasi pelaksanaan standar proses pendidikan pada SMP Negeri di Kabupaten Sleman. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *22*(1), 61–69. https://doi.org/10.21831/pep.v22i1.19018

Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A. M., & Javed, S. (2024). Project-based learning as a catalyst for 21st-Century skills and student

engagement in the math classroom. *Heliyon*, *10*(23), e39988. https://doi.org/10.1016/j.heliyon.2024.e39988

Sajidan, S., Suranto, S., Atmojo, I. R. W., Saputri, D. Y., & Etviana, R. (2022). Problem-Based Learning-Collaboration (PBL-C) Model in Elementary School Science Learning in the Industrial Revolution Era 4.0 and Indonesia Society 5.0. *Jurnal Pendidikan IPA Indonesia*, *11*(3), 477–488. https://doi.org/10.15294/jpii.v11i3.30631

Sofiani, Y., Istiqomah, P. N., & Muzdalifah, S. (2024). Peningkatan Kemampuan Berpikir Kritis Siswa melalui Model Pembelajaran Problem Based Learning. *Proceeding International Conference on Lesson Study*, *1*(1), 467. https://doi.org/10.30587/icls.v1i1.7395

Syahlan, I. D., Hidayat, D. R., & Hidayat, O. S. (2023). Application of the Project Based Learning Model in Elementary Schools: Obstacles and Solutions of Science and Environment Content. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2060–2067. https://doi.org/10.29303/jppipa.v9i4.3285

Upadhyay, B., Brady, C., Madathil, K. C., Bertrand, J., & Gramopadhye, A. (2023). Collaborative Augmented Reality in Higher Education Settings – Strategies, Learning Outcomes and Challenges. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *67*(1), 1090–1096. https://doi.org/10.1177/21695067231192199

Wang, S., Sung, R., Reinholz, D. L., & Bussey, T. J. (2023). Equity analysis of an augmented reality-mediated group activity in a college biochemistry classroom. *Journal of Research in Science Teaching*, *60*(9), 1942–1966. https://doi.org/10.1002/tea.21847

Widiasanti, I., Ramadhan, N. A., Alfarizi, M., Fairus, A. N., Oktafiani, A. W., & Thahur, D. (2023). Utilization of Multimedia Facilities and Internet Media as Effective Learning Tools. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 148–153. https://doi.org/10.29303/jppipa.v9i6.3805

Xu, E., Wang, W., & Wang, Q. (2023). The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature. *Humanities and Social Sciences Communications*, *10*(1), 16. https://doi.org/10.1057/s41599-023-01508-1

Zhang, R., Shi, J., & Zhang, J. (2023). Research on the Quality of Collaboration in Project-Based Learning Based on Group Awareness. *Sustainability*, *15*(15), 11901. https://doi.org/10.3390/su151511901