JPPIPA 11(3) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

The Effectiveness of the Problem-Based Learning Model Assisted by Augmented Reality on Learning Outcomes in the Science Subject of Light and Its Properties for Class V

Sagita Ayuk Lestari[1*], Novi Setyasto[1]

[1]Elementary School Teacher Education, FIPP, Universitas Negeri Semarang, Semarang, Indonesia

Received: January 11, 2025
Revised: February 21, 2025
Accepted: March 25, 2025
Published: March 31, 2025

Corresponding Author:
Sagita Ayuk Lestari
sagita02@students.unnes.ac.id

DOI: 10.29303/jppipa.v11i3.10350

Abstract: The use of learning models and media that do not comply with the process standards in Permendikbudristek Number 16 of 2022 has an impact on low student learning outcomes. This study examines the effectiveness of the AR-assisted PBL Model on the learning outcomes of Class V Science at Gugus Mawar Elementary School, Semarang City compared to the teacher-assisted PBL Model assisted by PPT. This study is included in the type of experimental research with a quasi-experimental research design in the form of Nonequivalent Control Group Design. The population in this study were 77 class V students of Gugus Mawar Elementary School using the purposive sampling technique. In this study, SDN Kemijen 02 acted as the experimental class and SDN Kemijen 01 as the control class. The results of the t-test obtained a sig value of 0.000, which is less than 0.05 so that Ho is rejected and Ha is accepted. This is supported by the results of the N-Gain test for the experimental class of 0.58 and the control class of 0.50. So it can be concluded that the AR-assisted PBL Model is more effective than the PPT-assisted teacher version of the PBL Model on the learning outcomes of class V of Gugus Mawar Elementary School.

Keywords: Augmented Reality; Learning Outcomes; Learning Models; Problem-Based Learning; Science

Introduction

Education is an important component in building quality human resources. Education aims to develop the potential of students to become people who believe and fear God Almighty, have noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens as stated in Law No. 20 of 2003 concerning the National Education System. To realize these educational goals, the government issued Permendikbudristek number 16 of 2022 concerning education process standards. To achieve the learning objectives in the process standards article 7 paragraph (2) the learning process is recommended to apply problem-based material or real contexts and apply the use of information and communication technology devices in learning. To support learning objectives, the learning process is carried out interactively and can be done by interacting in a dialogue between teachers and students, as well as fellow students; interacting actively with the learning environment and collaborating to foster a spirit of mutual cooperation, where teachers act as facilitators of the learning process and are not the only source of learning. However, in reality, there are still several schools whose learning processes tend not to be in accordance with existing process standards. Among them, teachers' limited mastery of the PBL concept causes the application of the Problem-Based Learning learning model to be less in accordance with the syntax

How to Cite:
Lestari, S. A., & Setyasto, N. (2025). The Effectiveness of the Problem-Based Learning Model Assisted by Augmented Reality on Learning Outcomes in the Science Subject of Light and Its Properties for Class V . *Jurnal Penelitian Pendidikan IPA*, *11*(3), 250–260. https://doi.org/10.29303/jppipa.v11i3.10350

it should be (Mulyadi & Ratnaningsih, 2022). The use of learning methods that tend to be centered on teachers and the lack of use of technology in supporting the learning process which results in low student learning outcomes (Ngatman et al., 2025; Hennessy et al., 2022).

Another problem found is that teachers sometimes only use easy learning media or even do not use media in the learning process, and teachers still have difficulty using the smartphones they have for classroom learning (Agustira et al., 2024; Pratidina et al., 2024). Teachers sometimes only use smartphones to communicate with students to inform them of an announcement or things that must be prepared for tomorrow's learning or exams. This also happened in class V of Gugus Mawar Elementary School, Semarang City which includes SDN Kemijen 01, SDN Kemijen 02 and SDN Kemijen 03. Based on the results of interviews conducted with class V teachers of the Mawar cluster, various problems were found, including those related to the learning model, where teachers still use learning models that are not in accordance with the standards that have been set. Gugus Mawar Elementary School has used the independent curriculum in its learning process so that the model used must be in accordance with the independent curriculum, one of which is the problem-based learning model (Problem-Based Learning). However, in the application of the Problem-Based Learning model, it does not contain problems that must be solved by students, so this model is applied without containing steps according to its syntax (Dewi et al., 2022; Suwandi et al., 2021).

Another problem is related to the learning method where teachers tend to dominate learning by emphasizing the lecture method or only giving assignments that cause students to feel less enthusiastic and get bored quickly, such as playing during the learning process, not paying attention when the teacher explains, and disturbing friends during learning. Another problem is the lack of use of media and utilization of technology in the learning process, for example, teachers only use PPT which tends to contain long sentences or paragraphs with only a few visualizations which causes the learning material to be less visualized well, such as in the science subject of Light and Its Properties, which makes the learning process less enjoyable and meaningful, resulting in a lack of understanding of students in the learning material which has an impact on student learning outcomes. Based on the results of the questionnaire and interviews, students have difficulty understanding how light propagates or interacts with objects around them. Those who are hearing words like "refraction", "dispersion", or "interference" for the first time sound foreign and difficult to understand. Examples that are too simple in the book do not provide a sufficient picture of more complex light phenomena. Limitations of Visualization in textbooks do not always have images or diagrams that are clear enough to help students visualize abstract concepts.

Based on the results of learning observations that have been carried out in class V of the Mawar cluster, the model used in the learning process is Problem-Based Learning. The Problem-Based Learning learning process is not in accordance with the stages that it should be. Based on Arends in the study in the Problem-Based Learning model there are 5 syntaxes that must be implemented, namely student orientation to the problem, organizing students to learn, guiding individual or group investigations, developing and presenting results, and analyzing and evaluating the problem-solving process. In the Problem-Based Learning learning process, students should be faced with problems to be solved together, to hone and improve students' abilities in communicating, collaborating, thinking critically and solving problems. In reality, this learning process has not been implemented in accordance with the learning model which causes low student learning outcomes and the learning objectives to be achieved are less than optimal. Based on the results of observations, SD Cluster Mawar already has a Wi-Fi network that can reach the entire school environment, each school also has a projector that can be used for the learning process and there are also computers and laptops to encourage the learning process.

However, the school has not optimized the use of learning resources with the help of IT. Where the projector is only used occasionally to display images or PPT which tend to still contain sentences that are not in accordance with the learning objectives to be achieved. Gugus Mawar also does not have a computer laboratory but has computers and laptops that are only used for ANBK activities. Gugus Mawar also does not have an IPS laboratory but has a kit (teaching aids and media) to do the practice. Teaching aids and media are divided into different classes but these tools are also rarely used. If the rainy season often occurs, Gugus Mawar floods will be affected which causes the learning support tools to be damaged. This is also a factor causing Gugus Mawar to rarely use teaching aids or media to assist in the learning process. Based on the results of the questionnaire from 3 schools, namely: SDN Kemijen 01 with 26 students, 23 of whom have smartphones that can access while SD Negeri Kemijen 02 with 28 students, 23 of whom have smartphones that can access the internet, and SD Negeri Kemijen 03 with 28 students, 24 of whom have smartphones that can access the internet. The total number of SDN Kemijen 01, 02 and 03 is 82 students, of which 70 out of 82 students (85%) have smartphones that

can be used to access the internet and can operate smartphones well.

However, students do not utilize smartphones for learning. Of the total 70 students who have smartphones, only 11 students (SDN Kemijen 01 has 3 students, SDN Kemijen 02 has 5 students and SDN Kemijen 03 has 3 students) who use smartphones to search for additional materials to help them learn, while 35 students (SDN Kemijen 01 has 11 students, SDN Kemijen 02 has 11 students and SDN Kemijen 03 has 13 students) use smartphones to play games, 12 students use smartphones to play social media 12 students (SDN Kemijen 01 has 3 students, SDN Kemijen 02 has 5 students and SDN Kemijen 03 has 4 students) 12 students (SDN Kemijen 01 has 5 students, SDN Kemijen 02 has 4 students and SDN Kemijen 03 there are 2 students) using smartphones to watch entertainment on YouTube. This means that 59 out of 70 students (84%) have not utilized their smartphones properly in searching for additional materials or supporting their learning process. Whereas based on the results of the questionnaire, many students like to use smartphones to access additional materials to support the learning process. Based on the filling out of the parent questionnaire, 80% of parents allow the use of smartphones in the process under teacher supervision. Parents on average allow their children to use smartphones in the learning process at the age of 10 years.

Of the 70 students who have smartphones, only 11 (15.7%) use them to search for additional information, indicating great potential for the use of smartphones to assist student learning as shown by the questionnaire data conducted in three schools. This suggests that students should be encouraged to use their smartphones to access learning resources such as e-books, AR and videos, as well as to collaborate in learning. With 80% of parents agreeing that the use of smartphones under teacher supervision in learning, there is an opportunity to develop programs that utilize technology to increase student enthusiasm. In addition, students can be directed to use social media for educational purposes and schools can develop applications to provide relevant content that can increase activeness and productivity during the learning process.

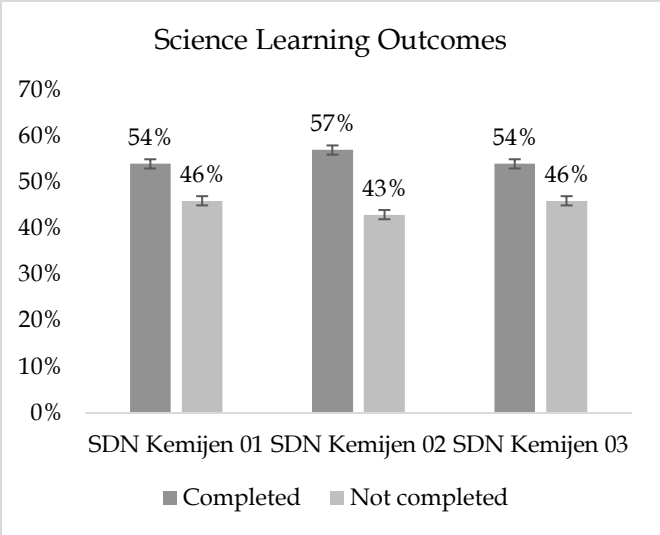

Figure 1. Diagram of Science Learning Outcome Completion

Based on the results of science learning at SD Kelompok Mawar in the 2023/2024 academic year, including SDN Kemijen 01, SDN Kemijen 02 and SDN Kemijen 03, 55% of students achieved KKTP (Learning Achievement Criteria) and 45% of students did not achieve KKTP (75). Of the 26 students at SDN Kemijen 01, 12 (46%) did not achieve completion, and 14 (54%) students achieved completion; while of the 28 students at SDN Kemijen 02, 12 (43%) students did not achieve completion and 16 (57%) achieved completion; while at SDN Kemijen 03, 13 (46%) students did not achieve completion and 15 (54%) other students achieved completion. Based on the problems that occur in science learning at SD Gugus Mawar, to achieve quality goals and education, good learning is needed which should be implemented in accordance with the independent curriculum and process standards as stated in article 7 paragraph 2 where to achieve learning goals, quality learning strategies are needed by encouraging the application of problem-based learning materials or real contexts, encouraging active interaction, optimizing the use of resources, and the use of information and communication technology devices.

The independent curriculum is specifically designed to provide freedom of learning or independent learning by educators in an effort to compile and implement an innovative and creative learning process by paying attention to each student's needs in receiving learning (Fransiska et al., 2023); (Yunaini et al., 2022). The independent curriculum has several learning models that can be applied, one of which is the learning model in the independent curriculum, namely Problem-Based Learning. The Problem-Based Learning model is a learning model that is centered on students by starting with the provision of problems that are in accordance with the real world so that students not only learn

concepts related to the problem and scientific techniques used to solve problems, but also become the foundation for character formation of students. (Effendi et al., 2021; Zulfa et al., 2023). PBL is considered a 21st-century learning model that encourages the achievement of learning objectives that are adapted to the real world and encourages students to apply ideas, improve school quality, and improve their thinking skills (Sarnoko et al., 2024). Problem-Based Learning facilitates active learning and improves understanding and retention of knowledge. Problem-Based Learning also helps develop critical thinking, communication, collaboration, problem solving, independent learning skills, and other life skills (Sakir & Kim, 2020).

Some of the advantages of the problem-based learning model are as follows: Challenges students' abilities and provides satisfaction for students to discover new knowledge; Increase students' motivation and learning activities; Help students transfer their knowledge to real-world problems; Help students expand their knowledge and take responsibility for what they learn. In addition, PBL can encourage students to self-assess their learning process and outcomes; PBL can help them think critically and adapt to new knowledge; PBL can also give them the opportunity to use what they know in the real world; In addition, PBL can foster students' interest in learning continuously, regardless of whether they attend formal education or not. 8) allows students to understand the concepts and ideas they learn to solve world problems. This is supported by previous research showing that the use of the Problem-Based Learning Model can increase students' motivation and learning outcomes. Other studies also show that the use of the PBL Model can improve students' critical thinking skills in solving problems.

Based on findings in the field, teachers at Gugus Mawar Elementary School tend not to implement problem-based learning that is in accordance with the syntax and the lack of application of technology, this is because teachers do not understand technology. Currently, teachers must change the culture in the learning process. Teachers are encouraged to learn to use technology, become proficient in designing creative learning, collaborating with students, thinking critically and communicatively, and making innovations based on life problems. Because this ability is related to TPACK (Learning Technology and Knowledge Content) skills including the use of the internet (Sofyan et al., 2023). Augmented Reality (AR) is one of the developing technologies that is increasingly recognized by educational researchers because it has great pedagogical potential and an important role in improving the learning experience. Augmented Reality is one of the media that can answer today's difficulties. AR offers a new way to enhance teaching and learning activities by integrating virtual objects into the real world (Amirahma & Setyasto, 2024; Hidayat et al., 2021; Volioti et al., 2023). The advantages of Augmented Reality in learning are that it helps improve students' conceptual understanding and makes the learning process more interesting and interactive. AR can also make learning more active and enjoyable because of the attractive visualizations. This is supported by previous research which states that the use of Augmented Reality can increase student motivation and learning outcomes (Baabdullah et al., 2022; Marini et al., 2022).

In this study, the learning process applies the Problem-Based Learning model assisted by Augmented Reality. The syntax of the Problem-Based Learning model used is sourced from Arends in research (Suciati et al., 2020), which consists of 5 stages that must be implemented, namely :orienting students to the problem, organizing students to learn, guiding individual or group investigations, developing and presenting results, and analyzing and evaluating the problem-solving process. Augmented Reality is used in the learning process when students have been formed into groups and given problems to solve according to the third syntax in PBL. AR is used as a tool or media that supports learning and the teacher remains the main facilitator. In the learning process, students can explore, study and analyze problems assisted by AR. Augmented Reality helps present objects about the concept of light where students can understand the role of light in life, such as the deflection of light, refraction of light and others. The nature of light that is refracted when passing through various mediums can be difficult to understand without visual aids. Students can use AR to see animations of how refraction occurs, light bends when passing through water, learn how the angle of incidence of light is, and see the angle of reflection on the surface of a mirror.

The function of AR is to help students understand the properties of light through 3D objects. The use of AR in this learning is done by pointing the smartphone camera at a marker that has been provided. The markers used can be pictures of objects that are found in the properties of light, for example a rainbow (decomposition), a glass of water (refraction) and a mirror (reflection). After moving the smartphone screen to the marker, students can see a visualization of the refraction of light. Based on this description, this study aims to test the effectiveness of the Problem-Based Learning Model assisted by Augmented Reality on the learning outcomes of Science on the material Light and Its Properties of class V Gugus Mawar, Semarang City.

Method

This research is an experimental research with a quasi-experimental design in the form of a nonequivalent control group design. At the beginning of learning, the experimental class and the control class were given a pretest first to measure the initial abilities of students. Furthermore, both classes were given different treatments. The treatment given to the experimental class used the Problem-Based Learning Model assisted by Augmented Reality while the control class used the Problem-Based Learning Model in accordance with what is commonly used by teachers assisted by PPT. At the end of learning, both classes were given a posttest to determine the effect of the different treatments that had been given to each class. The following is a form of quasi-experimental research design presented in the following table.

Table 1. Research Design

Group	*Pre-test*	Treatment	*Post-test*
Experiment	O1	X_1	O_2
Control	O_3	X_2	O_4

Information:
O1: Pretest of experimental class
O2: Posttest of experimental class
O3: Pretest of control class
O4: Posttest of control class
X1: Treatment in experimental class using Problem-Based Learning Model assisted by Augmented Reality
X2: Treatment in control class using Problem-Based Learning Model teacher version assisted by PPT.

The treatment in this study was carried out in the subject of Science in Chapter 1 (Seeing Because of Light, Hearing Because of Sound) Topic A Light and Its Properties with the following learning outcomes: Students understand the phenomenon of sound and light waves in everyday life. There are 9 learning objectives divided into 3 meetings. The population in this study were 77 students in class V Gugus Mawar consisting of (SDN Kemijen 01, and SDN Kemijen 02). This study used a purposive sampling technique. The sample in this study were 27 students of grade V of SD Negeri Kemijen 02 as the experimental class and 24 students of SD Negeri Kemijen 01 as the control class. There were 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 results of learning science in grade V of SD Gugus Mawar.

The hypothesis in this study is that the Problem-Based Learning Model assisted by Augmented Reality is not effective compared to the Problem-Based Learning Model teacher version assisted by PPT on the results of learning science in grade V of SD Gugus Mawar Semarang (Ho); The Problem-Based Learning Model assisted by Augmented Reality is effective compared to the Problem-Based Learning Model teacher version assisted by PPT on the results of learning science in grade V of SD Gugus Mawar Semarang (Ha).

Table 2. Recapitulation of the Results of the Analysis of Question Items

Analysis Criteria	Status	r count	Analysis Results
Validity	Valid		25
Reliability		0.902	
	Too difficult		0
Difficulty Level	Difficult		4
Analysis Criteria	Currently		14
	Easy		7
	Too Easy		0
Validity	Very good		14
	Good		6
	Enough, needs improvement		5
	Not Good (discarded)		0

Data collection techniques in this study used test and non-test techniques. The test technique was carried out by providing a pretest and posttest. This test technique was carried out by providing a test of 50 questions which then obtained 25 valid questions with a reliability level of 0.902 with a level of difficulty, namely, difficult as many as 4 questions, moderate as many as 14 questions and easy as many as 7 questions with a discriminatory power consisting of 14 very good questions and 6 good questions and 5 sufficient questions with minor improvements. While the non-test technique was carried out by observation, interviews, documentation, and distributing questionnaires. This study used initial and final data analysis. Initial data analysis with prerequisite tests including normality and homogeneity tests while final data analysis used the t-test and N-Gain test.

Result and Discussion

The results of the research conducted at SDN Kemijen 02 as an experimental class and SDN Kemijen 01 as a control class in Gugus Mawar, Semarang City, there are several things that will be studied in the results and discussions, namely: students' science learning outcomes; normality test of pretest and posttest data for experimental and control classes; homogeneity test of pretest and posttest data for experimental and control classes; hypothesis test for experimental and control

classes; N-Gain test for experimental and control classes. In this study, the science learning outcomes of students are in the form of cognitive learning outcomes. Student Learning Outcomes obtained from the pretest and posttest scores of the experimental and control classes. The following are the pretest and posttest learning outcomes of the experimental and control classes:

Table 3. Student Learning Outcomes

	Pre-test		*Post-test*	
Information	Treatment	Control	treatment	Control
Number of Students	27	30	27	30
Average	56.07	47.92	81.33	74.00
Highest Score	64	64	92	84
Lowest Score	44	40	72	64
Learning Mastery	56.07%	47.92%	81.33%	74.00%

Based on Table 3, it can be seen that the pretest and posttest learning outcomes of students who used the Problem-Based Learning Model assisted by Augmented Reality were higher compared to the control class that only used the Problem-Based Learning Model version of the teacher assisted by PPT. The normality test in this study used the assistance of the SPSS 25 program. Before being given treatment, the control class and the experimental class were first given a pretest. After being given treatment, the experimental class and control class were given a posttest. The normality test was conducted to examine the initial and final data of the results of learning science on the material of Light and Its Properties in grade V students of Gugus Mawar Elementary School, Semarang City. From the results of the normality test, it will be known whether the data is normally distributed or not. The following are the results of the normality test of the pretest and posttest data presented in Table 4.

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

		Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning outcomes	Experiment Pretest	0.163	27	0.063	0.928	27	0.061
	Control Pretest	0.139	24	0.200	0.918	24	0.054
	Experiment Posttest	0.154	27	0.097	0.940	27	0.124
	Control Posttest	0.147	24	0.192	0.945	24	0.214

Based on Table 4, the pretest significance value for the experimental class was 0.061 and the posttest was 0.124. While the significance value obtained for the pretest of the control class was 0.054 and the posttest was 0.214. From the results of the pretest and posttest normality tests for the experimental and control classes, it can be concluded that the significance value of the experimental and control classes is greater than 0.05 so that Ho is rejected and Ha is accepted. So, the initial pretest data and the final pretest data are normally distributed. The homogeneity test was carried out by testing the results of the pretest and posttest of students to determine whether the data for both classes is homogeneous or not. The following are the results of the homogeneity test of the pretest and posttest data presented in Table 5.

Table 5. Output of the Results of the Pretest and Posttest Data Homogeneity Test.

Learning outcomes		Levence Statistic	df1	df2	Sig.
	Pretest	0.537	1	49	0.467
	Posttest	0.018	1	49	0.893

Based on Table 5, the significance value of the pretest results of both classes was 0.467 and the significance value of the posttest of both classes was 0.893. From the results obtained, it can be concluded that the sig value of the homogeneity test results of the pretest and posttest data of both classes is greater than 0.05 so that Ho is rejected and Ha is accepted, which means that the data is homogeneous or there is no difference between the experimental class and the control class. Based on the results of the prerequisite test, it 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 was carried out by testing the results of the pretest and posttest of students to determine the effectiveness of the Problem-Based Learning model assisted by Augmented Reality in the experimental class and the Problem-Based

Learning model of the teacher version assisted by PPT in the control class. The hypothesis test used in this study is the t-test and the N-Gain test. The following are the results of the t-test with the help of SPSS 25 presented in Table 6.

Table 6. T-Test Result Output

		Leven's Test for Equality of Variances		The t-test for equality of means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Result	Equal variances assumed	0.018	0.893	-4.876	49	0.000	-7.333	1.504	-10.355	-4.311
	Equal variances not assumed			-4.872	48.110	0.000	-7.333	1.505	-10.360	-4.307

Based on Table 6, the t-test for Equality of Mean has a significance value of 0.000, which is less than 0.05, so it is known that Ho is rejected and Ha is accepted. Thus, it can be concluded that the AR-assisted Problem-Based Learning learning model is effective compared to the PPT-assisted teacher-version Problem-Based Learning learning model for science learning outcomes in grade V of Gugus Mawar Elementary School, Semarang. The N-Gain test was conducted to calculate the increase in student learning outcomes before and after being given treatment in the experimental class and also the control class. The N-Gain test in this study used SPSS 25. The increase in pretest and posttest scores of grade V Gugus Mawar students in Semarang City can be seen in Table 7.

Table 7. Average Gain Test Results (N-Gain)

	Average		N-Gain	Category
Class	Pretest	Posttest		
Experiment	56.07	81.33	0.58	Currently
Control	47.92	74.00	0.50	Currently

Based on Table 7, it can be seen that there was an increase in the pretest value to the posttest value in the experimental group of 0.58, which is included in the moderate category. In the control class, there was an increase of 0.50, which is included in the moderate category. The following (Figure 2) is a diagram of the increase in pretest scores to posttest scores.

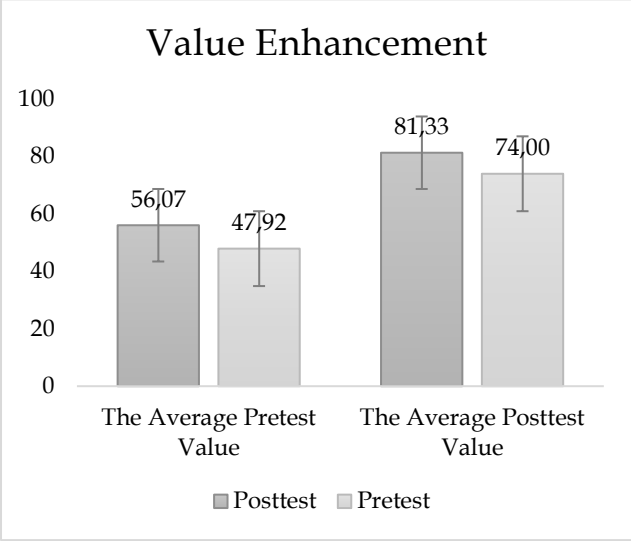

Figure 2. Pretest and Posttest Score Improvement Diagram

Based on Figure 2, both classes have almost the same initial abilities, but after being given different treatments where the experimental class was given treatment using the Problem-Based Learning model assisted by Augmented Reality there was a significant difference. The resulting increase was higher compared to the control class that implemented the Problem-Based Learning Model teacher version assisted by PPT.

Table 8. Results of the Summary of Teacher and Student Response Questionnaires

Respondent	Percentage (%)	Criteria
Teacher	85	Very Positive
Students	88	Very Positive

Based on the questionnaire responses to the model, media, materials and language from 13 questions using a Likert scale assessment of 1-4, it was found that

teachers and students strongly agreed on the use of the Problem-Based Learning model to increase student activity and cooperation in solving problems in learning. AR used as a medium that supports the learning process makes students enthusiastic and excited in participating in learning so that they can focus on learning. Teachers and students agree that the use of AR media is interesting and can improve student understanding. This certainly has a major impact on critical thinking skills and students' science learning outcomes on the material Light and its properties. The results of the data analysis showed that the science learning outcomes of grade V at SD Gugus Mawar increased with the AR-assisted PBL learning model. Several factors strengthen the results of this study, namely:

First, the Problem-Based Learning model can increase motivation and student activity so that their learning outcomes increase (Khakim et al., 2022; Prihatiningtyas & Astuti, 2024). PBL can also improve students' critical thinking skills to solve problems in real contexts and actively involve them in the learning process (Almulla, 2020; Gusti Alfiyanti & Erita, 2023; Jumhur et al., 2024). This helps them acquire new knowledge and skills (Aufa et al., 2021; Susino et al., 2023). The use of problem-based learning can also increase students' creativity in developing and finding solutions to problem solving (Safitri et al., 2023; Yu, 2024). Second, the use of Augmented Reality media by providing real 3D visualizations and providing interactive learning experiences makes students understand difficult concepts better so that it can increase learning effectiveness (Iskandar & Mayarni, 2022; Vari & Bramastia, 2021). The use of AR can increase student engagement, making it easier for them to remember and apply the information they have learned (O'Connor & Mahony, 2023; Radu et al., 2023; Amores-Valencia et al., 2023).

Third, the use of the Problem-Based Learning model assisted by Augmented Reality is certainly in accordance with the government's expectations in the learning process. Where the collaboration between this model and media can increase student interest and involvement in the learning process (Rihayati et al., 2023; Wiraha & Sudarma, 2023; Gopinathan et al., 2022). The use of this media-assisted model can also improve critical thinking and problem-solving skills assisted by the visual appearance of real learning media so that the combination of the two is effective in improving student learning outcomes (Ekayogi, 2023; Ulfah & Nasution, 2024; Guo et al., 2020).

Conclusion

Based on the discussion and findings conducted in this study, it can be concluded that the results of the questionnaire on the application of the Problem-Based Learning model assisted by Augmented Reality received a positive response from teachers and students. The application of the Problem-Based Learning model assisted by Augmented Reality is considered effective and has a higher average increase (N-Gain) of 0.58 while the teacher-assisted PBL version assisted by PPT has an increase of 0.50.

Acknowledgments
All praise be to Allah SWT for all His blessings and gifts, so that the author can complete this research well. The author's gratitude goes to the supervising lecturer and the relevant school parties who have taken the time and opportunity to help the author during this research process. The author would like to thank his family and friends for their prayers, support, and encouragement. The author's gratitude goes to all parties who helped this research.

Author Contributions
S. A. L, the first author, and N. S, the second author, collaborated to publish this research article. The authors have contributed to the paper by creating learning media and tools, conducting research, analyzing research data, and writing the article. The results have been evaluated and the final version of the manuscript was approved by the first author and the second author.

Funding
This research did not receive any external funding.

Conflicts of Interest
The publication of this article is very important for the author because it is a need for external research that requires publication in scientific journals as proof of performance. There is no conflict of interest in this research.

Reference

Agustira, Hamka, & Haeril. (2024). Pengaruh Penggunaan Smartphone Terhadap Hasil Belajar Siswa. *BEGIBUNG: Jurnal Penelitian Multidisiplin*, *2*(3), 96–104. https://doi.org/10.62667/begibung.v2i3.116

Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *Sage Open*, *10*(3), 2158244020938702. https://doi.org/10.1177/2158244020938702

Amirahma, S., & Setyasto, N. (2024). Development of Augmented Reality-Assisted Teaching Materials in Science Subjects: Solar System Topic. *Jurnal*

Penelitian Pendidikan IPA, *10*(5), 2346–2355. https://doi.org/10.29303/jppipa.v10i5.7027

Amores-Valencia, A., Burgos, D., & Branch-Bedoya, J. W. (2023). The Impact of Augmented Reality (AR) on the Academic Performance of High School Students. *Electronics*, *12*(10), 2173. https://doi.org/10.3390/electronics12102173

Aufa, M. N., Rusmansyah, R., Hasbie, M., Jaidie, A., & Yunita, A. (2021). The Effect of Using e-module Model Problem Based Learning (PBL) Based on Wetland Environment on Critical Thinking Skills and Environmental Care Attitudes. *Jurnal Penelitian Pendidikan IPA*, *7*(3), 401–407. https://doi.org/10.29303/jppipa.v7i3.732

Baabdullah, A. M., Alsulaimani, A. A., Allamnakhrah, A., Alalwan, A. A., Dwivedi, Y. K., & Rana, N. P. (2022). Usage of augmented reality (AR) and development of e-learning outcomes: An empirical evaluation of students' e-learning experience. *Computers & Education*, *177*, 104383. https://doi.org/10.1016/j.compedu.2021.104383

Dewi, C. A., Habiddin, H., Dasna, I. W., & Rahayu, S. (2022). Case-Based Learning (CBL) in Chemistry Learning: A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2219–2230. https://doi.org/10.29303/jppipa.v8i4.1971

Effendi, R., Herpratiwi, H., & Sutiarso, S. (2021). Pengembangan LKPD Matematika Berbasis Problem Based Learning di Sekolah Dasar. *Jurnal Basicedu*, *5*(2), 920–929. https://doi.org/10.31004/basicedu.v5i2.846

Ekayogi, I. W. (2023). Penerapan Problem Based Learning Berbantuan Media Augmented Reality untuk Meningkatkan Hasil dan Kemandirian Belajar. *Jurnal Didaktika Pendidikan Dasar*, *7*(1), 181–196. https://doi.org/10.26811/didaktika.v7i1.1126

Fransiska, J., Dumiyati, D., Mariam, P., Hikmah, N., & Haris, M. (2023). Education Management in the Independent Curriculum in Elementary Schools. *Al-Fikrah: Jurnal Manajemen Pendidikan*, *11*(1), 78. https://doi.org/10.31958/jaf.v11i1.8696

Gopinathan, S., Kaur, A. H., Veeraya, S., & Raman, M. (2022). The Role of Digital Collaboration in Student Engagement towards Enhancing Student Participation during COVID-19. *Sustainability*, *14*(11), 6844. https://doi.org/10.3390/su14116844

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, *102*, 101586. https://doi.org/10.1016/j.ijer.2020.101586

Gusti Alfiyanti, D., & Erita, Y. (2023). The Validity of Teaching Materials Using the Problem-Based Learning Model of Independent Curriculum Social Sciences Materials in Mobility Elementary Schools. *JOURNAL OF DIGITAL LEARNING AND DISTANCE EDUCATION*, *2*(1), 433–443. https://doi.org/10.56778/jdlde.v2i1.57

Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology Use for Teacher Professional Development in Low- and Middle-Income Countries: A systematic review. *Computers and Education Open*, *3*, 100080. https://doi.org/10.1016/j.caeo.2022.100080

Hidayat, H., Sukmawarti, S., & Suwanto, S. (2021). The application of augmented reality in elementary school education. *Research, Society and Development*, *10*(3), e14910312823. https://doi.org/10.33448/rsd-v10i3.12823

Iskandar, M. F., & Mayarni, M. (2022). Pengembangan Media Augmented Reality pada Materi Pengenalan Planet dan Benda Langit Pembelajaran IPA Sekolah Dasar. *Jurnal Basicedu*, *6*(5), 8097–8105. https://doi.org/10.31004/basicedu.v6i5.3730

Jumhur, A. A., Avianti, R. A., Nurfitri, P. E., & Mahir, I. (2024). Implementation of Problem-based Learning to Improve Critical Thinking Ability of Vocational Students in Jakarta. *European Journal of Education and Pedagogy*, *5*(5), 16–24. https://doi.org/10.24018/ejedu.2024.5.5.860

Khakim, N., Mela Santi, N., Bahrul U S, A., Putri, E., & Fauzi, A. (2022). Penerapan Model Pembelajaran Problem Based Learning Dalam Meningkatkan Motivasi Belajar PPKn Di SMP YAKPI 1 DKI Jaya. *Jurnal Citizenship Virtues*, *2*(2), 347–358. https://doi.org/10.37640/jcv.v2i2.1506

Marini, A., Nafisah, S., Sekaringtyas, T., Safitri, D., Lestari, I., Suntari, Y., Umasih, Sudrajat, A., & Iskandar, R. (2022). Mobile Augmented Reality Learning Media with Metaverse to Improve Student Learning Outcomes in Science Class. *International Journal of Interactive Mobile Technologies (iJIM)*, *16*(07), 99–115. https://doi.org/10.3991/ijim.v16i07.25727

Mulyadi, K., & Ratnaningsih, N. (2022). Analisis Pencapaian Dan Kendala Penerapan Problem Based Learning Pada Pembelajaran Tatap Muka Terbatas (PTMT). *J-KIP (Jurnal Keguruan Dan Ilmu Pendidikan)*, *3*(1), 37. https://doi.org/10.25157/j-kip.v3i1.7023

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

O'Connor, Y., & Mahony, C. (2023). Exploring the impact of augmented reality on student academic self-efficacy in higher education. *Computers in Human Behavior*, *149*, 107963. https://doi.org/10.1016/j.chb.2023.107963

Pratidina, N. A., Suriansyah, A., & Rafianti, W. R. (2024). Penggunaan Smartphone dalam Pembelajaran di Sekolah Dasar. *MARAS: Jurnal Penelitian Multidisiplin*, *2*(4), 2138–2145. https://doi.org/10.60126/maras.v2i4.575

Prihatiningtyas, M., & Astuti, T. (2024). The Effect the Canva Based Problem Based Learning Model on Student Motivation and Learning Outcomes in Science and Technology Subjects. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 5734–5740. https://doi.org/10.29303/jppipa.v10i8.7948

Radu, I., Huang, X., Kestin, G., & Schneider, B. (2023). How augmented reality influences student learning and inquiry styles: A study of 1-1 physics remote AR tutoring. *Computers & Education: X Reality*, *2*, 100011. https://doi.org/10.1016/j.cexr.2023.100011

Rihayati, I., Purnomo, Y. W., & Pamenan, M. S. (2023). Pengaruh Penerapan Problem Based Learning Berbantuan Augmented Reality terhadap Kemampuan Pemecahan Masalah Matematika. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(3), 2833. https://doi.org/10.24127/ajpm.v12i3.7027

Safitri, A., Chotimah, H., Hudha, A. M., & Rahardjanto, A. (2023). Application of Problem-Based Learning to Improve Problem Solving Skills and Creative Thinking Skills of Class XI Students. *JURNAL EKSAKTA PENDIDIKAN (JEP)*, *7*(2), 157–170. https://doi.org/10.24036/jep/vol7-iss2/757

Sakir, N. A. I., & Kim, J. G. (2020). Enhancing Students' Learning Activity and Outcomes via Implementation of Problem-based Learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(12), em1925. https://doi.org/10.29333/ejmste/9344

Sarnoko, S., Asrowi, A., Gunarhadi, G., & Usodo, B. (2024). An Analysis Of The Application Of Problem Based Learning (Pbl) Model In Mathematics For Elementary School Students. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 188–202. https://doi.org/10.22437/jiituj.v8i1.32057

Sofyan, S., Habibi, A., Sofwan, M., Yaakob, M. F. M., Alqahtani, T. M., Jamila, A., & Wijaya, T. T. (2023). TPACK–UotI: The validation of an assessment instrument for elementary school teachers. *Humanities and Social Sciences Communications*, *10*(1), 55. https://doi.org/10.1057/s41599-023-01533-0

Suciati, Imaningtyas, C. D., Octovi, C., & Yuliawanti, E. (2020). The effect of problem-based learning model to students' cognitive achievement on high and low students' problem-solving abilities. *Journal of Physics: Conference Series*, *1567*(4), 042040. https://doi.org/10.1088/1742-6596/1567/4/042040

Susino, S. A., Destiniar, D., & Sari, E. F. P. (2023). Pengaruh Model Pembelajaran Problem Based Learning (PBL) Terhadap Kemampuan Pemecahan Masalah Matematis Siswa Kelas X SMA. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *8*(1), 53–61. https://doi.org/10.31004/cendekia.v8i1.2918

Suwandi, A. F., Sahidu, H., & Gunada, I. W. (2021). Effectiveness of Problem-based Learning Model Devices with Multiple Intelligences Approach to Improve Learners' Physics Problem-Solving Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 238–243. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1064

Ulfah, I. F., & Nasution, H. (2024). Pengembangan Lembar Kerja Peserta Didik Berbasis Augmented Reality dengan Model Problem Based Learning untuk Meningkatkan Kemampuan Pemecahan Masalah. *Proximal: Jurnal Penelitian Matematika Dan Pendidikan Matematika*, *7*(2), 785–795. https://doi.org/10.30605/proximal.v7i2.4203

Vari, Y., & Bramastia, B. (2021). Pemanfaatan Augmented Reality Untuk Melatih Keterampilan Berpikir Abad 21 di Pembelajaran IPA. *INKUIRI: Jurnal Pendidikan IPA*, *10*(2), 132. https://doi.org/10.20961/inkuiri.v10i2.57256

Volioti, C., Orovas, C., Sapounidis, T., Trachanas, G., & Keramopoulos, E. (2023). Augmented Reality in Primary Education: An Active Learning Approach in Mathematics. *Computers*, *12*(10), 207. https://doi.org/10.3390/computers12100207

Wiraha, M. A., & Sudarma, I. K. (2023). Augmented Reality-Oriented Problem-Based Learning in Natural Science Materials. *International Journal of Elementary Education*, *7*(3), 458–466. https://doi.org/10.23887/ijee.v7i3.60618

Yu, H. (2024). Enhancing creative cognition through project-based learning: An in-depth scholarly exploration. *Heliyon*, *10*(6), e27706. https://doi.org/10.1016/j.heliyon.2024.e27706

Yunaini, N., Rukiyati, R., Prabowo, M., Hassan, N. M., & Hermansyah, A. K. (2022). The Concept of the Independent Learning Curriculum (Merdeka Belajar) in Elementary Schools in View Progressivism Educational Philosophy. *JIP Jurnal Ilmiah PGMI*, *8*(2), 95–105. https://doi.org/10.19109/jip.v8i2.14962

Zulfa, T., Tursinawati, T., & Darnius, S. (2023). Pengaruh Model Problem Based Learning (PBL) terhadap Hasil Belajar IPA Siswa di Sekolah Dasar. *Jurnal Basicedu*, *7*(4), 2111–2120. https://doi.org/10.31004/basicedu.v7i4.5451