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 of the Natural Sciences Subject of Plant Body Parts Material

Nova Dwiyanti[1*], Novi Setyasto[1]

[1] Elementary School Teacher Education, Faculty of Education and Psychology, Universitas Negeri Semarang, Semarang, Indonesia.

Received: January 10, 2025
Revised: February 11, 2025
Accepted: March 25, 2025
Published: March 31, 2025

Corresponding Author:
Nova Dwiyanti
dwiyantinova34@students.unnes.ac.id

DOI: 10.29303/jppipa.v11i3.10335

Abstract: The use of learning models and media that are not in accordance with Permendikbudristek Number 16 of 2022 concerning process standards has an impact on low student learning outcomes. This study examines the effectiveness of the Problem-Based Learning model assisted by Augmented Reality on the learning outcomes of class IV of SD Gugus Pringgodani, Banyumanik District, Semarang City. This study is included in the type of experimental research with a quasi-experimental design in the form of Nonequivalent Control Group Design. This study uses a purposive sampling method to take samples from students of SD Gugus Pringgodani, Banyumanik District, Semarang City. In this study, Prince Diponegoro Islamic Elementary School class IV C acted as the control class and class IV D as the experimental class. Initial data analysis techniques include normality and homogeneity tests and final data analysis with t-tests and N-Gain tests. The t-test results obtained a sig value of 0.000 (sig. <0.05), so H0 is rejected and Ha is accepted. The N-Gain test output of the experimental class is 0.57 and the control class is 0.38, so it can be concluded that the Problem-Based Learning model assisted by Augmented Reality is more effective than the Problem-Based Learning model that is not yet in according to the syntax assisted by image media on the learning outcomes of science subjects in grade IV of SD Gugus Pringgodani, Banyumanik District, Semarang City.

Keywords: Augmented reality; Learning model; Learning outcomes; Problem-based learning; Science

Introduction

Education is a conscious and planned effort to create a learning atmosphere and learning process so that students can actively develop their potential. According to the Regulation of the Minister of Education, Culture, Research and Technology of the Republic of Indonesia Number 16 of 2022 concerning Process Standards Article 9 Paragraphs (1) and (2), that the implementation of good learning is learning that is carried out interactively, inspiringly, fun, challenging, motivating students to actively participate, and providing sufficient space for initiative, creativity, independence according to the talents, interests, and physical and psychological development of students. The implementation of learning carried out by educators should provide an example, guidance, and facilities. In the process standards article 7 paragraph (2) point a, teachers are expected to be able to apply material to real problems or contexts. Teachers can carry out learning in the classroom that is problem-based and will later be solved by students. Then, appropriate learning is

How to Cite:
Dwiyanti, N., & Setyasto, N. The Effectiveness of the Problem-Based Learning Model Assisted by Augmented Reality on Learning Outcomes of the Natural Sciences Subject of Plant Body Parts Material. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 9-18. https://doi.org/10.29303/jppipa.v11i3.10335

learning that uses information and communication technology devices as a learning support. In the learning process, teachers should be able to create an interactive learning atmosphere, such as interaction between teachers and students, students with their learning environment, then teachers and students collaborate to foster a spirit of mutual cooperation.

However, in reality, learning that takes place in several schools is not in accordance with process standards. The problem that occurs is that there are no activities that encourage students to actively participate in the learning process and the learning model used is less innovative so that it has an impact on the attitude of students, namely they tend to be quiet and easily bored (Handayaningtyas, 2023; Milasari & Setyasto, 2023). Another problem found is that teachers have difficulty in implementing the Problem-Based Learning model. For example, there are still teachers who have difficulty with the syntax of the Problem-Based Learning model that will be carried out so that the syntax in the Problem-Based Learning model is not completely clear and smooth. The difficulties faced by teachers are in two main stages in problem-based learning, namely the syntax of student orientation to the problem, teachers have difficulty in choosing the right problem and in the syntax of organizing students to learn, teachers have difficulty in facilitating collaborative learning between students (Janah & Dimas, 2021). This results in a less effective learning process. Another problem is in choosing inappropriate learning media and minimal use of learning media during the learning process (Abdul Karim et al., 2020; Safitri & Kasriman, 2022). The use of smartphones is not optimal during classroom learning, because teachers still use smartphones as a means of communication even though smartphones can be used to create more interesting learning media.

These problems also occurred in the Pringgodani Cluster, Banyumanik District, Semarang City. Among them are, in class IV of SDN Srondol Wetan 05, SD Negeri Pedalangan 02, and SD Islam Pangeran Diponegoro. Based on the results of interviews with class IV teachers, questionnaires, and observations during learning in class IV which are part of the Pringgodani Cluster, they still apply the Problem-Based Learning model which is not in accordance with its syntax, seen from the learning process which is still centered on the teacher and tends to be dominated by the lecture method. This makes students passive in the learning process seen from students who tend to look bored and unenthusiastic during the learning process, such as when the teacher is explaining the material, some students look outside the classroom, often look at the clock, daydream, occasionally chat and joke with their deskmates, and are silent when the teacher tries to ask questions. Teachers tend to use existing media and around them that are easy to get and make, such as pictures in student books or pictures from the internet that are in accordance with the material to be taught and then printed and have not used technology optimally. Meanwhile, in science learning there is material that requires detailed visualization because the discussion in the student book is still shallow. For example, in the material on the process of photosynthesis and the process of pollination, although the material is close to students, some students may not have been able to see the process of photosynthesis and pollination directly, therefore a media is needed that can facilitate all students in the learning process. By using technology-based media, it will be able to provide visualization of the material to make it more interesting, close, and accessible to students, in addition to being able to add more complete material as knowledge for students, but teachers still use media around them and pictures.

The existence of facilities and infrastructure that are available and in good condition such as LCDs, Wi-Fi networks, and speakers have not been fully optimized by teachers. The use of LCDs is still alternating, so careful preparation is needed when using them and the Wi-Fi network used during computer classes and teacher activities in the office has not been used during the learning process. Meanwhile, students are already familiar with smartphones, supported by the results of filling out the questionnaire by students, as many as 87% already have smartphones that can be used to access the internet and the duration of smartphone use is more than 4 hours a day. The details of student smartphone use are as follows; 8% for studying, 45% for playing games, 31% for playing social media, 32% for watching YouTube. As many as 88% of students like using smartphones as a support for learning. This is reinforced by the results of filling out the parent questionnaire, as many as 75% of parents agree about allowing students to bring smartphones to school with the condition of teacher supervision. Based on the above, students can take advantage of using smartphones during the learning process with teacher supervision.

Based on observations of the results of learning in the 2023/2024 academic year at SD Gugus Pringgodani, Banyumanik District, Semarang City, namely at SDN Srondol Wetan 05, SD Negeri Pedalangan 02, and SD Islam Pangeran Diponegoro, it can be seen that the learning results are not yet optimal. From the data of the learning outcomes of grade IV students at SD Gugus Pringgodani in the subject of Science with a total of 110 students. The KKTP for Science content at SD Gugus Pringgodani is grade IV C & D SD Islam Pangeran Diponegoro 70, the number of students is 27 each, as many as 10 students (37%) in grade IV C have not met

the KKTP and in grade IV D there are 14 students (52%) who have not met the KKTP. Then at SD Negeri Pedalangan 02, with a KKTP of 75, the number of students is 28, as many as 20 students (71%) have not met the specified KKTP. Furthermore, at SDN Srondol Wetan 05, with a KKTP of 76, the number of students is 28, as many as 18 students (64%) have not met the specified KKTP.

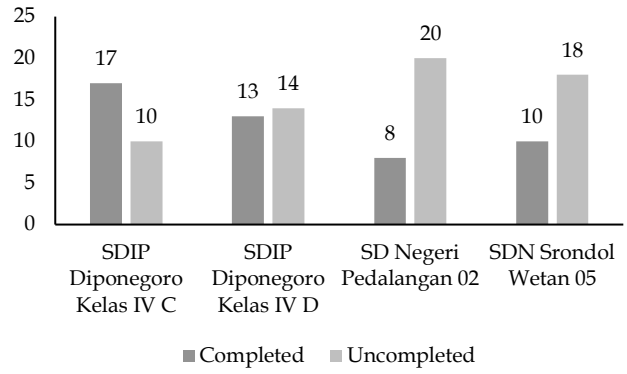

Figure 1. Graph of the completion of science learning outcomes

Based on the problems that occur, especially in science learning in class IV of SD Gugus Pringgodani, the learning that should occur is in accordance with Permendikbudristek Number 16 of 2022 concerning Process Standards, article 7 paragraph (2) point a, that in learning, material should be applied to real problems or contexts. According to Tanjung et al. (2022), the Problem-Based Learning model is a learning model that expects students to work on authentic problems to build their knowledge, develop curiosity, higher thinking skills, and develop independence and self-confidence. Problem-Based Learning helps students to train themselves to become independent learners and function effectively in their respective groups to solve real-world problems (Griffin, 2025). The problems used in the Problem-Based Learning model must be open, complex and authentic, namely problems that can motivate, interest and challenge students to learn. Problem-Based Learning enriches students' learning experiences by triggering high-level thinking activities so that it can improve their critical thinking skills.

Problem-Based Learning is a learning model that provides students with experiences to discover a concept and develop critical thinking skills, because this learning approach focuses on authentic problems and working together to solve these problems (Pertiwi et al., 2023). This learning model can improve students' critical thinking skills and learning outcomes (Cahyani et al., 2021). The role of the teacher as a facilitator, leader, and role model greatly influences the effectiveness of Problem-Based Learning (Ningsih & Rizki, 2024). In addition to developing students' critical thinking skills, the implementation of Problem-Based Learning also develops learning independence and social skills which result in students being active in acquiring their own knowledge (Mayasari et al., 2022). The Problem-Based Learning model has the advantage that students are involved in learning; practicing cooperation and discussion; finding solutions to problems with their own knowledge so that with these advantages it creates a quality learning atmosphere and further enhances the student experience. This is in line with the results of previous research which shows that students whose learning process uses the Problem-Based Learning model will improve their critical thinking skills. The results of other studies revealed that using the Problem-Based Learning model can increase student involvement so that the learning process becomes more qualified and meaningful, which has an impact on increasing student learning outcomes.

The use of learning media at SD Gugus Pringgodani, Banyumanik District, Semarang City, still uses image media and the use of technology that is not optimal. As a result, learning outcomes and student activity in the learning process are poor. In the learning process, especially in terms of learning media according to Permendikbudristek Number 16 of 2022 concerning Process Standards in article 7 paragraph (2) point d, learning that uses technology and communication devices as learning support. In utilizing technological advances in this era, educators must be technologically proficient in order to move towards innovative technology-based learning. The use of smartphones in learning has a positive impact, because students can access learning content that attracts attention and motivates students to learn. Learning materials and content can also be accessed anytime and anywhere. By seeing the potential and benefits, researchers utilize one of the technologies with great educational potential, namely augmented reality as a learning medium (Azizoon et al., 2025; Ratmaningsih et al., 2025). Augmented reality is a technology that enriches the real world with 3D virtual objects that users can rotate and interact with via a smartphone or tablet camera. Augmented reality learning media is a learning media that can increase student motivation and activeness in learning.

As in previous research related to augmented reality, this learning media can be used as a support in learning that can improve students' science learning outcomes. This augmented reality learning media also makes students more interested in participating in ongoing learning so that students become more active and understanding increases (Fajariyah & Hanik, 2024).

In this study, the problem-based learning model assisted by augmented reality is a problem-based learning model with augmented reality learning media on the material of plant body parts for grade IV elementary school. The syntax of the problem-based learning model used is according to Smeda et al. (2014), in the study as follows; student orientation to the problem, in this syntax the teacher and students together observe the learning video that has been prepared by the teacher, then the students provide responses and the teacher motivates the students to be actively involved and think critically in the problem-solving process , organize students to learn, the teacher directs students to discuss augmented reality-assisted worksheets in groups, previously the teacher has provided a tutorial on how to use augmented reality, guides individual and group investigations, in this case the teacher encourages students to solve problems through discussion and observation on augmented reality media of plant body parts, students can be active and work together in working on worksheets and take turns using smartphones if not all groups bring smartphones to access augmented reality, develop and present the results of the work, then students in groups collect information from the results of discussions and observations and prepare presentations, analyze and evaluate the problem-solving process, each group responds to the presentation by evaluating the answers of the presenting group.

When there is input from other groups and the answers are correct, the teacher directs students to draw conclusions on the problem. The learning media used is technology-based, namely augmented reality about plant body parts material created through the assembler edu application and accessed by students using smartphones or tablets. The visualization displayed by augmented reality increases students' understanding because it displays illustrations of the pollination process that are more complex and detailed than just looking at pictures. Augmented reality can facilitate students who have not been able to see the pollination process directly, so that augmented reality can provide a close and interesting experience for students. In addition, augmented reality can attract attention and increase student involvement, such as in the material on plant body parts and plant reproduction, because the visualization of objects displayed by augmented reality is interesting, can be clarified by rotating in all directions or enlarging, musically accompaniment that does not make you bored, practical use, and accompanied by information that provides more understanding to students compared to using pictures. Based on the existing description, the research to be conducted by the researcher aims to test the effectiveness of the problem-based learning model assisted by augmented reality on the learning outcomes of science subjects on plant body parts for grade IV at SD Gugus Pringgodani, Banyumanik District, Semarang City.

Method

This study is an experimental study with a quasi-experimental design in the form of Nonequivalent Control Group Design. The first step in this study is to provide a pretest to the experimental and control classes with the aim of determining the initial abilities of students. Then the experimental and control classes are given different learning treatments. In the experimental class, the treatment is given with a learning model that uses the Problem-Based Learning model assisted by augmented reality. Meanwhile, the control class is given treatment with learning using Problem-Based Learning which is not yet in accordance with the syntax with image media. At the end of the different learning treatments in each class, a posttest is given to determine whether there is an effect on learning outcomes in both classes. Below is a table of the form of research design used by the researcher.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Description:
O1: Pretest of experimental class
O2: Posttest of experimental class
O3: Pretest of control class
O4: Posttest of control class
X1: Learning treatment in experimental class using Problem-Based Learning model assisted by augmented reality.
X2: Learning treatment in control class using Problem-Based Learning model that is not yet in accordance with syntax assisted by image media.

The learning treatment was carried out in the subject of Natural Sciences, material on plant body parts, phase B with the following learning outcomes (CP). CP: Students can identify problems related to the preservation of natural resources in their surrounding environment and their relationship to efforts to preserve living things. The population used by the researcher was all students of grade IV of SD Gugus Pringgodani totaling 78 students. Therefore, the sample used in this study was 28 students in class IV D of SD Islam Pangeran Diponegoro in the 2023/2024 academic year, and 25 students in class IV C and D of SD Islam Pangeran Diponegoro in the 2024/2025 academic year. There are two variables in this study, namely the independent

variable (X) and the dependent variable (Y). In this case, the independent variable (X) is the augmented reality-assisted problem-based learning model. While the dependent variable (Y) is the results of learning science.

The hypothesis in this study is that the augmented reality-assisted problem-based learning model does not affect the results of learning science on the material of plant body parts at SD Gugus Pringgodani (H0).

The augmented reality-assisted problem-based learning model affects the results of learning science on the material of plant body parts at SD Gugus Pringgodani (Ha). The data collection technique in this study was using tests and non-tests. The test technique was carried out by providing a pretest and posttest, question validity test, reliability test, level of difficulty, and discrimination power. The results of the analysis of validity, reliability, discriminatory power, and level of difficulty can be seen in table 2.

Table 2. Results of the Analysis of Validity, Reliability, Discriminatory Power of Questions, and Level of Difficulty.

Analysis Aspect	Result
Question Validity	All 20 questions were declared valid
Question Reliability	0.822 (High)
Difficulty Level	5 Questions: Easy
Question Distinction Power	12 Questions: Medium

Based on the results of the analysis using excel in table 2 above, the pretest and posttest questions meet the criteria of validity, reliability, level of difficulty, and discrimination to be used in research. While non-test techniques are carried out by interview, observation, documentation, and distributing questionnaires. This study uses initial data analysis and final data analysis. Initial analysis is a prerequisite test that includes normality and homogeneity tests. While the final data analysis uses the independent t test and the N-Gain test.

Result and Discussion

Referring to the results of the experimental research that has been conducted at SD Islam Pangeran Diponegoro, where class IV C is the control class and class IV D is the experimental class in Gugus Pringgodani, Banyumanik District, Semarang City, there are several things that will be studied in the results and discussions, namely: pretest and posttest learning outcomes of students; 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 using the independent t-test; N-Gain test for experimental and control classes. The achievement of learning in science in this study is a learning outcome based on the results of the pretest and posttest of the experimental and control classes. Below are the learning outcomes based on the results of the pretest and posttest of the experimental and control classes.

Table 3. Cognitive Learning Outcomes

	N	Min.	Max.	Average	Completed (%)
Pretest					
Experiment	25	35	80	53	16
Control	25	30	70	47.40	4
Posttest					
Experiment	25	60	95	80.40	92
Control	25	50	85	67.20	48%

Based on Table 3, it can be seen that the cognitive learning outcomes of students taught using the Problem-Based Learning model assisted by augmented reality have a higher average result and percentage of completion compared to the cognitive learning outcomes of students taught using the Problem-Based Learning model that is not yet in accordance with the syntax assisted by image media, namely with an average of 80.40 and a percentage of completion of 92%. In this study, the normality test was assisted by using the SPSS 26 program. The pretest was given before the researcher gave treatment to the experimental and control classes. Then, after giving treatment to the experimental and control classes, the researcher gave a posttest. The normality test was used to examine the initial data and final data on the results of learning science on the material of plant body parts of grade IV students of SD Gugus Pringgodani, Banyumanik District, Semarang City. Whether it is normally distributed or not. Table 4 below is the result of the pretest and posttest data normality test.

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

		Shapiro-Wilk		
		Statistics	df	Sig.
Learning outcomes	Control Pretest	.959	25	.386
	Experimental Pretest	.968	25	.599
	Control Posttest	.941	25	.158
	Experimental Posttest	.946	25	.209

Based on the results of the pretest and posttest data normality test in Table 4, the experimental class pretest significance value was 0.599 and the control class was 0.386 which was tested using the Shapiro-Wilk method. Then, the experimental class posttest significance value was 0.209 and the control class was 0.158 which was tested using the Shapiro-Wilk method. It can be concluded that the significance value of all pretest and

posttest data for both the experimental and control classes is greater than 0.05 in the Shapiro-Wilk method, so the data is normally distributed. In the homogeneity test in this study, it was assisted by the SPSS 26 program. The homogeneity test uses the pretest and posttest values of students to determine whether the data is homogeneous or not. Table 5 below is the result of the homogeneity test.

Table 5. Homogeneity Test and Pretest and Posttest

		Lavene Statistic	df 1	df 2	Sig.
Based on Mean	Pretest	.939	1	48	.337
	Posttest	.756	1	48	.389

Based on the results of the homogeneity test of the pretest and posttest data of the experimental and control classes in table 5, the significance value of the pretest data of the two classes is 0.337. Meanwhile, the significance value of the posttest data of the two classes is 0.389. It can be concluded that the significance value of the pretest and posttest data of the two classes is greater than 0.05. Thus, the pretest and posttest data of the two classes are homogeneous. Based on the results of the normality test and the homogeneity test which are prerequisite tests, it can be concluded that the data in this study are normal and homogeneous. So that the hypothesis can be tested using the independent sample t-test. In this study, the hypothesis test was conducted to determine the effectiveness of the Problem-Based Learning model assisted by augmented reality in the experimental class and the Problem-Based Learning model that is not yet in accordance with the syntax assisted by image media in the control class through the posttest values of the two classes. The tests used in the hypothesis test in this study were the independent sample t-test and the N-Gain test. Table 6 below is the result of the independent sample t-test that has been tested using the SPSS 26 program.

Table 6. Results of the Independent Sample T-Test

		t-test for Equality of Means		
Result	Equal variances assumed	t	df	Sig. (2-tailed)
		4.315	48	0.000

Based on table 6, the results of the independent sample t-test, the sig. (2-tailed) value is 0.000 or less than 0.05, this means that the t-value is significant (0.000 <0.05). So, it can be concluded that H0 is rejected and Ha is accepted. This means that there is a significant difference in the average learning outcomes between students in the class that was given the Problem-Based Learning model treatment assisted by augmented reality and students in the class that was given the Problem-Based Learning model treatment that is not yet in accordance with the syntax assisted by image media. Thus, it can be concluded that the Problem-Based Learning model assisted by augmented reality is more effective in improving the learning outcomes of science in the material on plant body parts at SD Gugus Pringgodani, Banyumanik District, Semarang City, Central Java. The N-Gain test was conducted to determine the increase in cognitive learning outcomes of students before and after being given treatment in both research classes. The N-Gain test was assisted by the SPSS 26 program. Table 7 below is the result of the N-Gain test that has been carried out.

Table 7. Average Gain Results (N-Gain)

Class	Pretest	Posttest	N-Gain	Average Category
Experiment	53	80.40	0.57	Medium
Control	47.40	67.20	0.38	

Based on the results of the N-Gain test in table 7, it can be seen that both research classes have almost the same initial abilities. However, after being given different treatments, both research classes have different average increases (N-Gain) in learning outcomes. In the experimental class, the N-Gain value is 0.57 which is included in the moderate category. While in the control class, the N-Gain value is 0.38 which is included in the moderate category. This means that the learning outcomes of students in grade IV of SD Gugus Pringgodani, Banyumanik District, Semarang City who received learning treatment with the Problem-Based Learning model assisted by augmented reality have a higher average increase (N-Gain) compared to the learning outcomes of students who received learning treatment with the Problem-Based Learning model which is not yet in accordance with the syntax assisted by image media. This is supported by Laili et al. (2021) with their research showing that the use of problem-based learning models assisted by augmented reality can improve student learning outcomes, in line with Alisa et al. (2024) revealed that the use of problem-based learning models assisted by augmented reality is effective in improving students' understanding and learning outcomes.

Table 8. Results of Teacher and Student Response Questionnaire

Respondents	Percentage (%)	Criteria
Teachers	87	Very Positive
Students	94	Very Positive

Based on the results of filling out the response questionnaire in table 8, it shows a very positive response related to the application of the learning model and media used by students in the experimental class. The questionnaire covers 3 aspects, namely models,

learning media, materials and language. The assessment of this questionnaire uses a Likert scale calculation of 1-4 which has been filled out by teachers and students, based on their experiences when observing and receiving treatment in the experimental class. Students expressed that the learning model used can make them more active. Then, the use of augmented reality media can improve their understanding. This means that the use of a problem-based learning model assisted by augmented reality can make students more active in learning because problem solving requires active involvement of students. Visualization of 3D virtual objects in augmented reality can facilitate understanding and attract students' attention to the learning process (Yusa et al., 2023). Therefore, learning media assisted by augmented reality is very effective in supporting science learning activities in elementary schools (Sapira & Ansori, 2024).

Based on the results of data analysis, learning the problem-based learning model assisted by augmented reality is effective in improving the science learning outcomes of grade IV students of SD Gugus Pringgodani. The effectiveness is also strengthened by several factors. First, in the problem-based learning process, students are not just passive listeners in class. They are actively involved in completing worksheets that involve problem solving. This makes students more interested and directly involved in discussion activities. Each group member works together to complete the worksheets given by the teacher and also competes to be the first group to finish (Li et al., 2022). The use of problem-based learning models in learning makes students more creative because they solve problems and seek solutions to real-world problems in groups (Phungsuk et al., 2017; Weng et al., 2022). Second, the use of learning media that integrates technology such as augmented reality has proven successful in learning science material on plant body parts for grade IV elementary school (Anggriani et al., 2022; Strojny & Dużmańska-Misiarczyk, 2023; Iqbal et al., 2022). The use of augmented reality can improve students' understanding and learning abilities (Nindiasari et al., 2024; Darmawan et al., 2024; Endahati & Wardani, 2023). Because, this augmented reality media is able to visualize learning content more interactively and deeply while increasing student motivation and involvement in the learning process (AlGerafi et al., 2023; Wibowo, 2023; Zhao et al., 2023).

Thus, this media is one of the learning media that is able to create an interactive and meaningful learning environment (Song & Cai, 2024; Lestari, Winarsih, et al., 2023; Lestari, Murni Winarsih, et al., 2023). Third, the collaboration between the use of the problem-based learning model which is a problem-based learning model with the use of technology- based augmented reality media is certainly in accordance with the learning process in Permendikbudristek Number 16 of 2022 concerning Process Standards article 7 paragraph (2), learning is expected to be based on real problems or contexts and integrate technology in it. This means that the use of a problem-based learning model that is in accordance with syntax and centered on students, coupled with interesting object visualizations, can make students more active and interested in the learning process. Thus, student learning outcomes can improve. This study shows that the problem-based learning model assisted by augmented reality can support learning activities and is also effective in improving student learning outcomes. By adjusting the needs and challenges in the classroom, the problem-based learning model assisted by augmented reality has proven successful in improving student learning outcomes in science learning on plant body parts material for grade IV Elementary Schools.

Conclusion

Based on the results and discussions that have been carried out in this study, it can be concluded that the Problem-Based Learning model assisted by augmented reality is effective in improving the learning outcomes of students in grade IV of SD Gugus Pringgodani, Banyumanik District, Semarang City. In addition, the learning outcomes of students in science using the Problem-Based Learning model assisted by augmented reality experienced a higher average learning outcome. This is based on the results of hypothesis testing with the independent t-test and the average increase test (N-Gain). This study provides a positive contribution to science learning for students in grade IV of SD Islam Pangeran Diponegoro, Semarang City. This shows that the Problem-Based Learning model assisted by augmented reality can be an innovative solution in supporting the learning process in accordance with process standards.

Acknowledgments

Praise be to Allah SWT who has given ease so that this research can be completed well and smoothly. Thanks are also conveyed to the supervisor who has guided this research and to the schools that have allowed this research to be conducted. Thanks to family and friends for their prayers and support. Thanks to all who have contributed to this research.

Author Contributions

This research article was published thanks to the collaboration of the first author, N. D, and the second author, N. S. The authors' contributions to the article: creating learning media and tools; conducting research; analyzing data; and drafting

the article. All authors reviewed the results and approved the final version of the manuscript.

Funding
This research did not receive any external funding.

Conflicts of Interest
The author's interest in publishing this article is for the purpose of research output in the form of publication in a scientific journal as evidence of required performance. There is no conflict of interest.

References

Affandy, H., Sunarno, W., Suryana, R., & Harjana. (2024). Integrating creative pedagogy into problem-based learning: The effects on higher order thinking skills in science education. *Thinking Skills and Creativity*, *53*(June), 101575. https://doi.org/10.1016/j.tsc.2024.101575

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics*, *12*(18), 3953. https://doi.org/10.3390/electronics12183953

Alisa, Suwangsih, E., & Solihah, P. (2024). Pengaruh Model Problem Based Learning Berbantuan Augmented Reality (AR) Terhadap Peningkatan Kemampuan Pemahaman Matematika Siswa Kelas V Sekolah Dasar. *Jurnal Ilmiah Wahana Pendidikan*, *10*(2), 89–102. https://doi.org/10.5281/zenodo.10472526

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*(February), 101334. https://doi.org/10.1016/j.tsc.2023.101334

Anggriani, M. D., Haryanto, H., & Atmojo, S. E. (2022). The Impact of Problem-Based Learning Model Assisted by Mentimeter Media in Science Learning on Students' Critical Thinking and Collaboration Skills. *International Journal of Elementary Education*, *6*(2), 350–359. https://doi.org/10.23887/ijee.v6i2.46837

Arai, Y., Okanishi, T., Nakamura, Y., Ohta, K., Ueki, M., Kuramochi, I., & Maegaki, Y. (2025). Impact of problem-based learning on stigma toward epilepsy among medical students: An intervention verification study. *Epilepsy and Behavior*, *163*, 110200. https://doi.org/10.1016/j.yebeh.2024.110200

Azizoon, N. A. S., Ahmad, W. N. W., Fizal, Q. A., Rui, T. J., & Kamaruzaman, M. Y. (2025). iFoodAR: augmented reality for high school food design technology. *International Journal of Evaluation and Research in Education*, *14*(1), 406–414. https://doi.org/10.11591/ijere.v14i1.29702

Cahyani, H. D., Hadiyanti, A. H. D., & Saptoro, A. (2021). Peningkatan Sikap Kedisiplinan dan Kemampuan Berpikir Kritis Siswa dengan Penerapan Model Pembelajaran Problem Based Learning. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(3), 919–927. https://doi.org/10.31004/edukatif.v3i3.472

Darmawan, G. E. B., Parwati, N. N., Warpala, I. W. S., & Divayana, D. G. H. (2024). Augmented Reality Media to Improve Concepts Understanding and Biomotor Skills. *Jurnal Pedagogi Dan Pembelajaran*, *7*(1), 155–165. https://doi.org/10.23887/jp2.v7i1.67467

Dewi, T. N., Popiyanto, Y., & Yuliana, L. (2024). Pengaruh Media Augmented Reality Terhadap Hasil Belajar IPAS Siswa Kelas V Sekolah Dasar. *Indonesian Journal of Innovation Multidisipliner Research*, *2*(3), 212–219. https://doi.org/10.69693/ijim.v2i3.157

Endahati, N., & Wardani, S. (2023). Using Augmented Reality technology to improve English language learning by identifying objects around us. *English Language Teaching Educational Journal*, *6*(1), 73–83. https://doi.org/10.12928/eltej.v6i1.6497

Fajariyah, N., & Hanik, U. (2024). Pengembangan Media Beruang Berbasis Augmented Reality untuk Kelas 5 Sekolah Dasar. *Jurnal Basicedu*, *8*(2), 1524–1534. https://doi.org/10.31004/basicedu.v8i2.7346

Griffin, A. (2024). The pivot to online teaching: An opportunity to create effective problem-based learning environments for dietetic education. *Journal of Human Nutrition and Dietetics*, *January 2024*, 1–10. https://doi.org/10.1111/jhn.13378

Griffin, A. (2025). The pivot to online teaching: An opportunity to create effective problem-based learning environments for dietetic education. *Journal of Human Nutrition and Dietetics*, *38*(1), e13378. https://doi.org/10.1111/jhn.13378

Handayaningtyas, T. (2023). Upaya Meningkatkan Keaktifan Siswa Melalui Model Problem Based Learning Pada Mata Pelajaran IPA Di Sekolah Dasar. *Educational : Jurnal Inovasi Pendidikan & Pengajaran*, *3*(1), 118–124. https://doi.org/10.51878/educational.v3i1.2115

Iqbal, M. Z., Mangina, E., & Campbell, A. G. (2022). Current Challenges and Future Research Directions in Augmented Reality for Education. *Multimodal Technologies and Interaction*, *6*(9), 75. https://doi.org/10.3390/mti6090075

Janah, M., & Dimas, A. (2021). Kesulitan Guru SMP Dalam Mengimplementasikan Model Pembelajaran Discovery Learning Dan Problem

Based Learning. *Jurnal Tadris IPA Indonesia*, *1*(3), 420–426. https://doi.org/10.21154/jtii.v1i3.295

Karim, A., Savitri, D., & Hasbullah. (2020). Pengembangan Media Pembelajaran Matematika Berbasis Android Di Kelas 4 Sekolah Dasar. *Jurnal Lebesgue : Jurnal Ilmiah Pendidikan Matematika, Matematika Dan Statistika*, *1*(2), 63–75. https://doi.org/10.46306/lb.v1i2.17

Laili, A. M., & Nurmawati, R. (2021). Pengaruh Model Pembelajaran Pbl Berbantuan Media Assemblr Edu Terhadap Hasil Belajar IPA siswa. *Mathematic Education Journal*, *4*(3), 77. https://doi.org/10.24929/lensa.v14i2.555

Lestari, N., Murni Winarsih, & Dwi Kusumawardani. (2023). The Use of Meaningful Learning in Distance Learning. *JTP - Jurnal Teknologi Pendidikan*, *25*(1), 42–53. https://doi.org/10.21009/jtp.v25i1.33701

Lestari, N., Winarsih, M., & Kusumawardani, D. (2023). Research trends in meaningful learning in distance education environments: A review of articles published in Q1 to Q3 indexed journal from 2012 to 2022. *Jurnal Inovasi Teknologi Pendidikan*, *10*(2), 189–202. https://doi.org/10.21831/jitp.v10i2.56029

Li, J., Luo, H., Zhao, L., Zhu, M., Ma, L., & Liao, X. (2022). Promoting STEAM Education in Primary School through Cooperative Teaching: A Design-Based Research Study. *Sustainability*, *14*(16), 10333. https://doi.org/10.3390/su141610333

Mayasari, A., Arifudin, O., & Juliawati, E. (2022). Implementasi Model Problem Based Learning (PBL) Dalam Meningkatkan Keaktifan Pembelajaran. *Jurnal Tahsinia*, *3*(2), 167–175. https://doi.org/10.57171/jt.v3i2.335

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

Nindiasari, H., Pranata, M. F., Sukirwan, S., Sugiman, S., Fathurrohman, M., Ruhimat, A., & Yuhana, Y. (2024). The use of augmented reality to improve students' geometry concept problem-solving skills through the STEAM approach. *Infinity Journal*, *13*(1), 119–138. https://doi.org/10.22460/infinity.v13i1.p119-138

Ningsih, E. P., & Rizki, S. N. (2024). Peran Guru dalam Meningkatkan Keterampilan Berpikir Kritis Siswa Sekolah Dasar melalui Pembelajaran Berbasis Masalah. *Ludi Litterarri*, *1*(1), 11–17. https://doi.org/10.62872/y1t00a82

Pertiwi, F. A., Luayyin, R. H., & Arifin, M. (2023). Problem Based Learning Untuk Meningkatkan Keterampilan Berpikir Kritis: Meta Analisis. *JSE: Jurnal Sharia Economica*, *2*(1), 42–49. https://doi.org/10.46773/jse.v2i1.559

Phungsuk, R., Viriyavejakul, C., & Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences*, *38*(3), 297–306. https://doi.org/10.1016/j.kjss.2017.01.001

Ratmaningsih, N., Abdulkarim, A., Logayah, D. S., Anggraini, D. N., Sopianingsih, P., Adhitama, F. Y., & Widiawaty, M. A. (2025). Android-Based Augmented Reality Technology in the Application of Social Studies Textbooks in Schools. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *48*(1), 29–50. https://doi.org/10.37934/araset.48.1.2950

Safitri, R. L., & Kasriman, K. (2022). Pengaruh Media Audio Visual terhadap Hasil Belajar Materi Siklus Air pada Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(5), 8746–8753. https://doi.org/10.31004/basicedu.v6i5.3939

Sapira, & Ansori, I. (2024). Development of Science Learning Media Based on Augmented Reality Book with Problem Based Learning Model to Improve Learning Outcomes of Third Grade Students. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3249–3260. https://doi.org/10.29303/jppipa.v10i6.7642

Smeda, N., Dakich, E., & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: A comprehensive study. *Smart Learning Environments*, *1*(1), 6. https://doi.org/10.1186/s40561-014-0006-3

Song, H., & Cai, L. (2024). Interactive learning environment as a source of critical thinking skills for college students. *BMC Medical Education*, *24*(1), 270. https://doi.org/10.1186/s12909-024-05247-y

Strojny, P., & Dużmańska-Misiarczyk, N. (2023). Measuring the effectiveness of virtual training: A systematic review. *Computers & Education: X Reality*, *2*, 100006. https://doi.org/10.1016/j.cexr.2022.100006

Tanjung, S., Baharuddin, B., Ampera, D., Farihah, F., & Jahidin, I. (2022). Problem Based Learning (PBL) Model with Technological, Pedagogical, and Content Knowledge (TPACK) Approach. *International Journal of Education in Mathematics, Science and Technology*, *10*(3), 740–752. https://doi.org/10.46328/ijemst.2510

Weng, X., Chiu, T. K. F., & Tsang, C. C. (2022). Promoting student creativity and entrepreneurship through real-world problem-based maker education. *Thinking Skills and Creativity*, *45*, 101046. https://doi.org/10.1016/j.tsc.2022.101046

Wibowo, F. C. (2023). Effects of Augmented Reality Integration (ARI) based Model Physics Independent Learning (MPIL) for facilitating 21st-century skills (21-CS). *Journal of Technology and Science Education*, *13*(1), 178. https://doi.org/10.3926/jotse.1800

Yusa, I. W., Wulandari, A. Y. R., Tamam, B., Rosidi, I., Yasir, M., & Setiawan, A. Y. B. (2023). Development of Augmented Reality (AR) Learning Media to Increase Student Motivation and Learning Outcomes in Science. *Jurnal Inovasi Pendidikan IPA*, *9*(2), 127–145. https://doi.org/10.21831/jipi.v9i2.52208

Zaid, M., Razak, F., & Alam, A. A. F. (2022). Keefektifan Media Pembelajaran Augmented Reality Berbasis STEAM dalam Meningkatkan Kualitas Pembelajaran IPA di Sekolah Dasar. *Jurnal Pelita: Jurnal Pembelajaran IPA Terpadu*, *2*(2), 59–68. https://doi.org/10.54065/pelita.2.2.2022.316

Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). *Sage Open*, *13*(3). https://doi.org/10.1177/21582440231190821