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The Effectiveness of the Problem-Based Learning Model Assisted by Augmented Reality on Learning Outcomes of Natural and Social Sciences in Solar System Material

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Abstract: Learning models and media that are less in accordance with Permendikbudristek Number 16 of 2022 concerning Process Standards have an impact on low learning outcomes. This study examines the effectiveness of the Problem-Based Learning (PBL) model assisted by augmented reality (AR) on the learning outcomes of grade V science students at SD Gugus Kenanga, Songgom District, Brebes Regency. This type of research is experimental research with a Quasi Experiment design in the form of Nonequivalent Control Group Design. Data collection techniques were in the form of test techniques (pretest and posttest); non-test techniques, namely observation, interviews, questionnaires, and documentation. Initial data analysis techniques included normality and homogeneity tests and final data analysis with t-tests and N-Gain. The output of the t-test was in the form of sig. of 0.000 (sig. <0.05), so H_0 is rejected and H_a is accepted. The N-Gain test output of the experimental class is 0.60 and the control class is 0.32. In conclusion, the AR-assisted PBL model is effective and has a higher average increase compared to the teacher-assisted PBL model with image media on the learning outcomes of class V science science at SD Gugus Kenanga, Songgom District, Brebes Regency.

Keywords: Augmented Reality; Learning Outcomes; Learning Media; Learning Models; Problem-Based Learning.

Introduction

Education is a conscious and planned effort to create a learning environment and learning process that allows students to actively develop their potential. As in the Regulation of the Minister of Education, Culture, Research and Technology Number 16 of 2022 concerning Process Standards, Article 9 paragraph (1) & (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, assistance, and facilities. It is stated in the Process Standards, Article 7 paragraph (2) and Article 10 paragraph (2), that the learning material taught by teachers in the classroom should have been applied to real problems or contexts and the learning carried out should implement information and communication technology devices as learning support. In the learning process, teachers should create an interactive learning atmosphere, such as interaction between teachers and students, students and their learning environment, then there is good cooperation between teachers and students so that collaboration occurs that fosters a spirit of mutual cooperation.

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However, in reality, learning that takes place in several schools in Indonesia does not comply with process standards.

The problems that occur are the learning process that is less interactive and the learning model used is less innovative. In several Indonesian schools, it was found that teachers had difficulty in using the PBL model, especially in the PBL syntax itself.

Learning is still dominated by the role of the teacher, so students tend to be passive and silent during learning. This causes low cognitive, affective, and psychomotor learning outcomes (Aritonang & Moondra Zubir, 2022; Milasari & Setyasto, 2023; Nurkhasanah & Putrie, 2023). Another problem found is that teachers do not use IT-based learning media, teachers only use learning media that are considered easy. Some teachers in Indonesian schools tend not to use IT-based learning media to support learning, but rather use makeshift media. In fact, the main problem is that teachers do not use learning media in the learning process. These problems also occurred in grade V elementary schools that are part of the Kenanga Cluster, Songgom District, Brebes Regency, namely SD Negeri Karangsembung 01, SD Karangsembung 03, and SD Wanacala 02. Based on the results of interviews with grade V teachers, filling out questionnaires, observations, and documentation, in implementing learning in the classroom, the use of the PBL model used by teachers is not in accordance with the PBL syntax itself.

Teachers tend to only write the Problem-Based Learning model on the learning devices used without writing the syntax. It can be seen that teachers give provocative questions in the middle of the learning process, not at the beginning of learning. Thus, the problem-solving process by students is not coherent. Then, learning is still centered on the teacher. So that students do not get a direct problem-solving process and tend to be passive in learning. Based on the results of observations, students only sit quietly listening to their teachers when learning without good interactivity. Teachers tend to use media in the form of images in textbooks and have not integrated technology. In fact, abstract material that is difficult for students to reach, such as the solar system material in science learning, really needs good and real visualization (Istiqomah & Adi, 2024); (Didisyahrir et al., 2023). If the learning media used in the learning is only limited to images like those used by the teacher, then students will find it difficult to imagine the solar system material. The existence of supporting learning facilities and infrastructure such as LCDs, sound systems, and Wi-Fi networks, and smartphones have not been fully maximized by teachers.

The existence of LCDs tends to be used during teacher meetings, sound systems tend to be used for gymnastics only, Wi-Fi tends to be used to fill in administration in the office, and the use of smartphones tends to be used for communication. Based on the results of the smartphone ownership questionnaire by fifth-grade students in several elementary schools that are members of the Kenanga Cluster, as many as 106 out of 112 students (95%) have smartphones that can access the internet and can be used as a learning support. However, only 12 out of 112 students (11%) use smartphones for learning. In fact, 101 out of 112 students (90%) are very happy to study in class using smartphones. This is supported by the availability of 26 out of 30 parents of students if their children use smartphones for learning in class. This means that there is a very large potential in the use of information and communication technology devices as a learning support that has not been fully implemented by teachers. This has resulted in problems with the learning outcomes of fifth-grade students in elementary schools that are members of the Kenanga Cluster, Songgom District, Brebes Regency, Central Java.

Based on observations of the results of learning science in the 2023/2024 academic year at SD Gugus Kenanga, Songgom District, Brebes Regency, Central Java, namely at SD Negeri Karangsembung 01, SD Negeri Karangsembung 03, and SD Negeri Wanacala 02, learning results were seen to be less than optimal. At SD Negeri Karangsembung 01 with a total of 36 students, only 11 students out of 36 students (30.5%) managed to achieve the KKTP score. At SD Negeri Karangsembung 03 with a total of 28 students, only 12 students out of 29 students (41.4%) managed to achieve the KKTP score. At SD Negeri Wanacala 02 with a total of 20 students, only 9 students out of 20 students (45%) managed to achieve the KKTP score. From a sample of 3 elementary schools that are part of the Kenanga Cluster, with a total of 85 students, only 32 students (38%) were able to achieve the KKTP limit. The KKTP value used was 70.

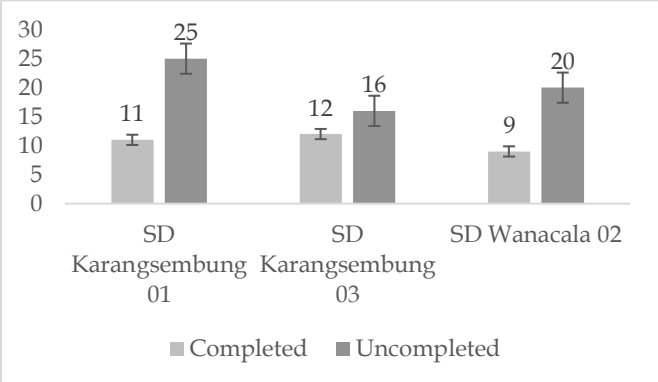

Figure 1. Graph of the completion of science learning outcomes

Based on the problems that occur, especially in science learning at SD Gugus Kenanga, the learning that should take place is learning as in the Process Standards article 7 paragraph (2) point a, that learning should be centered on real problems or contexts. The problem-based learning model is a learning model that provides a problem at the beginning of learning, so that students are able to solve the problem (Widyasari et al., 2024). Thus, the problem-based learning model can improve students' ability to think creatively and critically because in their learning, students are required to solve problems in real-world contexts. The problems used in this learning model are problems that exist in the real world, unstructured problems, presented as they are, and not solved just by listening to the information provided (Jatisunda & Nahdi, 2020; Mulyadi & Ratnaningsih, 2022).

The Problem-Based Learning learning model is an innovative and effective problem-based learning model to foster problem-solving skills and critical thinking, because in the Problem-Based Learning learning process, students' performance is maximized through systematic group activities (Hariyani, 2024). This learning model requires students to develop critical thinking skills, analysis, systematically and logically in finding solutions to the problems faced (Khakim et al., 2022). Teachers in the Problem-Based Learning learning model have a role as facilitators, guides, and as regulators of the problem-solving flow given to students. In addition to developing students' critical thinking skills, implementing learning with the Problem-Based Learning model can make students more active in learning because problem solving requires appropriate information and it is impossible for students to get it if students are passive in learning (Khusnun Nandifa et al., 2023; Rahmadana et al., 2023). So this activeness will make students have the ability to work together in their groups (Ramadhan, 2021).

The pattern of this Problem-Based Learning model is: giving students an authentic problem, the authentic problem is solved by students by looking for information relevant to the problem, students present the results of solving the problem, so that students are able to be involved during the learning process and are able to practice their ability to work together in solving problems with critical thinking skills. Previous research results show that students who are taught through the use of the Problem-Based Learning learning model will improve their critical thinking skills (Cahyani et al., 2021); (Risnawati et al., 2022). Other research results reveal that the Problem-Based Learning learning model can increase student involvement so that student learning outcomes increase significantly (Muhsam & Muh, 2022). The use of learning media at SD Gugus Kenanga, Songgom District, Brebes Regency, Central Java still tends to use only image media without integrating the use of technology in learning. As a result, student learning outcomes and activeness in learning are still low. The learning process, especially in terms of learning media as in the Process Standard Article 7 Paragraph (2) point d, is learning that implements information and communication technology devices as a learning support. In utilizing technological developments in education, educators must have a strong understanding of technology and be proficient in operating various methods, models, especially in the use of technology-based learning media (Mahbuddin, 2020; Nursyafitri et al., 2024). Based on smartphone ownership, student enthusiasm, and the availability of parents for their children who use smartphones for learning, researchers will implement learning that applies the use of technology in it. Researchers use augmented reality media as a learning medium.

Augmented reality learning media is a technology-based learning media that can be operated via smartphone. This learning media is a media that combines images, videos, audio, and text into a real display in the form of 2-dimensional or 3-dimensional animation (Faiza et al., 2022; Riskiono et al., 2020). This media is one of the learning media that can maximize the learning process in the classroom (Prabowo & Wakhudin, 2024). As in previous research related to augmented reality, this media can be used as a learning support that can improve students' science learning outcomes (Dewi et al., 2024). This augmented reality learning media can also make students more interested in participating in learning in the classroom. Thus, in the learning process, students will be more active and students' understanding of the material can be deeper (Ashari, 2023). In this study, the AR-assisted PBL model is a learning that integrates 5 PBL syntaxes, including; student orientation to the problem; organizing students to learn; guiding individual or group investigations; presenting work results; evaluating the problem-solving process.

In its implementation, namely in the second PBL syntax, students are divided into several groups and the teacher explains the implementation of group learning. Then, this AR media will help the PBL model, namely in the third PBL syntax. This AR media is used by students to find information asked in the LKPD on the solar system material. This AR media is able to project abstract solar system material. In one of the solar system materials, namely the revolution of the earth, AR can help project the movement of the solar system planets towards the solar system stars. students can directly understand the concept of the revolution of the earth and planets through the AR media. Based on the existing

description, the research that will 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 in solar system material for grade V in the Kenanga Cluster, Songgom District, Brebes Regency.

Method

This study is an experimental study with a quasi-experimental design and uses the nonequivalent control group design method. The first step in this study is to provide a pretest to the experimental class and the control class with the aim of determining the initial abilities of students. Then the experimental class and the control class are given different learning treatments. In the experimental class, the treatment is given with learning using the Problem-Based Learning model assisted by augmented reality media. Meanwhile, the control class is given treatment with learning using the Problem-Based Learning model assisted by 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 the two classes. Below is a table of the form of research design carried out by the researcher.

Table 1. Research Design

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

Description:
O1: pretest experimental class
O2: posttest experimental class
O3: pretest control class
O4: posttest control class
X1: learning treatment in the experimental class using the Problem-Based Learning model assisted by augmented reality.
X2: learning treatment in the control class using the Problem-Based Learning model teacher version assisted by image media.
The provision of learning treatment was carried out in the subject of Science, solar system material Phase C with the following learning outcomes (CP).
CP: Students understand the solar system and its relationship to the rotation and revolution of the earth.

The population used by the researcher was all grade V students of SD Gugus Kenanga as many as 60 students. Therefore, the sample used in this study was 12 students of grade V of SD Negeri Karangsembung 03 in the 2023/2024 academic year, 24 students of grade V of SD Negeri Karangsembung 03 in the 2024/2025 academic year, 24 students of SD Negeri Wanacala 02 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 Problem-Based Learning model assisted by augmented reality. Meanwhile, the dependent variable (Y) is the results of learning science.

The hypothesis in this study is that the Problem-Based Learning model assisted by augmented reality does not affect the results of learning science on the solar system material at SD Gugus Kenanga (H_0). The Problem-Based Learning model assisted by augmented reality affects the results of learning science on the solar system material at SD Gugus Kenanga (Ha). The data collection technique in this study was using test and non-test techniques. The test technique was carried out by giving a pretest and posttest. Before giving the pretest and posttest questions to the experimental and control classes, the researcher tested the validity, reliability, discrimination power, and level of difficulty of the 50 questions that had been created with the following test results.

Table 2. Results of Validity, Reliability, Distinction Power, and Level of Difficulty Tests

Test	Status	r count	Number of Questions
Validity	Valid		20
Reliability	Reliable	0,9317	20
	Very Good		4
Different Power	Good		10
	Fair		6
	Bad		0
Difficulty Level	Too difficult		0
	Difficult		2
	Too difficult		0
Difficulty Level	Difficult		2
	Currently		15
	Easy		3
	Too easy		0

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 test and homogeneity test. While the final data analysis uses t-test and N-Gain test.

Result and Discussion

Referring to the results of the experimental research that has been conducted at SD Negeri Karangsembung 03 as an experimental class and SD Negeri Wanacala 02 as a control class in Gugus Kenanga, Songgom District, Brebes Regency, 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 independent sample 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. Science Learning Outcomes

	N	Min.	Max.	Average	Completed (%)
Pretest					
Experiment	24	40	70	56.25	4.167
Control	24	40	70	55.63	4.167
Posttest					
Experiment	24	70	100	83.13	100
Control	24	60	80	70.21	66.67

Based on Table 3, it can be seen that the 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 learning outcomes of students taught using the Problem-Based Learning model assisted by image media, namely with an average of 83.13 and a percentage of completion of 100%. In this study, the normality test was assisted by using the SPSS 25 program. The pretest was given before the researcher gave treatment to the experimental class and the control class. Then, after giving treatment to the experimental class and the control class, the researcher gave a posttest. The normality test was used to examine the initial data and final data on the results of learning the science subject of the solar system of grade V students of SD Gugus Kenanga, Songgom District, Brebes Regency, whether they were normally distributed or not. Table 4 is the result of the normality test of the pretest and posttest data.

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

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistics	df	Sig.	Statistics	df	Sig.
Learning outcomes	Experiment Pretest	0.163	24	0.097	0.955	24	0.350
	Pretest Control	0.160	24	0.113	0.952	24	0.305
	Post-test Experiment	0.149	24	0.182	0.951	24	0.281
	Post-test Control	0.157	24	0.133	0.953	24	0.067

Based on the results of the normality test of the pretest and posttest data in Table 4, the pretest significance value of the experimental class was 0.097 and the control class was 0.113 which was tested using the Kolmogorov-Smirnov method. Meanwhile, the pretest significance value using the Shapiro-Wilk method for the experimental class was 0.350 and the control class was 0.305. Then, the posttest significance value of the experimental class was 0.182 and the control class was 0.133 which was tested using the Kolmogorov-Smirnov method. Meanwhile, the posttest significance value using the Shapiro-Wilk method for the experimental class was 0.281 and the control class was 0.067. 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 Kolmogorov-Smirnov and Shapiro-Wilk methods, so that H_0 can be accepted or the pretest data and posttest data are normally distributed. In the homogeneity test in this study, assisted by the SPSS 25 program. The homogeneity test uses the pretest and posttest scores of students to determine whether the data is homogeneous or not. Table 5 is the result of the homogeneity test.

Table 5. Output of Pretest and Posttest Data Homogeneity Test

		Levene			
Learning outcomes		Statistic	df1	df2	Sig.
Based on Mean	Pretest	0.032	1	46	0.860
	Post-test	3.176	1	46	0.081

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 0.860. Meanwhile, the significance value of the posttest data of the two classes is 0.081. It can be concluded that the significance value of the pretest and posttest data of the two classes are respectively 0.860 and 0.081 or the significance value is greater than 0.05. Thus, it can be concluded that 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 assisted by image media 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 is the result of the independent sample t-test that has been carried out using the SPSS 25 program.

Table 6. Output of Independent Sample T-Test Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval; of the Difference Lower	Upper
Result	Equal variances assumed	3.176	0.081	6.176	46	0.000	12.917	2.091	8.707	17.127
	Equal variances not assumed			6.176	42.742	0.000	12.917	2.091	8.698	17.135

Based on the output table of the independent sample t-test results in Table 6, the sig. value (2-tailed) 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 H_0 is rejected and H_a 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 assisted by image media. Thus, it can be concluded that the Problem-Based Learning model assisted by augmented reality is effective in improving the learning outcomes of science in solar system material at SD Gugus Kenanga, Songgom District, Brebes Regency. The N-Gain test was conducted to determine the increase in student learning outcomes before and after treatment in both research classes. The N-Gain test was assisted by the SPSS 25 program. Table 7 is the result of the N-Gain test that has been conducted.

Table 7. Average Gain Results (N-Gain)

	Average			
Class	Pretest	Posttest	N-Gain	Category
Experiment	56.25	83.13	0.6057	Medium
Control	55.63	70.21	0.3273	Medium

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 0.6057 which is included in the moderate category. While in the control class, the N-Gain value is 0.3273 which is included in the moderate category. This means that the results of learning science of grade V students of SD Gugus Kenanga, Songgom District, Brebes Regency who received learning treatment with the Problem-Based Learning model assisted by augmented reality have a higher average increase (N-Gain) compared to the average increase (N-Gain) learning outcomes of students who received learning treatment with the Problem-Based Learning model assisted by image media (Asmaniah & Wati, 2024; Al-Qoyyim et al., 2024).

Based on the results of filling out the response questionnaire on the learning model and media used in the experimental class students, as many as 20 students filled in "agree" and 4 students filled in "strongly agree" that the learning model used can make students more active. Then, on the indicator of the use of AR-assisted media, as many as 8 students filled in "strongly agree" and 16 students filled in "agree" that the use of AR-assisted media can improve student understanding. Then, on the results of filling out the response questionnaire on the use of the AR-assisted PBL model by teachers, on the indicators of student involvement and student understanding of the material, the teacher filled in the indicators with a maximum of 4 points for each indicator.

This means that the use of the Problem-Based Learning model assisted by augmented reality can make students more active in learning because problem solving requires appropriate information and is

impossible for students to obtain if students are passive in learning (Ang et al., 2021; Pimdee et al., 2024) and the use of AR can improve student understanding as indicated by increased student learning outcomes (Radu et al., 2023; O'Connor & Mahony, 2023). Based on the results of data analysis, AR-assisted PBL learning models are effective in improving the learning outcomes of grade V science students at SD Gugus Kenanga. This effectiveness is also strengthened by several factors. First, the Problem-Based Learning model can make students more active in learning because problem solving requires appropriate information and is impossible for students to obtain if students are passive in learning so that students are more active in participating in the learning process (Márquez et al., 2023; Al Shloul et al., 2024). The use of the Problem-Based Learning model in learning makes students much more creative and uses critical thinking skills in solving problems because the problems used are problems in students' daily lives or in real contexts (Dianita, 2023; Setyowidodo et al., 2019).

Second, the use of media that integrates technology such as augmented reality makes students understand the material more deeply (Pamungkas, 2020; Zhao et al., 2023). Because, this augmented reality media is able to visualize material into 3-dimensional images which can also increase student involvement in learning (Zakirman et al., 2023; Yusa et al., 2023; I Putu Gilang Leo Agusta, 2022). So, this media is one of the learning media that can maximize the learning process in the classroom (Widiasanti 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 augmented reality media is certainly a learning process that is in accordance with the Process Standards article 7 paragraph (2), that learning should be centered on real problems or contexts, and integrate technology in it. This means that the use of a student-centered PBL model coupled with good visualization of the material and student involvement in it, can make students more interested in carrying out the learning process. Thus, student learning outcomes can improve well (Sukackė et al., 2022).

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 received a positive response based on the response questionnaire distributed to teachers and students. In addition, the Problem-Based Learning model assisted by augmented reality is effective and has a higher average increase (N-Gain) compared to the Problem-Based Learning model version of the teacher assisted by image media on the learning outcomes of science and technology on the solar system material of class V SD Gugus Kenanga, Songgom District, Brebes Regency.

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The author's interest in publishing this article is as a research output requirement in the form of scientific journal publication as evidence of required performance. In this study, there is no conflict of interest.

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Al Shloul, T., Mazhar, T., Abbas, Q., Iqbal, M., Ghadi, Y. Y., Shahzad, T., Mallek, F., & Hamam, H. (2024). Role of activity-based learning and ChatGPT on students' performance in education. *Computers and Education: Artificial Intelligence*, *6*, 100219. https://doi.org/10.1016/j.caeai.2024.100219

Al-Qoyyim, T. M., Wahyudi, W., Gunawan, G., & Doyan, A. (2024). The Influence of Problem Based Learning Model Assisted by Video on Student's Problem-Solving Skills in Static Fluid Material. *Journal of Science and Science Education*, *5*(1), 22–30. https://doi.org/10.29303/jossed.v5i1.7382

Ang, K. C. S., Afzal, F., & Crawford, L. H. (2021). Transitioning from passive to active learning: Preparing future project leaders. *Project Leadership and Society*, *2*, 100016. https://doi.org/10.1016/j.plas.2021.100016

Aritonang, H. W. & Moondra Zubir. (2022). Perbedaan hasil belajar dan motivasi belajar siswa dengan menggunakan model PBL dan pembelajaran konvensional berbantuan media iSpring pada materi laju reaksi. *Educenter : Jurnal Ilmiah*

Pendidikan, *1*(8), 572–578. https://doi.org/10.55904/educenter.v1i8.107

Ashari, D. (2023). Analisis Pemanfaatan Media Pembelajaran Augmented Reality (AR) Untuk Meningkatkan Keterampilan Berpikir Kritis. *Khazanah Pendidikan*, *17*(1), 176. https://doi.org/10.30595/jkp.v17i1.16040

Asmaniah, T. G., & Wati, R. (2024). Powtoon Interactive Media with a Problem Based Learning Model on Student Learning Outcomes and Interests in Plane figure. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *8*(1), 326–339. https://doi.org/10.31004/cendekia.v8i1.2424

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

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

Dianita, B. (2023). Problem Based Learning Model with Experiential Learning to Increase Creative Thinking and Critical Thinking Ability. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *7*(2), 328–335. https://doi.org/10.23887/jppp.v7i2.62254

Didisyahrir, D., Firman, & Desyandri. (2023). The Effectiveness of Media Technology Assisted Webbed Thematic Learning Model on Learning Outcomes in Social Studies, Healthy Food Theme of Students in Class V. *Journal of Digital Learning and Distance Education*, *2*(1), 423–432. https://doi.org/10.56778/jdlde.v2i1.70

Faiza, M. N., Yani, M. T., & Suprijono, A. (2022). Efektivitas Penggunaan Media Pembelajaran IPS Berbasis Augmented Reality untuk Meningkatkan Kompetensi Pengetahuan Siswa. *Jurnal Basicedu*, *6*(5), 8686–8694. https://doi.org/10.31004/basicedu.v6i5.3901

Hariyani, S. (2024). Penerapan Model Problem-Based Learning untuk Meningkatkan Kemampuan Berpikir Kritis. *Buletin Pengabdian Multidisiplin*, *1*(1), 51–55. https://doi.org/10.62385/budimul.v1i1.97

I Putu Gilang Leo Agusta. (2022). Media Augmented Reality untuk Meningkatkan Literasi Sains dan Kemampuan Metakognitif Kelas V SD. *Journal for Lesson and Learning Studies*, *5*(2), 300–308. https://doi.org/10.23887/jlls.v5i2.50531

Istiqomah, I., & Adi, B. S. (2024). The Effect of Using Powtoon Animation Learning Media on Solar System Material on the Learning Outcomes of Class VI Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1450–1457. https://doi.org/10.29303/jppipa.v10i3.5909

Jatisunda, M. G., & Nahdi, D. S. (2020). Kemampuan Pemecahan Masalah Matematis melalui Pembelajaran Berbasis Masalah dengan Scaffolding. *Jurnal Elemen*, *6*(2), 228–243. https://doi.org/10.29408/jel.v6i2.2042

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

Khusnun Nandifa, N., Nuvitalia, D., Azizah, M., & Saraswati, D. (2023). Penerapan Model Problem Based Learning Untuk Meningkatkan Hasil Belajar Peserta Didik Kelas 1 Mata Pelajaran Bahasa Indonesia di SD Negeri Sawah Besar 01. *Didaktik : Jurnal Ilmiah PGSD STKIP Subang*, *9*(2), 4019–4031. https://doi.org/10.36989/didaktik.v9i2.1069

Mahbuddin, A. N. G. (2020). Model Integrasi Media dan Teknologi dalam Pembelajaran PAI. *Al-Mudarris (Jurnal Ilmiah Pendidikan Islam)*, *3*(2), 183–196. https://doi.org/10.23971/mdr.v3i2.2312

Márquez, J., Lazcano, L., Bada, C., & Arroyo-Barrigüete, J. L. (2023). Class participation and feedback as enablers of student academic performance. *Sage Open*, *13*(2), 21582440231177298. https://doi.org/10.1177/21582440231177298

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

Muhsam, J., & Muh, A. S. (2022). Penerapan Model Pembelajaran Problem Based Learning (PBL) Dalam Meningkatkan Hasil Belajar IPA Siswa Kelas IV Sekolah Dasar. *Jurnal Inovasi Pendidikan Dan Teknologi Informasi (JIPTI)*, *3*(1), 11–17. https://doi.org/10.52060/pti.v3i01.713

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

Nurkhasanah, S., & Putrie, C. A. R. (2023). Perbedaan Model Pembelajaran Project based Learning dan Model Konvensional terhadap Kemampuan Berpikir Kreatif Siswa Kelas VII SMPN 1 Wirosari.

FOCUS, *4*(1), 17–22. https://doi.org/10.37010/fcs.v4i1.979

Nursyafitri, A. A., Isrok'atun, I., & Hanifah, N. (2024). Pengaruh Penggunaan Media Pembelajaran Berbasis Augmented Reality terhadap Motivasi Belajar Siswa. *Jurnal Syntax Admiration*, *5*(5), 1750–1763. https://doi.org/10.46799/jsa.v5i5.1161

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

Pamungkas, T. D. (2020). Android-based augmented reality media and the curiosity about mathematics. *Journal of Physics: Conference Series*, *1663*(1), 012016. https://doi.org/10.1088/1742-6596/1663/1/012016

Pimdee, P., Sukkamart, A., Nantha, C., Kantathanawat, T., & Leekitchwatana, P. (2024). Enhancing Thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms. *Heliyon*, *10*(7), e29172. https://doi.org/10.1016/j.heliyon.2024.e29172

Prabowo, E., & Wakhudin, W. (2024). Pengembangan Media Augmenteded Reality (AR) untuk Meningkatkan Motivasi Belajar Siswa pada Mata Pelajaran IPAS Kelas 4 SD Negeri 3 Linggasari. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(2), 591–604. https://doi.org/10.53299/jppi.v4i2.552

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

Rahmadana, J., Khawani, A., & Roza, M. (2023). Penerapan Model Problem Based Learning untuk Meningkatkan Kemampuan Berpikir Kritis Peserta Didik Sekolah Dasar. *Jurnal Basicedu*, *7*(1), 224–230. https://doi.org/10.31004/basicedu.v7i1.4278

Ramadhan, I. (2021). Penggunaan Metode Problem Based Learning dalam meningkatkan keaktifan belajar siswa pada kelas XI IPS 1. *Cetta: Jurnal Ilmu Pendidikan*, *4*(3), 358–369. https://doi.org/10.37329/cetta.v4i3.1352

Riskiono, S. D., Susanto, T., & Kristianto, K. (2020). Augmented reality sebagai Media Pembelajaran Hewan Purbakala. *Krea-TIF*, *8*(1), 8. https://doi.org/10.32832/kreatif.v8i1.3369

Risnawati, A., Nisa, K., & Oktaviyanti, I. (2022). Pengaruh Model Pembelajaran Problem Based Learning terhadap Kemampuan Berpikir Kritis Siswa Kelas V Pada Tema Kerukunan dalam Bermasyarakat SDN Wora. *Jurnal Ilmiah Profesi Pendidikan*, *7*(1), 109–115. https://doi.org/10.29303/jipp.v7i1.426

Setyowidodo, I., Sutanto, Handayani, A. D., & Mahmudi, H. (2019). Problem based learning in mechanical engineering to train student's creativity. *Journal of Physics: Conference Series*, *1280*(5), 052072. https://doi.org/10.1088/1742-6596/1280/5/052072

Sukackė, V., Guerra, A. O. P. D. C., Ellinger, D., Carlos, V., Petronienė, S., Gaižiūnienė, L., Blanch, S., Marbà-Tallada, A., & Brose, A. (2022). Towards Active Evidence-Based Learning in Engineering Education: A Systematic Literature Review of PBL, PjBL, and CBL. *Sustainability*, *14*(21), 13955. https://doi.org/10.3390/su142113955

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

Widyasari, D., Miyono, N., & Saputro, S. A. (2024). Peningkatan Hasil Belajar melalui Model Pembelajaran Problem Based Learning. *Jurnal Inovasi, Evaluasi Dan Pengembangan Pembelajaran (JIEPP)*, *4*(1), 61–67. https://doi.org/10.54371/jiepp.v4i1.368

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

Zakirman, Z., Sukmayadi, D., Widiasih, W., & Risha, N. (2023). The Potential for The Development of Augmented Reality Media to Increase Student Understanding of Earthquake Material. *Jurnal Ilmiah Profesi Pendidikan*, *8*(4), 2173–2183. https://doi.org/10.29303/jipp.v8i4.1672

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), 21582440231190821. https://doi.org/10.1177/21582440231190821