Problem-based learning and its contribution to the analytical skills of 5th grade students in science learning

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ABSTRACT

Analytical skills are essential for students to understand scientific concepts and solve problems effectively. However, conventional learning methods often fail to optimally develop these skills in elementary school students. This research aims to analyze the effect of the problem-based learning (PBL) model on the analytical skills of fifth-grade students in science learning. The method used is a quasi-experimental design with a matching pretest-posttest control group design. The sample of this study consists of two classes, namely the experimental class that applies the PBL model and the control class that uses conventional learning methods. Data collection was conducted through descriptive tests to assess students' analytical skills and observation sheets to determine the implementation of PBL. The results of the study indicate that there is a significant difference in improving analytical skills between students who learn using the PBL model compared to those who use conventional methods. Therefore, the PBL model can be an alternative to enhance students' analytical skills in science learning. These findings implied that integrating PBL into the curriculum can support the development of higher-order thinking skills in elementary education.

1. Introduction

Education is the process of acquiring skills. Education provides every individual with academic knowledge, skills, and the ability to explore themselves (Puspita et al., 2023). Education has materials or learning models in schools. Education is a conscious and planned effort to create a learning atmosphere and a learning process so that students actively develop their potential (Krismayoni & Suarni, 2020). Education also plays a role in shaping the character and personality of individuals in accordance with the values adopted in society (Adnan, 2022; Khaidir & Suud, 2020). Through education, a person can develop social and emotional skills that support success in life (Guo et al., 2025; Váradi, 2022).

The study of Natural Sciences is the science that studies living beings from all processes of their life (Widodo et al., 2022). Natural Sciences is often referred to as the science that studies natural phenomena occurring in the surrounding environment (Sakila et al., 2023). Natural Sciences is one of the subjects related to natural knowledge systematically, which is directly related to the surrounding nature (Nikmah et al., 2020). The learning of Natural Sciences can be used as a process that is utilized to solve problems that occur, as a project in the form of facts, principles, or theories, and as an application in applying scientific methods (Eka et al., 2021).

The PBL model actively engages students in addressing real-world problems, thereby enhancing their analytical skills and promoting meaningful learning experiences. By moving beyond

passive receipt of information, PBL encourages students to apply their existing knowledge to solve authentic challenges, which has been shown to improve critical thinking, problem-solving, and creativity (Ernawati et al., 2023; Sakir & Kim, 2020). The advantages of PBL include creating meaningful lessons, where students learn through the process of solving problems that will be applied to the knowledge they have, and students strive to understand the knowledge needed (García et al., 2024; Vargas-Hernández & Vargas-González, 2022). The implementation of the PBL model used by teachers has several stages of learning, which are referred to as the syntax of PBL (Darussyamsu et al., 2024; Sajidan et al., 2022).

The PBL process typically encompasses several key stages: identifying real problems, organizing relevant tasks, facilitating both individual and collaborative investigations, developing and presenting solutions, and evaluating the problem-solving approach (Kasuga et al., 2022; Silvita et al., 2024). Effective implementation of PBL relies on teachers creating a supportive learning environment that fosters active participation and enhances students' analytical skills (Kasuga et al., 2022; Setyono et al., 2018). Research indicates that integrating PBL into the curriculum significantly enhances student engagement and yields better educational outcomes, equipping them with essential 21st-century skills (Al Said et al., 2019). Furthermore, authentic assessments within PBL frameworks can provide valuable insights into students' cognitive processes and learning trajectories (Herianingtyas et al., 2023). In essence, the structured nature of the PBL model not only facilitates the development of critical skills but also allows students to bridge theory and practice in their learning journeys.

Analytical skills are cognitive abilities that can be trained through relevant learning models (Astriani et al., 2018). This analytical ability is applied so that students can interpret, analyze, evaluate, argue, and solve problems; these skills can facilitate students in understanding the learning process (Shofiya & Wulandari, 2018). These analytical skills need to be possessed by both teachers and students to improve their learning outcomes. The indicators of analytical skills impact students' learning abilities in remembering, understanding, applying, and analyzing (Dasopang, 2021). Teachers have an important role in creating a pleasant learning atmosphere and encouraging students' analytical abilities in solving problems effectively (Sukowati & Harjono, 2023). Thus, this model not only improves students' conceptual understanding, but also trains critical (Seibert, 2021; Sumarni & Kadarwati, 2020; Wale & Bishaw, 2020) and collaborative thinking skills (Putri et al., 2023).

Elementary school students' analytical skills based on Anderson's taxonomy indicators, especially at level C4, enable them to understand and solve problems more deeply. This ability can be identified through three cognitive aspects proposed by Anderson and Krathwohl, namely distinguishing, organizing, and connecting attributes. In the context of elementary education, these analytical skill indicators are adjusted to the stage of students' cognitive development, so that they can accommodate achievements that are relevant to their age and level of understanding. This research aims to determine the implementation of PBL in science learning for fifth-grade elementary school students, to describe the analysis skills of students in science learning after using the PBL model, and to measure the impact of the PBL model on the analysis skills in science learning.

2. Method

2.1. Research design

This study employed a quantitative approach with a quasi-experimental design using a Non-Equivalent Control Group Design. The research involved two fifth-grade classes: an experimental class implementing the PBL model and a control class using conventional teaching methods. Both groups underwent a pretest to assess their initial analytical skills before the intervention. Data were collected through observation sheets to evaluate PBL implementation and written tests to measure students' analytical skills. Descriptive statistical analysis was conducted to assess learning implementation, while normality, homogeneity, and independent t-tests were used to examine differences between the two groups. This quasi-experimental approach was chosen to establish a causal relationship between PBL and students' analytical skills while maintaining external validity for broader educational contexts.

2.2. Participants

This research involved 54 elementary school students divided into two groups in the fifth grade. Then, both groups were randomized to determine the experimental class group and the control class group. A sample of 27 students was obtained for the experimental class and 27 students for the control class. Simple random sampling was used so that the research results could be generalized to other potentially similar conditions.

2.3. Data collection tools

Data were collected using observation sheets and written tests. The observation sheet, designed with a Guttman scale, was used to evaluate the implementation of the PBL model and its impact on students' analytical skills. This structured approach allowed for an in-depth analysis of students' engagement and participation in PBL. The observation data provided a comprehensive overview of how effectively the PBL model was implemented in the classroom. Additionally, written tests were administered to assess students' analytical skills in science learning. The tests included essay questions designed to evaluate students' ability to distinguish, organize, and attribute information. The validity and reliability of the test instruments were ensured to maintain measurement accuracy. Factors such as question construction, test instructions, and scoring criteria were carefully considered to ensure the quality of the assessment. These combined methods provided a robust framework for analyzing the effectiveness of PBL in enhancing analytical skills among fifth-grade students (Maryani et al., 2022).

2.4. Research procedure

This study employed a quasi-experimental method with a Non-Equivalent Control Group Design to examine the effect of the PBL model on the analytical skills of fifth-grade students in science learning. The research was conducted at Muhammadiyah Elementary School of Karangkajen from March to December 2024. The sample was selected using random sampling techniques and consisted of two classes: an experimental class, which received instruction using the PBL model, and a control class, which followed conventional teaching methods. The research procedure began with a pretest administered to both classes to assess students' initial analytical skills. The experimental class was then taught using the PBL model, while the control class continued with traditional instruction. After completing the learning process, both groups took a post-test to measure improvements in their analytical skills. Data were collected using two main instruments: descriptive tests to evaluate students' analytical skills and observation sheets to assess the implementation of the PBL model in the learning process. Data analysis involved descriptive statistics to evaluate PBL implementation and prerequisite tests, including the Shapiro-Wilk normality test to check data distribution and the Levene test to assess variance homogeneity. An Independent Sample t-test was conducted to compare pretest and post-test results between the experimental and control groups. The findings of this study are expected to provide insights into the effectiveness of the PBL model in enhancing students' analytical skills in science learning.

2.5. Data analysis technique

Data analysis was conducted using descriptive statistics to evaluate the implementation of the PBL model. Prerequisite tests included the Shapiro-Wilk normality test to assess whether the data were normally distributed and the Levene test to ensure homogeneity of variances across groups. To test the research hypothesis, an Independent Sample t-test was performed to compare the pretest and post-test results between the experimental and control classes. The findings of this study are expected to provide insights into the effectiveness of the PBL model in enhancing students' analytical skills in science learning. Additionally, this research serves as a reference for educators in selecting more innovative and effective instructional strategies.

3. Results and Discussion

The results of the study indicate that the implementation of the learning analysis method PBL using observation sheets achieved an optimal level. This also indicates the overall quality of the implementation of learning using the PBL model. The following is the percentage of the implementation results of the PBL model. The results of the descriptive statistical analysis show that the total score is 100%. Therefore, the statistical description is as follows: minimum 100%, maximum 100%, mean (Average) 100%.

This explains that the implementation of the PBL shows that it has been carried out very well. This result also indicates that the overall quality of the implementation of learning using the PBL model is at an optimal level. The following is the percentage of the implementation results of the PBL model based on the observations made by the researcher.

The observation was conducted to understand the implementation of the PBL model in teaching. The implementation was in accordance with the syntax of PBL during the learning process. The teacher introduced a real problem to the students, starting with the teacher presenting material about food webs. The students were very conducive and attentively listened to the material being explained. The teacher provided a problem topic related to food webs, where the teacher showed a video about rats eating agricultural products. The students were able to explain what happened regarding the impact of changes in the ecosystem.

The application of the PBL model during the learning process involved the teacher applying the first syntax, which is introducing a real problem to the students. This activity began with the teacher presenting material about food webs. The students were very conducive and paid attention to the material provided. After the teacher presented the material, the teacher gave a problem topic related to food webs, where the teacher showed a video about rats eating agricultural products. The students were able to explain what happened regarding the impact of changes in population. This can be seen during the observation that the teacher has perfectly implemented the first syntax.

The next step, after the students have watched the video provided by the teacher, is that the students are directed to form small groups where the teacher has applied the second syntax, which is to organize tasks that support problem exploration. The teacher explains the tasks that each group must complete. However, there were some challenges during the group division process where students chose friends according to their own preferences, which resulted in the class becoming less conducive. Although the group division time was not conducive, the teacher's demeanor in handling the situation was very calm, and the students were easily reconditioned.

The next activity, after the groups have been formed, is that the teacher provides the worksheets to the students to work on the tasks according to the instructions. During this activity, students are given time to work and discuss with their groups to solve the problems given by the teacher. This aligns with the syntax PBL independent and group investigation. In this process, students are very active in their respective groups, which indicates that there is good cooperation between the teacher and the students in implementing the syntax PBL investigation and group. The documentation of this activity is shown in Figure 1.

Fig. 1. Pretest and posttest results

The next step, after the students have discussed in groups and completed the tasks assigned by the teacher within the specified time, is for the teacher to provide guidance to each group to present the results of their group discussion in front of the class. At this stage, the teacher encourages the students to actively ask questions to the group that is presenting. From the research conducted during this activity, the students were very active in asking questions to the presenting group. During the

presentation of the results, the teacher conducts a draw, where each group representative picks a lot, and then the students present according to the lot they received. During the presentation, the students were very conducive and actively participated in the discussion process. The documentation of this activity is shown in Figure 2.

Fig. 2. Teacher providing guidance

At the end of the activity, after all groups have presented their discussion results, the teacher will provide analysis and evaluation of the problem-solving process. During this activity, some students asked the teacher questions about the material they did not understand. The teacher provided detailed explanations and responded to the questions posed by the students, so at this stage, students could understand the material on food webs. However, some students were still confused about grasping the material, as evidenced by the results of the pretest and post-test assessments. Table 1 shows the pretest post-test of student analytical skill.

Table 1. Student analytical skill score

Respondent	Pre-test	Post-test	Respondent	Pre-test	Post-test
1	60	75	15.	70	95
2	65	85	16.	65	80
3	60	85	17.	60	80
4	80	85	18.	70	80
5	75	75	19.	70	90
6	75	80	20.	75	85
7	55	85	21.	65	80
8	60	80	22.	80	80
9	60	75	23.	80	85
10	65	75	24.	65	80
11	60	75	25.	70	70
12	85	85	26.	75	70
13	80	80	27.	65	75
14	70	90			

The analysis in Table 1 describe the descriptive statistics of students' analytical skill scores, which include pretest and posttest data in the control and experimental groups. More detailed information on the distribution of scores and other statistical characteristics can be found in Table 2. Thus, the two tables complement each other in providing students' analytical skills.

Table 2. Statistical data of the pretest and the posttest

No	Aspect of Information	Pretest	Posttest
1	M= Mean	70.19	72.22
2	SD = Standard Deviation	7.27	7.25
3	M-1SD	63.00	65.00
4	M+1SD	77.45	79.47

Based on Table 2, it can be seen that the average scores of pretest and posttest show an increase. The average score of the pretest reached 70.185 and the average score of the posttest reached 72.2222, thus it can be concluded that there was an increase in scores after the posttest. The data of the pretest and posttest are shown in Figure 3.

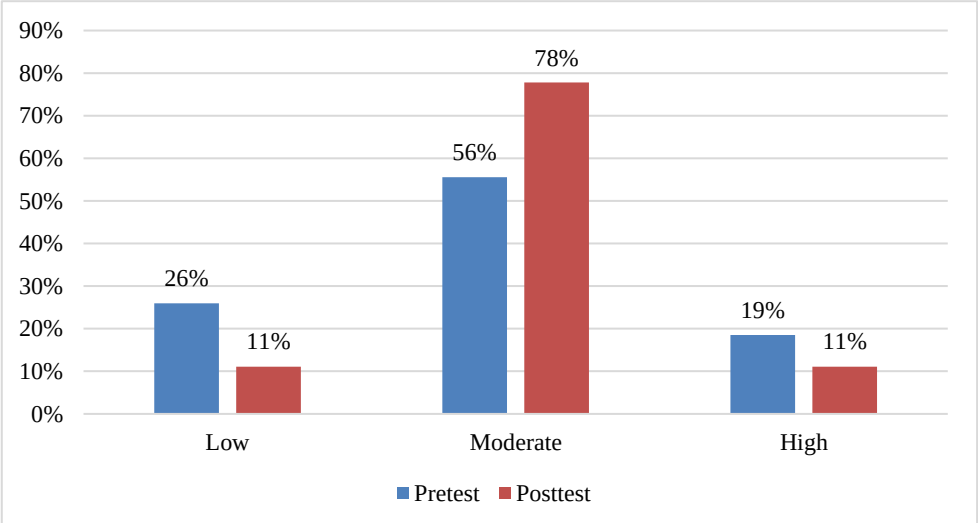

Fig. 3. Analysis skills of grade V

Based on Figure 3, the percentage of frequency distribution results shows a slight increase after the implementation of learning using the PBL model. This identifies an improvement in analytical skills collectively. Thus, the analytical skills of fifth-grade students in science learning have proven effective in reducing the number of students with low abilities. Table 3 presents the results of the classical assumption test analysis, namely the normality test.

Table 3. Results of normality test

	Class	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Analytical Skills	Experiment Pre-Test	.170	27	.045	.952	27	.234
	Post-Test Experiment	.139	27	.195	.942	27	.137
	Pre-Test Control	.126	27	.200*	.954	27	.272
	Post-Test Control	.172	27	.040	.961	27	.392

Based on Table 3. The results of the normality test, as seen from the Shapiro-Wilk test, indicate that the analytical skills tend to be normally distributed. For the pretest value of the experimental group, the significance value is 0.234, and for the posttest of the experimental group, it is 0.137. Therefore, it can be concluded that the pretest and posttest data of the experimental class are normally distributed. Furthermore, the normality calculation for the data distribution of the control class pretest is 0.392.

Based on the results of the normality test, both classes have significant values, indicating that all data have values >0.05. It can be concluded that the results of the normality test of students' analytical skills in the two classes meet the assumption of normal distribution. Furthermore, another classical assumption is the homogeneity test, shown in Table 4.

Table 4. Results of homogeneity test

		Levene Statistic	df1	df2	Sig.
Analysis Skills	Based on mean	2.480	3	104	.065
	Based on Median	1.682	3	104	.175
	Based on Median and with adjusted df	1.62	3	85.081	.177
	Based on trimmed mean	2.445	3	104	.068

Based on Table 4, it can be obtained from the calculations of the posttest data of the experimental group and the control group data, with the results of the homogeneity test showing that the significance values from all testing techniques, whether using mean, median with degrees of freedom adjustment, or trimmed mean, are greater than 0.0, with a range of significance values between Sig = 0.065, where the Sig value is > 0.05. This identifies that there is not enough statistical evidence to reject the assumption of homogeneity of variance. Therefore, based on the results of the homogeneity test, the research data is said to be homogeneous, as the significance value is greater than 0.05. This indicates that the data groups come from populations with the same variance. Table 5 presents the results of the independent samples T-test.

Table 5. Results of the independent samples T-test

F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
4.373	.041	.592	52	.557	1.481	2.504	-3.543	6.506

Based on Table 5. The results of the hypothesis test using the independent sample t-test showed that the output from SPSS software v2 indicated a Sig value of 0.041, which is less than 0.05. According to the hypothesis testing criteria, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected. This indicates that there is a significant difference in the average analysis skills scores between the experimental class and the control class with the application of the PBL model.

The learning process in elementary schools is concrete (Yuristia et al., 2022). The learning efforts applied logically and systematically, as well as learning that leads to enjoyable experiences and involves events in the surrounding environment (Prananda et al., 2020). This can be seen from the observations made by the researcher regarding the application of the learning model used in the teaching and learning process. Natural Science contains various life materials, and improving the quality of Natural Science learning in elementary schools requires learning innovations, including the selection of appropriate methods and learning models (Widyaningrum et al., 2022). The teacher, as a facilitator, plays a role in innovating the development of appropriate learning models (Wahyuni, 2022). Observations conducted by the researcher with the fifth-grade teacher at Muhammadiyah Elementary School of Karangkajen indicate that the implementation of the learning model is in accordance with its steps. PBL in developing students' abilities in problem-solving is very beneficial in cognitive, psychomotor, and affective aspects. Students' habits in solving problems in Natural Science learning will be better trained in analytical skills (Puspita et al., 2023b). PBL can enhance students' analytical skills in Natural Science learning, as the PBL model requires students to be active in order to reach the problem-solving stage (Imaroh et al., 2022; Safira et al., 2020).

The goal of science learning in elementary school is to instill a sense of curiosity in students and a positive attitude towards the surrounding environment (Azizah & Sholikhah, 2021). The objectives of science learning include developing useful science concepts that can be applied in everyday life (McGill & Bax, 2005). This can be seen when the researcher observed the classroom teacher during the science learning process; students were very interested and listened to the lesson attentively. The application of an appropriate learning model made students not bored during the lesson. The learning model PBL is an approach that focuses on problem-solving as the main step in the teaching and learning process (Martaningsih et al., 2022). The PBL model has been effectively implemented by classroom teachers by applying the syntax of PBL. This approach has a positive impact on students in analyzing and solving problems in science learning.

PBL has several advantages, which can better prepare students to face problems in real and concrete situations according to the events occurring in their surroundings. Students can be assisted in developing communication skills and directing them to be active in expressing opinions independently, creating an active and enjoyable learning atmosphere, thus improving students' grades (Suharyat et al., 2022). The learning process requires teachers to develop student engagement in analytical skills. Analytical skills play an important role in education. Skills are the ability to generate

new ideas to create innovations that can be used to solve problems or identify new relationships between existing elements, which can encourage progress in all disciplines and provide benefits for students.

The application of the PBL model into the lesson plan. Not just merely delivering material, but the teacher has implemented the learning model according to the syntax of PBL, where the teacher introduces real problems to the students (Martaningsih et al., 2022). This can be seen during the observation conducted by the researcher, where the teacher provides case examples to the students regarding the components of the food web. The teacher organizes tasks that support the material being taught, for example, when the teacher divides students into small groups to complete the assigned task of constructing a food web diagram can be seen from the observations made by the researcher that the students' responses to the material presented by the teacher are very good (Setyawan & Kristanti, 2021). However, there are some challenges faced in the grouping of students, as they choose group members according to their own preferences, which impacts the classroom atmosphere, making it less conducive.

Subsequently, the teacher applies the investigation syntax individually and in groups so that students can categorize information into clearer categories in the problem-solving process. The teacher also provides opportunities for students to present the results of discussions individually and in groups in front of the class, and at the end of the lesson, the teacher applies analysis and evaluation to the students' work (Fitri et al., 2020). Thus, the application of the PBL model not only enhances students' understanding of the subject matter but also equips students with essential analytical skills in facing real-life problems (Utama & Kristin, 2020).

During the implementation of the PBL model, fifth-grade students actively engaged in paying attention to the teacher. From the results of the implementation of PBL, fifth-grade students were actively involved in research activities and group discussions (Tabun et al., 2020). This was evident when students worked on the problems given by the teacher; they were able to discuss and solve the problems according to the agreed time, although organizing students during group division took a long time. The teacher provides an opportunity for the groups to present the results of their discussions, which is in accordance with the syntax PBL for the development and presentation of results. Through this activity, the teacher can assess the students' understanding of the material presented (Novia et al., 2023). This can be observed by the researcher when students are willing to respond to the presentation of results from the assigned group, and other groups are also willing to ask questions.

After the discussion process takes place, the teacher's task is to provide feedback to the students to review the material that has been presented. During the observation, the researcher noted that the teacher applied PBL, which involves evaluating the students based on the results of the discussion that has taken place. The teacher summarizes the questions that have been posed by the students for further explanation. This is evident from the scores obtained by the students, proving that the implementation of the PBL model can enhance students' analytical results in problem-solving (Mayasari et al., 2022).

PBL has successfully improved students' analytical skills regarding the food web material, making students actively involved and able to relate theoretical concepts to their applications in everyday life(Utama & Kristin, 2020). This is evidenced by the increase in the average scores from the pretest to the posttest. However, there are challenges that arise related to students' analytical skills (Sari & Nada, 2022), which are related to students' abilities to ask questions and their ability to seek information from sources outside the provided material. As a solution, teachers need to take an intensive approach to students to enhance their confidence in asking questions.

Based on the implementation observation of the PBL model on analytical skills for fifth-grade students, it can be said to be effective. The teacher was able to present the food web material by applying the PBL method according to the established syntax. This can be seen from the students' analytical skills in solving problem-solving questions. In this material, students successfully engaged actively in answering the questions given both individually and in groups (Puspita, 2022). Based on the explanation above, it can be stated that the implementation of the PBL model in the analysis skills of fifth-grade students in science lessons is carried out according to the syntax of the PBL model and its implementation is executed well. The results obtained by students in analysis skills show an average score of the pretest and post-test given, indicating an increase in the average score of students. This

shows that PBL is effective in promoting students' analysis skills, although the improvement needs to be further optimized.

This improvement can be linked to the characteristics of PBL that encourage students to actively identify and solve real problems, thus helping students develop their analysis skills. However, there are challenges in implementing analysis skills, such as students still experiencing difficulties in understanding concepts independently and a lack of deep understanding of the interconnections between concepts in food webs. The PBL model can be applied to enhance students' analytical skills in science learning, as PBL has advantages that can help students improve their analytical skills, motivate them to solve problems, and enable them to face understanding in new situations. Students can also gain meaningful learning by integrating and applying understanding and skills in a stimulating manner within relevant scopes, with students' thinking improving during group discussions.

In the research results, the PBL model has a significant impact on improving students' analytical skills in science learning. This can be seen from the average scores. Many factors influence the use of the PBL model in the research, ranging from the research duration, student conditions, and the teacher's skills in designing and implementing the steps of the PBL model in teaching. Nevertheless, it can be generally concluded that the use of the PBL model has proven to be effective in enhancing students' analytical skills. Therefore, further research is needed to explore how different variables, such as student backgrounds and subject areas, affect the effectiveness of the PBL model. Additionally, future studies could investigate the long-term impact of PBL on students' critical thinking and problem-solving abilities.

4. Conclusion

This study confirms that the implementation of the PBL model positively influences the analytical skills of fifth-grade students in science learning. The PBL model, applied through structured steps including problem introduction, task organization, investigation, result presentation, and evaluation supports students' ability to distinguish, organize, and attribute information. Although the improvement in analytical skills was not highly significant, PBL still provided valuable opportunities for collaborative problem-solving and active learning. The findings imply that PBL can be an effective alternative to enhance students' analytical thinking, but its implementation should be optimized to maximize its impact. Future research is recommended to explore variations in PBL strategies, integrate digital tools, and extend the study to diverse educational settings to strengthen its effectiveness in fostering higher-order thinking skills. Future studies could also examine the long-term effects of PBL on students' critical thinking and problem-solving abilities. Additionally, investigating teachers' perspectives on the challenges and benefits of implementing PBL could provide insights for more effective instructional practices.

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References

Adnan, M. (2022). Islamic education and character building in the 4.0 industrial revolution. *Nazhruna: Jurnal Pendidikan Islam*, *5*(1), 11–21. https://doi.org/10.31538/nzh.v5i1.1771

Al Said, R. S., Du, X., Al Khatib, H. A. H. M., Romanowski, M. H., & Barham, A. I. I. (2019). Math teachers' beliefs, practices, and belief change in implementing problem based learning in Qatari primary governmental school. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(5), em1710. https://doi.org/10.29333/ejmste/105849

Astriani, D., Susilo, H., Suwono, H., & Lukiati, B. (2018). Profil keterampilan berpikir analitis mahasiswa calon guru IPA dalam perkuliahan biologi umum. *Jurnal Penelitian Pendidikan IPA*, *2*(2), 66-70. https://doi.org/10.26740/jppipa.v2n2.p66-70

Azizah, M., & Sholikhah, I. R. (2021). Penggunaan media montase untuk meningkatkan kemampuan berpikir kritis siswa pada mata pelajaran IPA. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)* , *4*(1), 65–69. 10.55215/jppguseda.v4i1.3279

Darussyamsu, R., Lufri, L., Ahda, Y., Alberida, H., Ambiyar, A., & Samsudin, S. (2024). The effectiveness of project-based learning model with RAHMA syntax to improve prospective biology teachers' critical thinking skills. *Jurnal Pendidikan IPA Indonesia*, *13*(4), 688-699. https://doi.org/10.15294/xy8mr440

Dasopang, M. D. (2021). Effectivity of interactive multimedia with theocentric approach to the analytical thinking skills of elementary school students in science learning. *Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran*, *11*(2), 215–226. https://doi.org/10.25273/pe.v11i2.9658

Eka, I., Irawan, E., Ekapti, R. F., & Faizah, U. N. (2021). Efektivitas penerapan model pembelajaran problem based learning terhadap peningkatan keterampilan berpikir analitis. *Jurnal Tadris IPA Indonesia*, *1*(2), 108–117. https://doi.org/10.21154/jtii.v1i2.142

Ernawati, M. D. W., Yusnidar, Haryanto, Rini, E. F. S., Aldila, F. T., Haryati, T., & Perdana, R. (2023). Do creative thinking skills in problem-based learning benefit from scaffolding? *Journal of Turkish Science Education*, *20*(3), 399–417. https://doi.org/10.36681/tused.2023.023

Fitri, M., Yuanita, P., & Maimunah, M. (2020). Pengembangan perangkat pembelajaran matematika terintegrasi keterampilan abad 21 melalui penerapan model problem based learning (PBL). *Jurnal Gantang*, *5*(1), 77–85. https://doi.org/10.31629/jg.v5i1.1609

García, E. B., Perez, E. T., Naranjo, C. A., & Rosales, J. M. (2024). Meaningful learning of natural sciences based on PBL. In Á. Rocha, C. Montenegro, E. T. Pereira, J. A. M. Victor, & W. Ibarra (Eds.), *Management, Tourism and Smart Technologies* (Vol. 1190, pp. 473–483). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-74825-7_42

Guo, Y., Xu, B., Lyu, B., & Chen, C. (2025). How social and emotional skills affect Chinese college student engagement in high-impact educational practices: A moderated mediation model. *Studies in Higher Education*, *50*(1), 27–46. https://doi.org/10.1080/03075079.2024.2328828

Herianingtyas, N. L. R., Rohman, C., Widiyanto, R., & Amarulloh, R. R. (2023). Authentic assessment teaching and learning trajectory with E-Student Activity Sheet (E-Sas) to improve the quality of learning process. *JMIE (Journal of Madrasah Ibtidaiyah Education)*, *7*(2), 219–234. https://doi.org/10.32934/jmie.v7i2.602

Imaroh, R. D., Sudarti, S., & Handayani, R. D. (2022). Analisis korelasi kemampuan berpikir kreatif dan hasil belajar kognitif pembelajaran IPA dengan model problem based learning (PBL). *Jurnal Pendidikan Mipa*, *12*(2), 198–204. https://doi.org/10.37630/jpm.v12i2.580

Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of problem-based learning on developing science process skills and learning achievement on the topic of safety in our environment. *Journal of Turkish Science Education*, *19*(3), 872–886. https://doi.org/10.36681/tused.2022.154

Khaidir, E., & Suud, F. M. (2020). Islamic education in forming students' characters at As-Shofa Islamic High School, Pekanbaru Riau. *International Journal of Islamic Educational Psychology*, *1*(1), 50–63. https://doi.org/10.18196/ijiep.1105

Krismayoni, P. A. W., & Suarni, N. K. (2020). Pembelajaran IPA dengan model pembelajaran children learning in science meningkatkan hasil belajar ditinjau dari minat belajar. *Jurnal Pedagogi dan Pembelajaran*, *3*(2), 138-151. https://doi.org/10.23887/jp2.v3i2.25258

Martaningsih, S. T., Maryani, I., Prasetya, D. S., Prwanti, S., Sayekti, I. C., Aziz, N. A. A., & Siwayanan, P. (2022). STEM problem-based learning module: A solution to overcome elementary students' poor problem-solving skills. *Pegem Journal of Education and Instruction*, *12*(4), 340–348. https://doi.org/10.47750/PEGEGOG.12.04.35

Maryani, I., Prasetyo, Z. K., Wilujeng, I., Purwanti, S., & Fitrianawati, M. (2022). HOTs multiple choice and essay questions: A validated instrument to measure higher-order thinking skills of prospective teachers. *Journal of Turkish Science Education*, *18*(4), 674–690. https://doi.org/10.36681/tused.2021.97

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

McGill, T., & Bax, S. (2005). Learning IT. *International Journal of Information and Communication Technology Education*, *1*(3), 36–46. https://doi.org/10.4018/jicte.2005070103

Nikmah, L., Maryani, I., & Purwanti, S. (2020). Analisis kemampuan berpikir tingkat tinggi mahasiswa pgsd universitas ahmad dahlan pada pembelajaran IPA. *Natural: Jurnal Ilmiah Pendidikan IPA*, *7*(2), 40–51.

Novia, N. A., Radya Nasyawa, Susilo Tri Widodo, & Junianto. (2023). Penerapan problem based learning guna meningkatkan kecakapan berpikir kritis bagi siswa dalam pembelajaran PKn SD. *Jurnal Basicedu*, *7*(6), 3923–3930. https://doi.org/10.31004/basicedu.v7i6.6428

Prananda, G., Saputra, R., & Zuhar, R. (2020). Meningkatkan hasil belajar menggunakan media lagu anak dalam pembelajaran IPA Sekolah Dasar. *Journal of IKA PGSD*, *8*(2), 304–314. https://doi.org/10.36841/pgsdunars.v8i2

Puspita, A. D., Maryani, I., & Sukma, H. H. (2023). Problem-based science learning in elementary schools: A bibliometric analysis. *Journal of Education and Learning*, *17*(2), 285–293. https://doi.org/10.11591/edulearn.v17i2.20856

Puspita, J. A. D. (2022). Penerapan model pembelajaran problem based learning terhadap hasil belajar IPA siswa kelas V SD. *Educenter : Jurnal Ilmiah Pendidikan*, *1*(5), 491–495. https://doi.org/10.55904/educenter.v1i5.168

Putri, C. N. D., Sedyati, R. N., & Zulianto, M. (2023). Students' collaboration and communication skills with problem-based learning model. *Jurnal Inovasi dan Teknologi Pembelajaran*, *10*(3), 225–233. https://doi.org/10.17977/um031v10i32023p225

Safira, C. A., Setyawan, A., & Citrawati, T. (2020). Identifikasi permasalahan pembelajaran IPA pada siswa kelas III SDN Buluh 3 Socah. *Jurnal Pendidikan MIPA*, *10*(1), 23-29. https://doi.org/10.37630/jpm.v10i1.277

Sajidan, S., Suranto, S., Atmojo, I. R. W., Saputri, D. Y., & Etviana, R. (2022). Problem-based learning-collaboration (PBL-C) model in elementary school science learning in the industrial revolution era 4.0 and Indonesia society 5.0. *Jurnal Pendidikan IPA Indonesia*, *11*(3), 477–488. https://doi.org/10.15294/jpii.v11i3.30631

Sakila, R., Lubis, N. F., Mutiara, & Asriani, D. (2023). Pentingnya peranan IPA dalam kehidupan sehari-hari. *Jurnal Adam*, *2*(1), 119–123. https://doi.org/10.30598/pattimura-mengabdi.2.1.119-124

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

Sari, W. K., & Nada, E. I. (2022). Marzano taxonomy-based assessment instrument to measure analytical and creative thinking skills. *Jurnal Pendidikan Kimia Indonesia*, *6*(1), 46–54. https://doi.org/10.23887/jpk.v6i1.40117

Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing*, *16*(1), 85–88. https://doi.org/10.1016/j.teln.2020.09.002

Setyawan, R. A., & Kristanti, H. S. (2021). Keterampilan berpikir kritis pada pembelajaran ipa melalui model pembelajaran discovery learning bagi siswa sekolah dasar. *Jurnal Basicedu*, *5*(2), 1076–1082. https://doi.org/10.31004/basicedu.v5i2.877

Setyono, D., Prasetyo, K., & Turhan, M. Y. (2018, December). Influence of problem based learning model on thinking skills critical and student learning outcomes elementary school. In *2nd International Conference on Education Innovation (ICEI 2018)* (pp. 326-331). Atlantis Press. https://doi.org/10.2991/icei-18.2018.72

Shofiya, N., & Wulandari, F. E. (2018). Model problem based learning (PBL) dalam melatih scientific reasoning siswa. *JPPIPA (Jurnal Penelitian Pendidikan IPA) 12*(2), 344–349. https://doi.org/10.26740/jppipa.v3n1.p33-38

Silvita, Sutarno, & Indrowati, M. (2024). Improving evaluation skills through flipped-problem-based learning with digital storytelling task: A systematic review. *Journal of Higher Education Theory and Practice*, *24*(1), 167–185. https://doi.org/10.33423/jhetp.v24i1.6769

Suharyat, Y., Ichsan, I., Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-analisis penerapan model pembelajaran problem based learning untuk meningkatkan ketrampilan abad-21 siswa dalam pembelajaran IPA. *Jurnal Pendidikan dan Konseling (JPDK)*, *4*(5), 5081–5088. https://doi.org/10.31004/jpdk.v4i5.7455

Sukowati, V. P., & Harjono, N. (2023). Penerapan model problem based learning untuk meningkatkan kemampuan berpikir kritis dan hasil belajar IPA siswa kelas V SD. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *6*(12), 10641–10646. https://doi.org/10.54371/jiip.v6i12.3212

Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Tabun, H. M., Taneo, P. N. L., & Daniel, F. (2020). Kemampuan literasi matematis siswa pada pembelajaran model problem based learning (PBL). *Edumatica : Jurnal Pendidikan Matematika*, *10*(01), 1–8. https://doi.org/10.22437/edumatica.v10i01.8796

Utama, K. H., & Kristin, F. (2020). Meta-analysis pengaruh model pembelajaran problem based learning (PBL) terhadap kemampuan berpikir kritis IPA Di Sekolah Dasar. *Jurnal Basicedu*, *4*(4), 889–898. https://doi.org/10.31004/basicedu.v4i4.482

Váradi, J. (2022). A review of the literature on the relationship of music education to the development of socio-emotional learning. *Sage Open*, *12*(1), 1–11. https://doi.org/10.1177/215824402110685

Vargas-Hernández, J. G., & Vargas-González, O. C. (2022). Strategies for meaningful learning in higher education. *JISTECH: Journal of Information Science and Technology*, *2*(1), 47–64. https://doi.org/10.30862/jri.v2i1.41

Wahyuni, A. S. (2022). Literature Review: Pendekatan berdiferensiasi dalam pembelajaran IPA. *Jurnal Pendidikan Mipa*, *12*(2), 118–126. https://doi.org/10.37630/jpm.v12i2.562

Wale, B. D., & Bishaw, K. S. (2020). Effects of using inquiry-based learning on EFL students' critical thinking skills. *Asian-Pacific Journal of Second and Foreign Language Education*, *5*(1), 9. https://doi.org/10.1186/s40862-020-00090-2

Widodo, A., Angga, P. D., Syazalli, M., & Umar. (2022). Pengembangan lembar observasi aktivitas belajar dalam pembelajaran jarak jauh di Sekolah Dasar. *Jurnal Pendidikan dan Konseling*, *4*(6), 10931–10936. https://doi.org/10.31004/jpdk.v4i6.10145

Widyaningrum, F. A., Maryani, I., & Vehachart, R. (2022). A Literature Study on Science Learning Media in Elementary School. *International Journal of Learning Reformation in Elementary Education*, *1*(01), 1–11. https://doi.org/10.56741/ijlree.v1i01.51

Yuristia, F., Hidayati, A., & Ratih, M. (2022). Pengembangan modul pembelajaran IPA berbasis problem based learning pada pembelajaran tematik sekolah dasar. *Jurnal Basicedu*, *6*(2), 2400–2409. https://doi.org/10.31004/basicedu.v6i2.2393