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The Application of Problem-Based Learning Models with Peer Tutoring Assistance on Problem-Solving Abilities and Cognitive Learning Outcomes in Science for Junior High School Students

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Abstract

The implementation of the Merdeka curriculum as an effort to improve the quality of education focuses on 21st-century skills, including critical thinking skills, which are essential for problem-solving. Evidence indicates junior high school students exhibit low problem-solving and cognitive ability. This study aims to analyze the differences and levels of problem-solving ability and cognitive outcomes in science after implementing a Problem-Based Learning model supported by Peer Tutoring. This quasi-experimental research used a non-equivalent control group design at Semarang State Junior High School 8, with cluster random sampling. Data were gathered through observation, test, and documentation. The research results showed a significant improvement in problem-solving ability and cognitive outcomes in science after implementing the Problem-Based Learning (PBL) model with Peer Tutoring. This is evidenced by the results of an independent t-test, which found that t_{count} was greater than t_{table}. The average posttest problem-solving score in the experimental class was higher (80.8) than in the control class (70.7). Similarly, the average posttest score for cognitive learning outcomes in science in the experimental class was higher (81.6) than in the control class (74.4). Analysis of problem-solving ability level and cognitive learning outcomes level showed an increase in the number of students in each indicator's good and very good criteria.

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INTRODUCTION

Education in Indonesia continues to adapt to develop competencies relevant to the times by implementing an independent curriculum. One of the Independent Curriculum's main focuses is improving 21st-century skills, including communication, collaboration, critical thinking, and creativity (Erdoğan, 2019). Critical thinking skills are important in improving problem-solving abilities because logical and analytical thinking help find effective solutions to problems. Problem-solving skills are important because every human being is inevitably faced with problems. Problem-solving can be trained through science learning, where problem-solving skills provide direct experience to students to improve their ability to construct, understand, and apply the concepts they have learned (Sumiantari et al., 2019). Lamalani et al. (2025) stated that problem solving generally uses the final results of students' calculations and the steps students take to find those results. According to Polya (1973), there are four indicators in problem solving: understanding the problem, planning the solution, implementing the plan, and reviewing the process and result.

Based on interviews with science teachers at Semarang state Junior High School 8, it was found that the types of questions presented did not lead to detailed answers from students in accordance with the stages of problem solving. Preliminary research was conducted to determine the initial problem-solving abilities by giving students questions with problem-solving indicators, and the preliminary research results showed that most of the problem-solving abilities were at an adequate level, and 25% of students had poor problem-solving abilities. In addition, based on direct observation in the classroom, students tended to be passive in analyzing problems, expressing opinions, or asking questions, and only relied on their friends during learning activities. The low problem-solving skills were also evidenced by students' low scores on the TIMSS (Trends International Mathematics and Science Study) test, which scored 397 out of an international average score of 500 (Hamzah, 2023). In the 2022 PISA results, Indonesia scored 366 out of a global average of 472. Based on this score, Indonesia still ranks low.

Pradestya et al. (2019) revealed that cognitive abilities influence problem-solving skills. Completing the stages of problem-solving requires appropriate cognitive abilities. Good cognitive abilities directly impact the improvement of cognitive learning outcomes. From the data on the Final Semester Summative Assessment (ASAS) scores for Grade VII at Semarang state Junior High School 8 in Science lessons from one of the classes, 11 students achieved KKTP (Learning Objective Achievement Criteria) with good criteria, while most of the other students achieved KKTP with sufficient and poor criteria. Interviews with science teachers revealed that low learning motivation resulted in suboptimal cognitive learning outcomes in science. It was found that some students did not pay attention and were not interested in the material being taught, while others were passive during learning activities.

Problem-solving skills can be developed with learning models that can create an active teaching (Aji & Nugroho, 2015). The Problem-Based Learning model can train problem-solving skills because it involves the role of students in solving problems through the stages of the scientific method, so that students can explore their own knowledge by finding solutions to problems (Hasanah et al., 2021). Student involvement in finding solutions to problems directly improves cognitive learning outcomes, resulting in better learning outcomes than listening to teacher explanations (Utami et al., 2023). In implementing Problem-Based Learning (PBL), teachers only act as facilitators. However, teachers must always monitor the progress of student activities and encourage them to achieve the desired targets (Muhammad et al., 2021). However, classroom observations show that some students feel embarrassed and afraid to ask questions when allowed to do so in class, so they ask questions independently, repeating the same questions. In addition, some students have difficulty constructing concepts from the problems presented.

This results in students not understanding the material being studied. Furthermore, this problem-focused learning model has a disadvantage, namely that it is not suitable for application in classes with a high level of student diversity, making it difficult for teachers to distribute tasks (Shoimin, 2014) in (Idris & Nisa, 2023). Peer tutoring utilizes the abilities of heterogeneous students to create a complementary learning process (Mursyida et al., 2024). In her research, Yunita (2022) explains that through peer tutoring, learning is more student-centered, with students as research subjects, so that tutors become a source of learning and a place for their friends to ask questions. In this way, students who act as tutors can repeat and explain the material, so they understand it better. Other students who are not tutors will also understand the material better because they do not feel embarrassed or afraid to ask questions to their peers who are tutors. Peer teaching improves cognitive and social development (Macapayad et al., 2024). This study aims to analyze the differences and levels of problem-solving skills and cognitive learning outcomes in science among junior high school students after implementing the Problem-Based Learning model with the Peer Tutoring Method.

METHOD

This research type includes quasi-experimental design experiments and uses a non-equivalent control group design model. There are two classes, namely the experimental class, which receives learning using the Problem-Based Learning approach supported by the Peer Tutoring method. In contrast, the control class receives learning through the Discovery Learning model. The research was conducted at Semarang State Junior High School 8. Sampling was conducted using cluster random sampling based on the ASAS scores of students in grades VII A to VII H in the odd semester. The research design in this study is presented in Table 1 (Sugiyono, 2018).

Tabel 1. Reseach design

Group	*Pretest*	*Treatment*	*Posttest*
Eksperimen	O_1	X	O_2
Kontrol	O_3	Y	O_4

Homogeneity test

The homogeneity test aims to determine whether the variance between samples is similar. If the data variance is uniform, then the data is considered homogeneous. This study conducted the homogeneity test using ASAS data for grade VII in the odd semester of the 2024/2025 academic year. The data analyzed included ASAS scores from all grade VII classes at SMP N 8 Semarang, namely classes VII A to VII H. The initial homogeneity test was conducted using the Levene test with the help of SPSS version 25 software. The formula used to analyze population homogeneity data is as follows:

$$W = \frac{(n-k)}{(k-1)} \frac{\sum_{i=1}^{k} n_i (\bar{Z}_{i.} - \bar{Z}_{..})^2}{\sum_{i=1}^{k} \sum_{j=1}^{n_i} (Z_{ij} - \bar{Z}_{i.})^2}$$

(Sugiyono, 2018)

Normality test

The normality test is used to determine whether the pretest and posttest data in the control and experimental classes are normally distributed. According to Sugiyono (2018), data normality can be calculated using the Chi-square formula as follows:

$$X^2 = \sum_{t=1}^{k} \ . \frac{(Oi - fe)^2}{fe}$$

T-independent test

This analysis was used to determine whether there was a significant difference between the improvement in problem-solving skills and cognitive learning outcomes in the control class and the experimental class after the experimental class. The formula used in the Independent T-test, according to Sugiyono (2018), is as follows:

$$t_{hitung} = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \text{ dengan } s^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}$$

Dependen T-test

The dependent t-test is used in the data analysis process to further determine the difference in the average of one sample group before and after applying a learning model. The statistical formula for the dependent t-test is as follows:

$$t = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} - 2r\left(\frac{s_1}{\sqrt{n_1}}\right)\left(\frac{s_2}{\sqrt{n_2}}\right)}}$$

An Analysis of the Level of Problem-Solving Ability of Students

Students' problem-solving ability level can be seen from their post-test scores. To determine the ability of all students in solving problems in each indicator, it is necessary to calculate the percentage for each indicator. The analysis of the level of problem-solving ability uses the following formula (Sudijono, 2018):

$$P = \frac{f}{N} \times 100$$

Table 2. Criteria of problem-solving ability levels of students

Score	Criteria
P > 75	Very good
50 < P ≤ 75	Good
25 < P ≤ 50	Sufficient
0 ≤ P ≤ 25	Low

Analysis of the Level of Cognitive Learning Outcomes

The cognitive learning outcomes of students can be seen from the posttest scores, which will be analyzed using the following formula (Sudijono, 2018):

$$P = \frac{f}{N} \times 100$$

Table 3. Criteria of problem-solving ability levels of students

Score	Criteria
80 < P ≤ 100	Very good
60 < P ≤ 80	Good
40 < P ≤ 60	Sufficient
20 ≤ P ≤ 40	Low
0 < P ≤ 20	Very Low

RESULT AND DISCUSSION

Problem-solving skills and cognitive learning outcomes in science were measured using test instruments. The problem-solving skills test instrument consisted of essay questions that had to be solved using Polya's problem-solving steps. At the same time, cognitive learning outcomes in science were measured using multiple-choice questions.

The results of the data analysis showed that the average pretest score for problem-solving skills in the control class was 35.5, while in the experimental class, the average pretest score was 37.4. The average posttest score for problem-solving skills in the control class was 70.7, while in the experimental class, the average score was 80.78. The pretest cognitive learning outcomes for science showed an average score of 50 for the experimental class, while the control class had an average of 47.2. There was an increase in the posttest stage with an average posttest score for the experimental class of 81.6, while the control class had an average of 74.4. The normality test results showed that the pretest-posttest scores were normally distributed, thus meeting the requirements for parametric testing.

Table 4. T-independent test problem-solving ability

Data	Class	x	T count	T table
Pretest	Experiment	37,4	0,90	2,039
	Control	35,5		
Posttest	Eksperimen	80,8	3,20	2,039
	Control	70,7		

Table 5. T-independent test cognitive learning outcomes

Data	Class	x	T count	T table
Pretest	Experiment	50	0,99	1,998
	Control	47,2		
Posttest	Eksperimen	81,6	2,53	1,998
	Control	74,4		

Tables 1 and 2 show the results of the analysis of the posttest scores of the experimental class and the control class, which showed that t count > t table, so H_0 was rejected and H_1 was accepted, indicating that there was a difference in problem-solving abilities and cognitive learning outcomes between the experimental class and the control class.

Table 6. Dependent T-test results problem-solving ability

Class	Data	T count	T table	description
Experiment	Pretest Posttest	28,8	2,039	There was a difference

Control	Pretest Posttest	19,99	2,039	between the pretest and posttest results

Table 7. Dependent T-test results cognitive learning outcomes

Class	Data	T count	T table	description
Experiment	Pretest Posttest	20,6	1,998	There was a difference between the pretest and posttest results
Control	Pretest Posttest	2,53	1,998	

The implementation of the Problem-Based Learning model with the help of Peer Tutoring was carried out in accordance with the syntax of the Problem-Based Learning (PBL) model, which includes: (1) student orientation students to the problem, (2) organizing students to learn, (3) guiding individual and group investigations, (4) developing and presenting work results and (5) analyzing and evaluating the problem-solving process. The first syntax of the Problem-Based Learning model is orienting students to the problem. The first syntax of the PBL model supports problem-solving skills in understanding the problem indicator. Students are presented with problems that must be analyzed. Students are asked to formulate problems in their own words based on the information obtained. Like that, students can understand the problem in depth. The presentation of a problem is the first step for students to find a solution because they already know the problem that has occurred. This can foster a desire to develop the ability to explore, thereby supporting the improvement of problem-solving skills in understanding the problem indicator (Hindiyati et al., 2022). Students read the reading material and identify the problems presented, practicing their cognitive memory skills (C1). Formulating problems trains C2 cognitive skills (understanding). Overall, the problem orientation stage effectively trains students to understand basic concepts through new situations, thereby facilitating the formation of new knowledge (Aftriani et al., 2018).

The second syntax of the Problem-Based Learning model is organizing students to learn. In this syntax, students in one class are divided into eight groups, each with one student acting as a tutor. The student assigned as the tutor is given the responsibility to help other students who experience learning difficulties based on the instructions given by the teacher (Yunita, 2022). After each group receives the LKPD, the students are directed to discuss and find information related to the material to be studied by answering the questions presented in the LKPD. Before looking for solutions, students need to understand the material to be studied to relate problems to relevant concepts in the material, thereby training their cognitive comprehension skills (C2).

The third syntax of the Problem-Based Learning model is guiding individual and group problem-solving investigations. The third syntax of PBL is relevant to Polya's problem-solving indicators, namely, planning solutions where students must choose the appropriate approach, formula, or method to solve the problem. The learning activity in the guiding investigation syntax is that students conduct practical work to plan the solution to the problem. This is in line with the research by Wulansuci et al. (2021), which states that practical activities provide real experiences for students in solving problems contextually. Practical activities aim to investigate the validity of materials and theories in real-life situations and then relate them to the problems presented. These activities train cognitive abilities in application (C3), as students apply previously learned concepts and information in the context of experiments. The practical activities in the experimental class were guided by tutors in each group. Aulia & Savitri (2021) in their research explained that the presence of student facilitators helps provide explanations to other students so that active learning is created which can improve problem-solving skills.

The fourth syntax of the Problem-Based Learning (PBL) model is developing and presenting the results of the work. Producing research results trains and improves thinking skills by collecting data to find alternative solutions to problems (Nur Isra Jairina et al., 2020). Unknown data from the practicum results is sought using physics formulas. The process of calculating data using physics formulas is the starting point for building students' applied skills. This is in line with Ngadinem (2022), who states that in physics learning, it is not enough only to master existing theories and formulas. However, it is also necessary to have the ability to apply them in solving real problems. Apply relevant physics concepts and formulas as a basis for scientific calculation and reasoning train cognitive application skills (C3).

The fifth syntax of the Problem-Based Learning (PBL) model is analyzing and evaluating problem-solving. Students discuss in groups to answer the analysis questions presented in the LKPD. This activity trains cognitive analysis skills (C4). Through discussion, students connect the experiment's results with the material concepts to test the validity of the concepts and create solutions.. This stage helps improve problem-solving skills as an indicator of implementing problem-solving. In line research by Ummayah & Dewi (2021) on the PBL model, the data obtained from practical activities are compiled according to the procedures on the student worksheets which direct practical activities towards problem-solving activities. The tutor's role in this syntax is to guide friends who do not yet understand the analysis of problem solving while leading the discussion to obtain the overall answer. This relates to problem-solving skills, including identifying problems, generating solutions, and assessing their effectiveness (Valdez Pasion & Marcelo, 2024).

The results of the group discussions are then presented and followed by a question-and-answer session. Through this process, the results of each group's discussions are compared with other group members' thoughts to identify the most appropriate ideas. Students are allowed to express their opinions. This stage trains students to solve problems. In the evaluation stage, all students and teachers evaluate the results of the discussions that have been presented and draw conclusions from the problem-solving results. Hasan & Andayani (2025) state that evaluation is an important stage in problem solving, where students must assess the effectiveness of the solutions implemented and make improvements if any inconsistencies or shortcomings are found. Student activities during question and answer sessions and responses to discussion outcomes involve cognitive skills for comparing and evaluating (C5). The activity of formulating solutions to produce comprehensive conclusions and reflections at the end of learning trains creative cognitive abilities (C6). At the end of the lesson, students are given questions related to the material studied. The habit of working on questions using these stages helps students improve their systematic thinking skills and overall problem-solving abilities.

Table 8. Level of problem-solving ability in the experimental class

Indicator	Criteria			
	Very good	Good	Sufficient	Low
Understand the problem	31	1	0	0
Plan the solution	26	5	1	0
Implement the plan	17	8	7	0
Review/evaluate the results	6	12	9	5

Table 9. Level of problem-solving ability levels in the control class

Indicator	Criteria			
	Very good	Good	Sufficient	Low
Understand the problem	27	5	0	0
Plan the solution	18	12	2	0
Implement the plan	5	14	11	2
Review/evaluate the results	0	8	15	9

In understanding the problem indicator, students in the experimental and control classes were rated as very good and good. This shows that students could understand the problems presented by identifying what was known and what was asked in the questions. The ability to understand problems is an important foundation for implementing the next stage. Students cannot solve problems correctly if they do not understand the problems given (Kania & Ratnawulan, 2022). The ability to plan problem solving among students in the experimental and control classes was in the very good, good, and Sufficient categories. Students in the experimental class who were in the Sufficient category were those who had difficulty determining which formula to use. Students in the experimental class who were in the adequate category had difficulty determining the formula to use. The ability to implement solutions in the experimental class was in the very good, good, and Sufficient categories.

Meanwhile, the control class was in the very good, good, Sufficient, and low categories. Pramesti & Rini (2019) found that students who can perform calculations correctly can determine the problem's final result. Meanwhile, students who are low at implementing solutions are unable to implement solutions and do not realize that the steps used are incorrect. The ability to recheck and evaluate students' results in the experimental class was in the perfect, good, Sufficient, and low criteria. Meanwhile, in the control class, it was in the good, Sufficient, and low criteria. Students in the low criteria for rechecking and evaluating results rarely wrote conclusions consistently on all questions. Students who do not recheck their answers assume that the answers they find are the final results of the problems (Setyawan et al., 2020).

Table 10. Level of cognitive learning outcome in the experimental class

Indicator	Criteria				
	Very good	Good	Suffi cient	Low	Very Low
C1	32	0	0	0	0
C2	25	5	2	0	0
C3	22	10	0	0	0
C4	17	0	15	0	0
C5	3	16	13	0	0
C6	8	0	22	0	2

Table 11. Level of cognitive learning outcome in the control class

Indicator	Criteria				
	Very good	Good	Suffici ent	Low	Very Low
C1	29	0	3		
C2	21	9	2		
C3	17	14	0		
C4	10	0	20		
C5	0	15	13		
C6	4	0	14		

The ability of students to remember (C1) in the experimental class was very good, while in the control class it was very good and sufficient. The ability to remember is influenced by learning motivation. As stated by Rahman (2022), students with high motivation and interest in the material tend to better remember information.

The comprehension ability (C2) in the experimental and control classes showed comprehension abilities in the very good, good, and sufficient categories. Students in the sufficient category in both the experimental and control classes were excluded due to their reluctance to ask questions about things they did not understand, resulting in suboptimal cognitive comprehension abilities.

The ability to apply (C3) of students in the experimental class was in the very good and good criteria, while in the control class it was in the very good, good, and sufficient criteria. Students with a strong understanding of concepts tend to be more capable of applying knowledge to various contexts. Conversely, student errors in C3 (applying) include inaccuracies in understanding and interpreting questions, the use of incorrect concepts, and errors in performing calculations (Nabilah et al., 2020).

The ability to analyze (C4) in the experimental class was rated very good and sufficient. Meanwhile, in the control class, it was in the very good, sufficient, and very low criteria. The ability to analyze was supported by group discussion activities, so that students who actively expressed their opinions had a higher ability to analyze. In their research, Nurdin et al. (2023) emphasized that by applying a peer tutor discussion method, students can participate more actively in discussions and improve their learning outcomes during the learning process. The selected tutors have been trained. Lin et al., (2025) explained that tutors who receive training are better prepared to address diverse learning needs and can create more meaningful learning interactions with their tutees.

The ability to evaluate (C5) in the experimental class was rated as very good, good, and sufficient. Meanwhile, the control class rated it as good, sufficient, and low. Overall, the evaluation ability (C5) in the experimental class by applying the Problem-Based Learning model with the help of Peer Tutoring was higher than in the control class. Nurlaily et al. (2019) stated that the Problem-Based Learning Model can improve evaluation skills because it requires students to make critical assessments of the information they receive. Cognitive ability C6 (creating) was mainly at the adequate level for most experimental and control students. Students with a very inadequate level had difficulty developing their ideas. Students' limited understanding of managing the thinking process resulted in low creating ability (Niswah & Dewi, 2024).

CONCLUSION

Based on the results of the study, it can be concluded that there is a significant difference in the problem-solving abilities and cognitive learning outcomes of science students after applying the Problem-Based Learning model with the help of Peer Tutoring. The improvement can be seen from the significant difference between the control and experimental classes and between the conditions before and after the treatment. After the treatment, Analysis of problem-solving ability level and cognitive learning outcomes level showed an increase in the number of students in each indicator's good and very good categories.

REFERENCES

Aftriani, D. N., Muntari, M., Haris, M., & Anwar, Y. A. S. (2018). Pengaruh pembelajaran inkuiri terbimbing pada pelajaran kimia terhadap kemampuan berpikir kreatif siswa Kelas XI IPA SMAN 2 Mataram. *Chemistry Education Practice*, *1*(2), 1–6.

Aji, S., & Nugroho, S. E. (2015). Pengembangan Asesmen Untuk Mengukur Kemampuan Memecahkan Masalah, Bekerjasama Dan Berkomunikasi Calon Guru Fisika. *Journal of Innovative Science Education*, *4*(2).

Aulia, H., & Savitri, E. N. (2021). The Effectiveness of Student Facilitator and Explaining Learning Model Assisted by Edmodo to Enhanced Students' Problem Solving Ability. *Journal of Environmental and Science Education*, *1*(2), 11-17. https://doi.org/10.15294/jese.v1i2.49558.

Djonomiarjo. (2020). Pengaruh model problem based learning terhadap hasil belajar. Aksara: Jurnal Ilmu Pendidikan Nonformal, 5(1), 39-46.

Erdoğan, V. (2019). Integrating 4C skills of 21st century into 4 language skills in EFL classes. *International Journal of Education and Research*, *7*(11), 113-124.

Hasan, Y., & Andayani, Y. (2025). Pengembangan E-Modul Berbasis Etnosains Alat Transportasi Cidomo Dengan Model PBL Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Kemampuan Pemecahan Masalah. *Jurnal Pendidikan, Sains, Geologi, Dan Geofisika (GeoScienceEd Journal)*, *6*(2), 1033–1044. https://doi.org/10.29303/goescienceed.v6i2.994

Hasanah, U., Sarjono, S., & Hariyadi, A. (2021). Pengaruh Model *Problem Based Learning* Terhadap Prestasi Belajar IPS SMP Taruna Kedung Adem. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *7*(1), 43. http://dx.doi.org/10.37905/aksara.7.1.4352.201

Hindiyati, K., Wirahayu, Y. A., Astina, I. K., & Soekamto, H. (2022). Pengaruh model pembelajaran *Problem Based Learning* (PBL) berbantuan media animasi terhadap kemampuan memecahkan masalah Geografi siswa. *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial*, *2*(12), 1249–1259. https://doi.org/10.17977/um063v2i122022p129-1259

Idris, M., & Nisa, A. (2023). Penerapan Model Pembelajaran Berbasis Masalah Menggunakan Pendekatan Tutor Sebaya Untuk Meningkatkan Hasil Belajar Siswa Smk Negeri 2 Palu Pada Materi Matriks: The Implementation of Problem-Based Learning Models Using Peer-Tutor Approaches to Improve Student Learning Outcomes SMK Negeri 2 Palu on Matrix Material. *Jurnal Elektronik Pendidikan Matematika Tadulako*, *11*(1), 83–90.

Kania, N., & Ratnawulan, N. (2022). Kompetensi matematika: Kemampuan pemecahan masalah matematis siswa menurut Polya. *Journal of Research in Science and Mathematics Education*, *1*(1), 17–26. https://doi.org/10.56855/jrsme.v1i1.10.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, *41*(4), 212-218.

https://doi.org/10.1207/s15430421tip4104_2

Lin, P., Zhou, Q., Ma, J., Wang, X., & Wu, J. (2025). Peer tutoring in higher education: power from pedagogical training. Humanities and Social Sciences Communications, 12(1). https://doi.org/10.1057/s41599-02504860-6.

Macapayad, G. L., Lapinid, E. L., Valmoria, G. P., Colis, K. V., & Bacalso, L. (2024). Efficacy Of One-On-One Peer Tutoring In Improving The Problem-Solving Performance Among The Grade 10 Learners. European Journal of Education Studies, 11(11). https://doi.org/10.46827/ejes.v11i11.5692.

Hamzah, A. M. (2023). Trends in International Mathematics and Science Study (TIMSS) as a measurement for students' mathematics assessment development. *12 Waiheru*, *9*(2), 189-196.

Muhammad, S., Tawil, M., & Rahman, Y. (2021). Penerapan model pembelajaran pbl dalam meningkatkan keaktifan belajar peserta didik. *Jurnal Profesi Kependidikan*, *2*(1), 51-56.

Mursyida, L., Dewi, I. P., Samala, A. D., & Ranuharja, F. (2024). E-Modules for Computer Network Practicum Based on Problem-Based Learning and *Peer Tutoring*: A Practical Solution to Develop 21st-Century Skills. *Journal of Education Technology*, *8*(1), 77–85. https://doi.org/10.23887/jet.v8i1.63568

Nabilah, M., Sitompul, S. S., & Hamdani, H. (2020). Analisis kemampuan kognitif peserta didik dalam menyelesaikan soal momentum dan impuls. *Jurnal Inovasi Penelitian Dan Pembelajaran Fisika*, *1*(1), 1-7. https://doi.org/10.26418/jippf.v1i1.41876.

Ngadinem. (2022). Pemanfaatan Edmodo dalam Pembelajaran Fisika untuk Meningkatkan Keterampilan Pemecahan Masalah dan Kemampuan Komunikasi. *Jurnal Praktik Baik Pembelajaran Sekolah Dan Pesantren*, *1*(01), 1–6. https://doi.org/10.56741/pbpsp.v1i01.9.

Niswah, P. U., & Dewi, N. R. (2024). Development of E-Worksheet with the TPACK Approach to Train Students' Digital Literacy and Higher Order Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3473–3485.

Nur Isra Jairina, S., Handoyo, B., Komang Astina, I., & Artikel Abstrak, I. (2020). *Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Mitigasi Bencana*. http://journal.um.ac.id/index.php/jptpp/

Nurdin, M., Amin, M., & Fiqrah Mutmainnah3, N. (2023). Penerapan Metode Diskusi Tutor Sebaya Dalam Meningkatkan Hasil Belajar PKn Siswa Kelas V. In *Jurnal Pendidikan & Pembelajaran Sekolah Dasar* , 124(1).

Nurlaily, V. A., Soegiyanto, H., & Usodo, B. (2019). Elementary School Teachers' Obstacles in the Implementation of Problem-Based Learning Model in Mathematics Learning. *Journal on Mathematics Education*, *10*(2), 229–238.

Polya, George. 1973. How To Solve It: A New Aspect of Mathematical Method. New Jersey: Pricenton University Press

Pradestya, R., Balkist, P., & Imswatama, A. (2019). Langkah-Langkah Pemecahan Masalah Dan Kemampuan Kognitif. *Jurnal Peka*, *2*(2), 43–49. https://doi.org/10.37150/jp.v2i2.1113.

Pramesti, S. L. D., & Rini, J. (2019). Analisis kemampuan pemecahan masalah peserta didik berdasarkan strategi polya pada model pembelajaran *Problem Based Learning* berbasis hands on activity. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *3*(2), 223–236. https://doi.org/10.31331/medivesveteran.v3i2.768.

Rahman, S. (2022). Pentingnya motivasi belajar dalam meningkatkan hasil belajar. *Prosiding Seminar Nasional Pendidikan Dasar*.

Rois, M., Sunanti, T., Aviory, K., & Arista, D. (2025). Self Efficacy Terhadap Kemampuan Pemecahan Masalah Matematika pada Siswa. *Indo-MathEdu Intellectuals Journal*, *6*(1), 1228–1234.

Setyawan, D. (2020). Proses memeriksa kembali dalam memecahkan masalah kontekstual matematis ditinjau dari gaya belajar. *MATHEdunesa*, *9*(2), 455-460. https://doi.org/10.26740/mathedunesa.v9n2.p455-460.

Sudijono, Anas. (2018). Pengantar statistika pendidikan. Jakarta: Rajawali Press.

Sugiyono. 2018. Metode Penelitian Kuantitatif, Kualitatif dan R&D. Alfabeta: Bandung.

Sumiantari, N. L. E., Suardana, I. N., & Selamet, K. (2019). Pengaruh model *Problem Based Learning* terhadap kemampuan pemecahan masalah IPA siswa kelas VIII SMP. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *2*(1), 12–22. https://doi.org/10.23887/jppsi.v2i1.17219.

Ummayah, F. F. D., & Dewi, N. R. (2021). Analysis of students metacognition ability through problem based learning assisted by worksheets on environmental pollution material. *Journal of Environmental and Science Education*, *1*(2), 32-40. https://doi.org/10.15294/jese.v1i2.45773.

Utami, N., Fitriani, H., & Efendi, I. (2023). Pengaruh Model *Problem Based Learning* (PBL) terhadap Kemampuan Memecahkan Masalah dan Hasil Belajar Kognitif Biologi Siswa Kelas VIII. *Bioscientist : Jurnal Ilmiah Biologi*, *11*(1), 783. https://doi.org/10.33394/bioscientist.v11i1.7984.

Valdez Pasion, O., & Marcelo, P. I. (2024). Benefits of Peer Tutoring in Enhancing Students' Academic Performance in Mathematics. International Journal Of Advanced Multidisciplinary Studies, IV. https://doi.org/10.47134/ptk.v2i1.983.

Wulansuci, R. A., Restian, A., & Iza, M. (2021). Peningkatan kemampuan pemecahan masalah kontekstual materi IPA melalui penggunaan model *Problem Based Learning*. *Jurnal Pendidikan Profesi Guru*, *2*(2), 76–82. https://doi.org/10.22219/jppg.v2i2.16805.

Yunita, I. (2022). Peningkatan Hasil Belajar Peserta Didik Melalui Metode Tutor Sebaya Pada Pokok Bahasan Penyetaraan Reaksi Redoks. *LAMBDA : Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, *2*(3), 118–127. https://doi.org/10.58218/lambda.v2i3.340.