



BERKALA ILMIAH PENDIDIKAN FISIKA

<https://ppjp.ulm.ac.id/journal/index.php/bipf>

Implementation of Problem-Based Learning to Improve Cognitive Understanding and Quality of Learning of Global Warming's Topic

Anggrian Anggraeni^{1*}, Kholifah², and Suliyanah¹

¹Universitas Negeri Surabaya, Jl. Lidah Wetan, Lakarsantri, Surabaya, Indonesia

²SMA Negeri 13 Surabaya, Jl. Raya Menganti, Lakarsantri, Surabaya, Indonesia

*anggriaenianggrian@gmail.com

DOI:10.20527/bipf.v12i1.17462

Received: 18 September 2023 Accepted: 1 January 2024 Published: 1 February 2024

Abstract

Implementation of one learning model in the classroom will stimulate student learning outcomes. Class X-1 at SMA Negeri 13 Surabaya shows that student learning outcomes must be upgraded based on the researcher's observation. The objective of fulfilling the Problem-Based Learning model with the Lesson Study approach in this research is to upgrade the cognitive competencies and the value of learning in class X-1 SMA Negeri 13 Surabaya. This type of research is Classroom Action Research, with a total research target of 36 students in class X-1 SMA Negeri 13 Surabaya. The teacher conducts learning for three cycles on global warming material, with each cycle using a lesson study approach. Research data was attained from observer observations and data on students' cognitive abilities. Then, it was analyzed to define the percentage of learning completion and the intensification of cognitive competencies using n-gain. The research results show an improvement in cognitive competencies with a value of 0.557 in the moderate category. Apart from that, the research results show an improvement in the percentage of learning operations. Therefore, it can be established that the research directed by the teacher can develop cognitive competencies and the quality of learning in class X-1 SMA Negeri 13 Surabaya.

Keywords: Global warming; Lesson study; Problem based learning

© 2024 Berkala Ilmiah Pendidikan Fisika

How to cite: Anggraeni, A., Kholifah, K., & Suliyanah, S. (2024). Implementation of problem-based learning to improve cognitive understanding and quality of learning of global warming's topic. *Berkala Ilmiah Pendidikan Fisika*, 12(1), 74-83.

INTRODUCTION

The variety of suitable learning models in education is crucial in producing the finest learning. It is also in the discipline of physics. Physics is a complex natural science content and expects a learning approach so students can recognize these challenging and complex concepts (Darmatiara, 2023; Ince, 2018; Wangchuk et al., 2023). In addition, students assess physics as non-contextual learning (Asri et al., 2017; Samudra et al., 2014). The internal factors that

encourage this state include the deficiency of the competency of students in mathematics when discussing physics concepts (Amanah et al., 2017; Wangchuk et al., 2023), lack of awareness in learning (Azzahra et al., 2022), and lack of thoughtfulness to teachers in learning (Lumbantoruan & Jannah, 2019). External factors include carrying out large amounts of learning, being dynamic in organizations, relationships with associates, and the deficiency of control from parents



(Abbas & Hidayat, 2018; Wangchuk et al., 2023). Therefore, the accurate learning model can construct an applicable and fascinating learning environment for students (Gambo & Shakir, 2023), aggregating the motivation (Zhang, 2023), growing the learning outcomes (Zhang, 2023), aggregating critical thinking skills (Anggraeni et al., 2023), and actively participating students in the learning course.

One of the learning models that can be implemented in the Merdeka Curriculum is the Problem-Based Learning (PBL) Model. The PBL model suggests a groundbreaking learning approach by concentrating on solving real problems that are appropriate to the perspective of students' lives (Putri, 2023; Tan, 2003; Yuberti et al., 2019). Through implementing PBL, students can develop critical thinking skills (Kumar & Refaei, 2017; Palinussa et al., 2023), problem-solving, and collaboration to understand complex physics concepts (Davidi et al., 2021). Apart from that, the PBL model assists students to be aware of the significance of physics in ordinary life. The teacher's role in this learning model is as an organizer who supports students to construct understanding through discovery activities and group discussions (Ariandi, 2017). Although PBL requires time and effort to design and implement appropriate learning activities, the benefits of improving students' talent and awareness in studying physics make it a viable option to be executed in the physics learning curriculum.

One approach that can be taken in executing this PBL is lesson study. Lesson study is a mutual approach where teachers work together to design, witness, and reflect on the execution of a lesson (Elkomy & Elkhail, 2022; Wahyuni, 2020). Lesson Study consists of three stages: explicitly plan, do, and see (Nursyahidah & Mulyaningrum,

2022; Tanujaya & Mumu, 2020; Waluyo & Nuraini, 2022). At the planning stage, teachers collaborate to regulate the accurate strategy for the learning process. In the do stage (implementation), the teacher conducts learning, conferring on the results of the previous plan. At the see (reflection) stage, the teacher can categorize the strengths and challenges that arise in the learning process so that the teacher can define the solutions to overcome these challenges. This reflection is not only through fellow teachers, but students also have a key role in reflecting. Students offer input and feedback so that subsequent learning can construct a learning environment more focused on students' needs.

Based on the observation results made at SMA Negeri 13 Surabaya, students have cognitive awareness that needs improvement. This can be seen from the previous material's cognitive learning results, which were less than optimal. Students are not yet accustomed to analyzing problems in daily life given by the teacher. Furthermore, many students' undertakings outside of learning, such as OSIS, hinder students' learning process. This causes students to be inexperienced in analyzing problem data and acquiring solutions that students can carry out. Therefore, this research aims to implement the PBL model so that students are accustomed to solving problems that arise in everyday life. This application was also carried out to determine the increase in cognitive competencies of students at SMA Negeri 13 Surabaya.

METHOD

This type of research is Classroom Action Research. Classroom action research is carried out to test the actions taken by researchers towards research targets (Azizah & Fatamorgana, 2021; Nurhassanah et al., 2020). This research was conducted in class X-1 SMA Negeri 13 Surabaya with 36 students as research

targets. The sample of this study consisted of 15 men and 21 women. The research was carried out by providing a learning process using the PBL model using a lesson study approach for three cycles. Each cycle consists of three stages: plan, do, and see (Tanujaya & Mumu, 2020; Waluyo & Nuraini, 2022). The stages of lesson study can be seen in Figure 1.

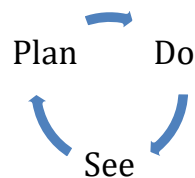


Figure 1 Lesson study stages
Source: (Waluyo & Nuraini, 2022)

At the planning stage, the researcher arranges documents that will be used throughout the learning process, such as teaching modules, worksheets, assessment instruments, and tools used for recording, such as cell phones and tripods. At the do (implementation) stage, the researcher, as a model teacher, carried out the learning process in class X-1 on global warming material under the activity planning confined in the teaching module. During the implementation of learning, observers also contribute to the class to assess the implementation of the learning process. At this stage, the supporting documents are observation sheets of learning implementation, student activity assessment sheets, and instruments for students' cognitive competencies. In the final stage, the see (reflection), the observer, and the model teacher reflect on the learning. The observer delivers a response to the model teacher's learning based on the results of his observations regarding students' deeds and the learning process's implementation.

Research data was attained from the students' cognitive assessments and observations of learning implementation. The results of the learning

implementation data were analyzed using descriptive statistics to conclude the percentage of learning activities. The cognitive assessment results were analyzed using n-gain to define the increase in students' cognitive competencies. The indicators of success in this research are the percentage of implementation of the PBL model of at least 85% and intensification in students' cognitive competencies on the medium n-gain indicator.

RESULT AND DISCUSSION

Researchers began the research (plan stage) by arranging research documents consisting of teaching modules, student assessment instruments, worksheets, and learning observation sheets. Then, researchers managed a Forum Group Discussion (FGD) with physics teachers at SMA Negeri 13 Surabaya to gain assessments and input for improvements to the instruments that had been equipped. This assessment is used as a reference for reviewing research documents that will be used during research.

At the learning implementation stage (do), the model teacher carries out the learning process in one research class, including one observer. The learning model used is PBL, which consists of five phases such as 1) facing students toward the problem, 2) establishing students, 3) managing students in group investigations, 4) emerging and presenting results, and 5) analyzing and evaluating the solution process problem (Arends, 2008). Learning is carried out in three cycles, with explanations for each cycle below.

Meeting 1

This first learning cycle was carried out on February 14, 2023, for 2x45 minutes. In this lesson, the model teacher applied the PBL model in class X-1 for material on global warming facts. The implementation of this learning involves

observers assessing the implementation of the learning. In this first cycle, participants were also given a pretest to determine the students' initial abilities. Learning activities carried out in the classroom can be seen in Figure 2.



(a)



(b)

Figure 2 (a) and (b). Learning activities in the first cycle

Observers make observations during learning in the classroom. The results of the model teacher's observation of students' activities in following the learning process can be seen in Table 1.

Table 1 Observation results by first cycle observers

Aspects of Learning Activities Observed	Score	
	Obsv	Max
Introduction	17	20
Phase 1: Problem Orientation	10	10
Phase 2: Organizing Students	19	20
Phase 3: Group Investigation Guidance	10	15
Phase 4: Development and Presentation of Results	27	30
Phase 5: Analysis and Evaluation of the Problem-Solving Process	9	10
Closing	13	25
Score	105	130

Aspects of Learning Activities Observed	Score	
	Obsv	Max
Percentage of learning implementation	80.8%	

*Obsv = Observation

Furthermore, the results of the student pretest assessment can be seen in Table 2.

Table 2 Student pretest results

Number of Students	Complete Study	30
	Not Completed Studying	6
	Total	36
Pretest Cognitive Score	Minimum Value	30
	Maximum Value	80
	Test Average	73.6
	Completion Percentage	83%

Based on Table 1, the observer's observations show that the percentage of implementation of learning carried out by model teachers is 80.8%, which is still below 85%. This shows that there are several parts of the learning process that need to be improved. The results of the observations made by the observer showed that the learning carried out was good. However, several parts could still be improved, such as providing posttests and student reflection during the learning process.

Furthermore, Table 2 shows that the average initial ability of students is still below the specified value set by the school ($73.6 < 75$). This shows that the model teacher needs to pay attention to students' cognitive abilities. The students' initial abilities will be analyzed with the results of the students' summative tests in cycle three.

Meeting 2

This second learning cycle was carried out on May 16th, 2023, for 2x45 minutes. In this lesson, the model teacher implemented the PBL model in class X-1 in the material on the causes, impacts, and solutions of global warming. The implementation of this learning involves observers assessing the implementation

of the learning. Learning activities are carried out through 5 PBL phases. Learning activities carried out in the classroom can be seen in Figure 3.



(a)



(b)

Figure 3 Learning activities in the second cycle

Observers make observations during learning in the classroom. The results of the model teacher's observation of students' activities in following the learning process can be seen in Table 3.

Table 3 Observation results by second cycle observers

Aspects of Learning Activities Observed	Score	
	Obsv	Max
Introduction	19	20
Phase 1: Problem Orientation	10	10
Phase 2: Organizing Students	20	20
Phase 3: Group Investigation Guidance	11	15
Phase 4: Development and Presentation of Results	29	30
Phase 5: Analysis and Evaluation of the Problem-Solving Process	8	10
Closing	14	25
Score	111	130
Percentage of learning implementation	85.4%	

*Obsv = Observation

Based on Table 3, the observer's observations show that the percentage of implementation of learning carried out by the model teacher is 85.4%, where this result has exceeded 85%. The learning carried out by the model teacher has met the criteria determined in this research. However, the learning process continues to determine students' cognitive abilities in the next cycle. The implementation of learning in the next cycle considers the results of the observer's reflection. The observations made by the observer showed that PBL implementation activities were better than in the previous cycle. Time management needs to be improved in the next lesson so that reflection is carried out in class.

Meeting 3

This third learning cycle was carried out on May 23, 2023, for 2x45 minutes. In this lesson, the model teacher implements the PBL model in the sample class in the material for selecting solutions based on the problems presented by the teacher. The implementation of this learning involves observers to assess the learning implementation. Learning activities are carried out through five PBL phases. Learning activities carried out in the classroom can be seen in Figure 4.



(a)



(b)

Figure 4 Learning activities in the third cycle

Table 4. Observation results by Third Cycle Observers

Aspects of Learning Activities Observed	Score	
	Obsv	Max
Introduction	20	20
Phase 1: Problem Orientation	10	10
Phase 2: Organizing Students	20	20
Phase 3: Group Investigation Guidance	14	15
Phase 4: Development and Presentation of Results	29	30
Phase 5: Analysis and Evaluation of the Problem-Solving Process	8	10
Closing	22	25
Score	123	130
Percentage of learning implementation	94.6%	

*Obsv = Observation

Observers make observations during learning in the classroom. The results of the model teacher's observation of students' activities in following the learning process can be seen in Table 4. Furthermore, the students' post-test assessment results can be seen in Table 5.

Table 5 Student posttest results

Number of Students	Complete Study	35
	Not Completed Studying	1
	Total	36
Posttest Cognitive Score	Minimum Value	0
	Maximum Value	100
	Test Average	86.6
	Completion Percentage	97%

Furthermore, Table 5 shows that the average summative test of students still exceeds the specified value set by the school ($86.6 > 75$). Based on the average value, it shows that there are positive changes from the use of the PBL learning model. The results of these cognitive abilities are then analyzed to determine the increase in students' cognitive

abilities. The results of the analysis can be seen in Table 6.

Table 6 N-gain analysis results

Indicator	Hasil	Criteria
Average N-Gain	0.557	Currently
N-Gain Percentage	56%	Effective enough

Based on the analysis results in Table 6, the N-gain value obtained is 0.557, indicating moderate criteria. This shows a significant increase in students' cognitive abilities after using the PBL model with the lesson study approach. Apart from that, the N-gain percentage result of 56% shows a sufficient level of effectiveness in improving students' cognitive abilities. Thus, it is concluded that the PBL model with the lesson study approach used in this research is sufficiently effective in achieving the learning objectives the model teacher targets.

At the reflection (see) stage, the model teacher and observer discuss the implementation of the learning carried out at meetings 1, 2, and 3. The model teacher conveys the advantages and obstacles during the learning process. After that, the observer also conveyed the results of his findings during the learning activities that had been carried out. The results of the reflection showed that the monitoring carried out by the model teachers in each group at the first meeting was still not optimal. Model teachers are still dominant in one group compared to other groups. Apart from that, posttests and reflections are also carried out outside the meeting. The reflection results at the second meeting showed that the time management for implementing learning was not by planning. The model teacher did not show the implementation duration in front of the class because of technical problems, so the learners did not pay attention to the duration of each activity. Finally, due to reflection at the third meeting, the implementation of learning has improved, but the student

worksheet given by the model teacher still needs to be reviewed with other education practitioners. Observers provide criticism, suggestions, and praise for the learning carried out by the model teacher (Amini & Golami, 2018). The assessment carried out by the observer is used as a basis for revisions to the learning process at the next meeting.

The quality of learning in class X1 is greatly influenced by the model teacher who implements PBL in the classroom. Findings obtained from the absence of learning meetings include that the model teacher has followed the learning steps by the PBL syntax in the previously created teaching module, the model teacher still dominates learning, students still need to be guided by the model teacher in understanding the student worksheet, and the model teacher has implemented a discussion timer so that time allocation can run well. Some of these findings show that the learning carried out by model teachers can still be improved. Determining and implementing appropriate learning strategies can influence students' learning processes and outcomes (Kizkapan & Bektas, 2017). Therefore, learning carried out in the classroom must be student-centered (Arrohman & Lestari, 2023).

In the learning process, the teacher must continue to monitor the progress of group discussions to resolve the problems presented. Teachers must be able to support students in finding and discussing problems to determine the right solution (Celik & Bukova, 2022). This is done to increase students' curiosity about the material being studied. Teachers must also be able to coordinate the learning environment in the classroom during the learning process until concluding the material being taught (Nurhidayati, 2017). If the learning process is carried out in a comfortable environment and the teacher has guided the learning process, then

students will more easily receive information (Safitri et al., 2022).

Consequently, it can be determined that the treatment of the PBL model in learning global warming material positively impacted the excellence of students' learning. It can be seen from the growth of the learning outcomes, creativity, and understanding of students' concepts after implementing the PBL model. Therefore, scientific articles about the influence of PBL in learning global warming material have important relevance in increasing students' understanding and awareness of this important environmental issue. Apart from that, the results of this research contribute to the development of effective learning methods for conveying information about climate change and the environment to students (Fitriyyah & Wulandari, 2019).

Learning activities carried out by students through PBL will also influence their cognitive understanding. The learning process carried out by tutors in the first, second, and third lessons always involves students in real problem-solving processes. Students identify, analyze, and determine solutions to problems discussed in class (Aliya, 2023; Irawati, 2023). This is what causes students to practice critical thinking (Nuzula & Jatmiko, 2023), apply the knowledge they already have (Makiyah et al., 2023), and develop collaboration skills within their groups (Pujiningtyas et al., 2023). Therefore, PBL can help students better understand the material because students will know the relevance of the learning material to the real world.

CONCLUSION

Based on the results of this research, it can be concluded that using the PBL model can improve students' cognitive abilities. It can be seen from the results of the N-gain analysis with a value of 0.557. It shows there are still potential advances to improve students' cognitive abilities.

Even though the increase in cognitive abilities is still within the moderate criteria, the percentage of students' learning completion has reached 97%.

The percentage of implementation of learning carried out in this research has also increased. This is shown from the results of the assessments carried out by observers in the first cycles to the third cycle of 80.8%, 85.4%, and 94.6%. This increase occurred due to improvements in the implementation of learning carried out after obtaining the results of learning reflection together with the observer. Apart from that, this percentage increase was caused by the lesson study approach, where there are stages that must be passed, namely plan, do, and see.

REFERENCES

- Abbas, & Hidayat, M. Y. (2018). Faktor-faktor kesulitan belajar fisika pada peserta didik kelas ipa sekolah menengah atas. *Jurnal Pendidikan Fisika*, 6(1), 45 – 49.
- Aliya, D. (2023). Efektivitas problem based learning dalam meningkatkan kemampuan berpikir kritis pada siswa sd. *OSF Preprints*.
- Amanah, P. D., Harjono, A., & Gunada, I. W. (2017). Kemampuan pemecahan masalah dalam fisika dengan pembelajaran generatif berbantuan scaffolding dan advance organizer. *Jurnal Pendidikan Fisika Dan Teknologi*, 3(1).
- Amini, S., & Golami, J. (2018). Professional development of efl teachers through rotatory peer supervision. *Journal of Teacher Education for Sustainability*, 20(2), 107 – 117.
- Anggraeni, D. M., Prahani, B. K., Suprpto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, 49, 101334.
- <https://doi.org/10.1016/j.tsc.2023.101334>
- Arends, R. I. (2008). *Learning to teach: Belajar untuk mengajar*. Yogyakarta: Pustaka Pelajar.
- Ariandi, Y. (2017). Analisis kemampuan pemecahan masalah berdasarkan aktivitas belajar pada model pembelajaran pbl. *Prosiding Seminar Nasional Matematika X 2016*.
- Arrohman, D. A., & Lestari, T. (2023). Analisis keragaman peserta didik dan implementasi kurikulum merdeka pada mata pelajaran fisika. *Journal of Science and Education Research*, 2(2).
- Asri, Y. N., Rusdiana, D., & Feranie, S. (2017). ICARE model integrated with science magic to improvement of students' cognitive competence in heat and temperature subject. *Advances in Social Science, Education and Humanities Research (ASSEHR)*, 57.
- Azizah, A., & Fatamorgana, F. R. (2021). Pentingnya penelitian tindakan kelas bagi guru dalam pembelajaran. *Jurnal Prodi Pendidikan Guru Madrasah Ibtidaiyah*, 3(1).
- Azzahra, S., Khassanah, N. I., Kurniawan, D. A., Maison, M., Wibisono, G., Sari, D. P., & Nasution, O. S. M. (2022). Analisis minat belajar peserta didik dalam pembelajaran fisika menggunakan website sebagai media pembelajaran di sman 8 tanjung jabung barat. *Jurnal Pendidikan MIPA*, 12(2).
- Celik, A. O., & Bukova, E. (2022). How to improve a mathematics teacher's ways of triggering and considering divergent thoughts through lesson study. *International Electronic Journal of Mathematics Education*, 15(3).
- Darmatiara, D. (2023). *Pengembangan video pembelajaran fisika berbasis pendekatan science, technology, engineering, and mathematics*

- (STEM) pada materi momentum dan impuls. Universitas Jambi.
- Davidi, E. I. N., Sennen, E., & Supardi, K. (2021). Integrasi PENDEKATAN STEM (science, technology, enggeenering and mathematic) untuk peningkatan keterampilan berpikir kritis siswa sekolah dasar. *Jurnal Pendidikan Dan Kebudayaan*, 11(1).
- Elkomy, M. M., & Elkhail, N. H. (2022). The lesson study approach to professional development: promoting teachers' peer mentoring and communities of practice and students' learning in egypt. *Teaching And Teacher Education*, 109.
- Fitriyyah, S. J., & Wulandari, T. S. H. (2019). Effect of problem based learning model on critical thinking of junior high school students on biology learning about global warming. *BIOEDUKASI: Jurnal Pendidikan Biologi*, 12(1), 1–7.
- Gambo, Y., & Shakir, M. Z. (2023). Evaluating students' experiences in self-regulated smart learning environment. *Education and Information Technologies*, 28(1), 547–580.
<https://doi.org/10.1007/s10639-022-11126-0>
- Ince, E. (2018). An overview of problem solving studies in physics education. *Journal of Enducation and Learning*, 7(4).
- Irawati, I. (2023). Meningkatkan aktivitas dan hasil belajar fisika siswa melalui pemanfaatan e-book interaktif berbasis problem based learning. *Wawasan: Jurnal Kediklatan Balai Diklat Keagamaan Jakarta*, 4(1).
- Kizkapan, O., & Bektas, O. (2017). The effect of project based learning on seventh grade students' academic achievement. *International Journal of Instruction*, 10(1), 37 – 54.
- Kumar, R., & Refaei, B. (2017). Problem-based learning pedagogy fosters students' critical thinking about writing. *Interdisciplinary Journal of Problem-Based Learning*, 11(2).
- Lumbantoruan, A., & Jannah, N. (2019). Analisis minat belajar peserta didik dalam pembelajaran fisika menggunakan website sebagai media pembelajaran di sman 8 tanjung jabung barat. *Jurnal Kajian Pendidikan Sains*, 5(2), 161 – 172.
- Makiyah, Y. S., Diana, R., & Septiana, S. (2023). Analisis efektivitas worksheet blended problem based learning (b-pbl) dan worksheet contextual teaching and learning (ctl) untuk meningkatkan keterampilan pemecahan masalah. *Jurnal Pendidikan Fisika*, 12(1), 14 – 21.
- Nurhassanah, F., Sukandi, U., Kuncoro B, A., Rusilowati, A., Hastuti S, W., & Prabowo, A. (2020). Collaborative classroom action research for mathematics and science teachers in indonesia. *Journal of Physics*.
- Nurhidayati, E. (2017). Pedagogi konstruktivisme dalam praksis pendidikan indonesia. *Indonesian Journal of Educational Counseling*, 1(1).
- Nursyahidah, F., & Mulyaningrum, E. R. (2022). The impacts of stem on mathematics and science through lesson study: A systematic literature review. *Kalamatika: Jurnal Pendidikan Matematika*, 7(2), 125–142.
<https://doi.org/10.22236/KALAMATIKA.vol7no2.2022pp125-142>
- Nuzula, F., & Jatmiko, B. (2023). Pembelajaran fisika dengan model pbl berbasis stem untuk meningkatkan keterampilan berpikir kritis peserta didik sma. *Student Scientific Creativity Journal*, 1(5).
- Palinussa, A. L., Lakusa, J. S., & Moma, L. (2023). Comparison of problem-based learning and discovery learning to improve students' mathematical critical thinking skills. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 13(1).

- <https://doi.org/10.30998/formatif.v13i1.15205>
- Pujiningtyas, M. R., Sumarno, & Prasasti, D. (2023). Penerapan model pembelajaran problem based learning untuk meningkatkan kolaborasi siswa pada pembelajaran biologi. *Seminar Nasional Optimalisasi PKB Melalui Penelitian Tindakan Kelas*.
- Putri, D. A. (2023). *Model pembelajaran: Peningkatan proses pembelajaran*. Program Studi Pendidikan Bahasa dan Sastra Indonesia.
- Safitri, A. O., Handayani, P. A., Sakinah, R. N., & Prihantini. (2022). Implementasi kurikulum 2013 dalam pembelajaran jarak jauh pada masa pandemi covid-19. *Jurnal Basicedu*, 6(1), 116 – 128.
- Samudra, G. B., Suastra, I. W., & Suma, K. (2014). Permasalahan-permasalahan yang dihadapi siswa sma di kota singaraja dalam mempelajari fisika. *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, 4.
- Tan, O. S. (2003). *Problem-based learning innovation: Using problems to power learning in the 21st century*. Cengage Learning.
- Tanujaya, B., & Mumu, J. (2020). Improvement of mathematics learning activity through lesson study. *Journal of Physics*.
- Wahyuni, R. (2020). Efektivitas implementasi lesson study learning community dalam meningkatkan kualitas pembelajaran. *Equity in Education Journal (EEJ)*, 2(1), 11 – 18.
- Waluyo, E., & Nuraini. (2022). Lesson study: Implementasi project based learning untuk meningkatkan kemampuan berpikir kreatif mahasiswa. *Jurnal Pengembangan Pembelajaran Matematika*, 4(2).
- Wangchuk, D., Wangdi, D., Tshomo, S., & Zangmo, J. (2023). Exploring students' perceived difficulties of learning physics. *Educational Innovation and Practice*, 6. <https://doi.org/10.17102/eip.6.2023.03>
- Yuberti, Y., Latifah, S., Adyt, A., Saregar, A., Misbah, M., & Jermisittiparsert, K. (2019). Approaching problem-solving skills of momentum and impulse phenomena using context and problem-based learning. *European Journal of Educational Research*, 8(4), 1217-1227.
- Zhang, C. (2023). Influences of problem-based online learning on the learning outcomes of learners. *International Journal of Emerging Technologies in Learning (IJET)*, 18(01), 152–163. <https://doi.org/10.3991/ijet.v18i01.36705>