IMPLEMENTATION OF PROBLEM BADES LEARNING (PBL) BASED LESSON STUDY (LS) MODEL TO IMPROVE COGNITIVE LEARNING OUTCOMES VIII STUDENTS OF TONDANGOW CHRISTIAN JUNIOR HIGHT SCHOOL

Nomi Desmawati
Alfonds Andrew Maramis
Herry Maurits Sumampouw

Author Affiliations

[1] *Department of Biology Education, Faculty of Mathematics, Natural Sciences, and Earth, Manado State University, Manado, Indonesia*
[2] *Department of Biology Education, Faculty of Mathematics, Natural Sciences, and Earth, Manado State University, Manado, Indonesia*
[3] *Department of Biology Education, Faculty of Mathematics, Natural Sciences, and Earth, Manado State University, Manado, Indonesia*

Author Emails
Corresponding author: [a]nomisembiring83@gmail.com

Abstract. Improving cognitive learning outcomes can be assisted by problem-based learning (PBL) based on Lesson Study (LS), where in the characteristics of PBL there is a question posed as a problem for students to work on. LS is learning through collaboration of subject teachers in discussing the direction of learning objectives in finding suitable learning strategies or methods to help achieve learning objectives. This study aims to determine the effectiveness of PBL model based on LS in improving students' cognitive learning outcomes. The research sample was 10 students in Tondangow Christian Junior High School, Tomohon City, North Sulawesi, Indonesia. The research data were obtained through teacher and student learning activity questionnaires, and cognitive learning outcomes through test questions in the form of essays. This learning activity was carried out using 2 learning cycles, with the acquisition of scores in cycle I amounting to 62.1% and cycle II amounting to 92%. The results showed an increase in students' cognitive learning outcomes. Furthermore, the N-Gain test was carried out with a value of 80.19% with the interpretation of "effective", and the results of the division of the N-Gain score, which is greater than g> 0.7, namely with a value of 0.80 with a "high" category. Based on the results of these calculations, it can be concluded that.

Keyword: Classroom Action Research, Cognitive, Lesson Study, Problem Based Learning,

INTRODUCTION

Decision-making in action is a mental and structured activity through thinking (Isnaini & Mulyono, 2019). Someone will be faced with a problem in which someone must take action to solve the problem, as well as in the learning process faced by students, they are faced with a problem to find answers / solutions to go through the problem solving process (Kim et al., 2018). The learning process that emphasizes activities by providing problems and is carried out with activities to find answers based on problems will have an impact on students' cognitive abilities (Kuisma & Nokelainen, 2018; Khotimah et al., 2021). A problem is a situation that hinders or becomes a barrier in a person to progress, limited in developing, inappropriate expectations, and a situation that confuses a person (Maulyda et al., 2019), but these things can be solved by various processes, ways or actions in solving problems so that they have an impact on cognitive learning outcomes (Yulindar et al., 2018; Apriyani et al., 2019; Wang, 2021; Tung & Alissa, 2021). Cognitive learning outcomes are the acquisition of knowledge through a series of receiving information in student learning activities carried out both in class and outside the classroom through a series of investigations to obtain answers that can be accepted as true, thus influencing and improving student learning outcomes significantly (Senisum et al., 2022). Cognitive learning outcomes can be improved through learning that emphasizes the problem-solving process of giving problems by the teacher based on the material to be taught (Ilma et al., 2022). Cognitive learning outcomes are a

series of learning carried out by students during learning activities, gaining knowledge, being able to explain, summarize, and conclude learning (Permatasari et al., 2019; Hanif, 2020). Cognitive abilities that students have affect all aspects of learning activities related to thinking, reasoning and brain activity (Saarinen et al., 2021). Cognitive learning outcomes are based on the clarity of important information generated based on student actions in searching for answers (Bagassi & Macchi, 2020). Good cognitive learning outcomes must be possessed by students to facilitate thinking activities and learning activities to be more effective. The domain of cognitive learning outcomes by Bloom's taxonomy includes remembering, understanding, applying, analyzing, evaluating, and creating (Das et al., 2020). The impact of good student cognitive learning outcomes affects aspects including thinking activities, making observations, trying, asking questions, discussing, and even conducting experiments (Gunawan et al., 2020; Adnan et al., 2021; Khairani & Aloysius, 2023; Wola et al., 2023). Students who have good cognition are able to face difficulties, pressures, and can think logically in making the best decisions (Kew & Tasir, 2021; Arono et al., 2022). Cognitive learning outcomes that are continuously trained make students have good abilities in analyzing and processing information (Kivi et al., 2021; Yıldırır, 2020).

Based on initial observations, conducted during 2 face-to-face meetings of learning activities, students tend to only learn independently through the textbooks provided by the teacher, students have not been taught with cognitive learning outcomes activities with groups, students lack courage in asking teachers and friends. Furthermore, researchers conducted an initial test to determine students' cognitive learning outcomes by giving questions or description tests. The making of essay questions is adjusted to the indicators of learning outcomes at the C2-C6 level cognitive domain. The average results of the acquisition of cognitive learning outcomes for each indicator include understanding (C2) with a score of 32.44, applying (C3) with a score of 31.22, analyzing (C4) with a score of 28.68, evaluating (C5) with a score of 27.55, and creating (C6) with a score of 27.54. and if averaged, the total score of students' cognitive learning outcomes is 29.48. Based on observations and pre-research results by doing calculations, the average value of students' cognitive learning outcomes is still very poor. The low cognitive learning outcomes of students can be overcome by conducting meaningful and varied learning activities by emphasizing the process of activities to find sources of answers through problems or topics that are faced with students.

In order for learning to take place in accordance with the expected goals, it is necessary to vary student learning activities assisted by learning models. The implementation of learning models in the stages of learning can improve various student skills in the 21st century (Mamahit et al., 2020; Matraeva et al., 2020; Y. Rahmawati et al., 2020) among them cognitive learning outcomes (Evendi et al., 2022). Various kinds of learning models exist, the problem-based learning (PBL) model based on lesson study (LS) can be used to improve students' cognitive learning outcomes (Bayram & Deveci, 2022; Surur et al., 2020). LS is an activity of a circle or group of educators in formulating problems that arise in student learning activities, how to teach students with good methods and strategies, so that learning objectives for students can be achieved (Huong et al., 2020; Richit et al., 2021). The LS stage, consisting of Plan, is the stage where the subject teacher, in this case the biology teacher with the team, conducts a discussion in determining what meaningful learning will be taught to students by the model teacher, the second stage Do, where this stage is the activity of the model teacher in carrying out learning according to the agreement made with the team at the plan stage, which includes the implementation of the PBL model syntax, and the third stage is see where this stage is to conduct a series of reflections on all learning activities carried out from the beginning to the end of learning by the model teacher and students who are presented with the findings by the observer (Ogegbo et al., 2019; Wahman et al., 2020; Wake & Seleznyov, 2020; et al., 2021). The PBL model is a learning activity that can guide students in learning, by emphasizing the process of finding an answer carefully, systematically, accurately, critically and analytically so that it can be trusted in producing new theories (Saputra et al., 2019; Sousa & Costa, 2022). The problem-based learning process can be done in groups, outside the classroom or in group discussions, so that these activities can lead to direct student activity (student centered) in their learning activities in seeking and finding answers (Duda et al., 2019; Funa & Prudente, 2021; Laksmi et al., 2021). Based on the description of the problems above, research can be carried out using the LS-based PBL model on student cognitive learning outcomes.

METHOD

This study used a type of classroom action research (PTK) with the aim of improving cognitive learning outcomes with the LS-based PBL model on the learning material "Plant Structure and Development" conducted on students at Tondangow Christian Junior High School, Tomohon City, North Sulawesi, Indonesia. The number of samples in this study were 10 students. The implementation of the research was carried out as many as 2 learning cycles. The treatment in each cycle was carried out based on the syntax of the LS-based PBL model, which included the stages of planning, implementation (learning

model treatment), and reflection. The research instruments used included essay questions, rubrics for assessing cognitive learning outcomes indicators, lesson plans and observation sheets. The research data were analyzed descriptively and statistically, where data were obtained from observation data, questionnaires, and comparison of average scores between cycle I and cycle II which were carried out by calculating N-Gain to determine the effectiveness of the incuri model on cognitive learning outcomes. The formula for calculating the N-Gain value can be seen in equation (1), and the scoring of the N-Gain effectiveness test can be seen in table 1.

$$N - Gain \frac{Posttest\ score - pretest\ score}{ideal\ score - pretest\ score} \quad (1)$$

Table 1
N-Gain Test Effectiveness Scoring Categories

N-Gain Effectiveness Interpretation Category		N-Gain Score Distribution	
Percentage (%)	Interpretation	N-Gain Score	Category
< 40	Not Effective	g > 0.7	High
40 – 50	Less Effective	0.3 ≤ g ≤ 0.7	Medium
56-75	Moderately Effective	g < 0.3	Low
> 76	Effective		

DISCUSSION

Data on Student Learning Activities

The results of observations through questionnaires conducted by observers of student activities in the LS-based PBL model showed an increase in learning activities from cycle I and cycle II in learning activities. Student learning activities in cycle I with an average score of 48.33. The results of student activity in cycle II with an average score of 90.16%. The acquisition of average scores proves that learning PBL models based on LS can increase student learning activities between cycle I to cycle II with a difference of 41.33% increase. Data on student learning activity results can be seen in table 2.

Table 2
Data on Student Learning Activities

No	Activity Student Learning	Cycle I Scores (%)	Cycle II Scores (%)
1	Active	45	90
2	Enthusiastic	52	88
3	Ask	48	90
4	Collaborate	52	88
5	Information Absorption	55	95
6	Expressing Opinions	38	90
Average Score		48.33	90.16
Difference of Improvement Between Cycles		-	41.33

Implementation Data of LS-based PBL Model by Model Teacher

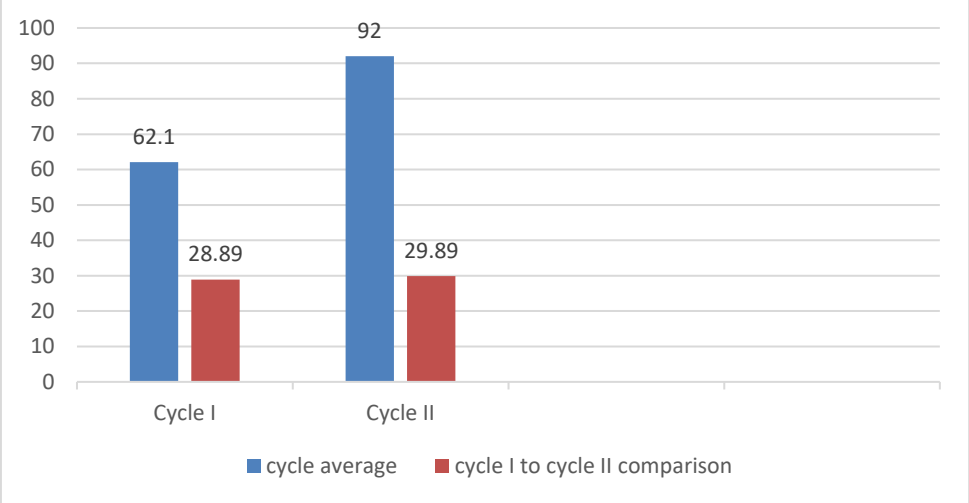
The implementation of the PBL model syntax carried out by the model teacher with indicators of learning implementation carried out through observation by the observer team obtained results including, among others, indicators of the ability to open lessons cycle I 2.75, cycle II 3.75, learning process cycle I 2. 5, cycle II 4, mastery of subject matter cycle I 2.75, cycle II 3.75, implementation of learning syntax cycle I 3.28, cycle II 3.71, use of media / learning resources cycle I 3.25, cycle II 4, evaluation cycle I 2.35, cycle II 3.75, and ability to close the lesson cycle I 2.75, cycle II 3.75. The implementation of the LS-based PBL model in cycle I with an average score of 2.93 with the category "sufficient", while in cycle II there was an increase in learning implementation, which amounted to 3.81 with the category "good". The increase was due to the evaluation of the model teacher delivered by the observer team to follow up or improve learning in the next cycle. The results of the implementation of the LS-based PBL model by the model teacher can be seen in table 3.

Table 3
Implementation Data of LS-based PBL Model by Model Teacher

Indicators of Assessment	Cycle I (average score on a scale of 1-4)	Cycle II (average score on a scale of 1-4)
Ability to open the lesson	2.75	3.75
Learning process	2.5	4
Mastery of subject matter	2.75	3.75
Implementation of learning Scenarios/syntaxes	3.28	3.71
Use of media/learning resources	3.25	4
Evaluation	2.35	3.75
Ability to close the lesson	2.75	3.75
Conclusions	2.93 " Sufficient Category"	3.81 " Good Categories"

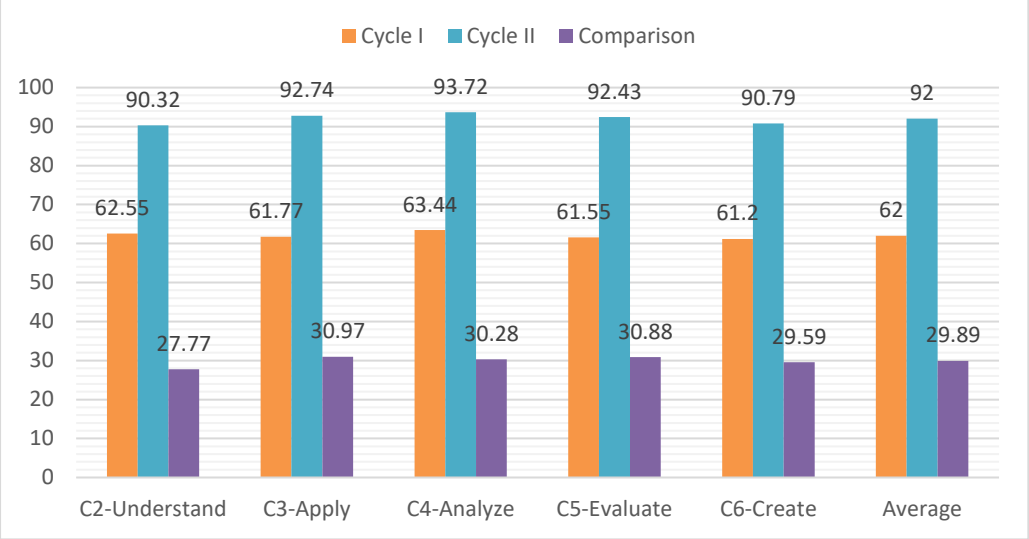
Data on Students' Cognitive Learning Outcomes
Comparison of the total overall cognitive learning outcomes of students can be seen from the average value of learning activities in cycle I of 62.1%, and cycle II of 92%. The difference in improvement from cycle I to cycle II amounted to 29.9. The difference in the average cognitive learning outcomes between cycle I and cycle II was influenced by the LS-based PBL model with various methods, approaches, learning resources, and other instruments that supported the achievement of increased cognitive learning outcomes in cycle II. The average cognitive learning outcomes can be seen in Figure 1.

Figure 1
Average and difference in Students' Cognitive Learning Outcomes



Furthermore, the indicators of cognitive learning outcomes used are only C2-C6 indicators, with the average value of each indicator including: understanding indicators (C2) with an average acquisition of cycle I 62.55, cycle II 90.32, with a difference in cycles I and II of 27.22. Application indicators (C3) with an average acquisition of cycle I 61.77, cycle II 92.74 with a difference in cycles I and II of 30.97. Indicators analyze (C4) with an average acquisition of cycle I 63.44, cycle II 93.72, with a difference in cycles I and II of 30.28. Indicators evaluate (C5) with an average acquisition of cycle I 61.55, cycle II 92.43 with a difference in cycle I and cycle II of 30.88 Indicators create (C6) with an average acquisition of cycle I 61.1, cycle II 90.79 with a difference in cycle I and II of 29.59. The results of the acquisition of the overall average value of the cognitive learning outcomes indicators of cycle I amounted to 62.1, cycle II amounted to 92, with the difference in the average values of cycles I and II amounting to 29.89. Based on the average value obtained, it is known that there is an increase in cognitive learning outcomes using the LS-based PBL model from cycle I to cycle II. The average results and differences for each cognitive indicator can be seen in Figure 2.

Figure 2
Average Indicators of Students' Cognitive Learning Outcomes



Data on the Effectiveness of LS-based PBL Model on Cognitive Learning Outcomes
The results of calculations using N-Gain showed the acquisition of effectiveness values above the value of the provisions of >76, where a value of 80.19% was obtained with the interpretation of "effective". Furthermore, the calculation of the division of the N-Gain score on cognitive learning outcomes with the acquisition of values above the value of the provisions g> 0.7 with a value obtained above 0.80 with the category "high". The acquisition of values through the calculation of N-Gain can be said that the LS-based PBL model is effective in improving the cognitive learning outcomes of students who are taught starting from the learning activities of cycle I and cycle II. Data on the results of the N-Gain calculation can be seen in table 4.

Table 4
Categories of N-Gain Effectiveness on Cognitive Learning Outcomes

Category of N-Gain Effectiveness of Cognitive Learning Outcomes		
Percentage (%)	Interpretation	Conclusions
< 40	Not Effective	
40 – 50	Less Effective	86.6379%
56-75	Moderately Effective	Category >76 : " Effectively"
> 76	Effective	
N-Gain Score Distribution of Cognitive Learning Outcomes		
N-Gain Score	Categories	Conclusions
g > 0.7	High	0.86638%
0.3 ≤ g ≤ 0.7	Medium	Category g > 0.7 : "High"
g < 0.3	Low	

Implementation of Learning Actions
The planning stage is important before carrying out learning activities so that it is carried out properly in accordance with the scenario that has been made to realize the achievement of learning objectives (Sutiani et al., 2021). Furthermore, the implementation stage is carried out by applying the problem-based learning model based on lesson study for all learning cycles that have been designed learning scenarios through the learning syntax of the learning model. After the implementation stage is carried out, it is necessary to have reflection activities, namely conducting meaningful learning evaluations to determine the extent of student involvement and activity in learning at that time, where the researcher conducts a follow-up process on what will be used in the next learning cycle, whether there are things that are still lacking or unexpected obstacles experienced by students during the learning process. Reflection aims to find out the difficulties or learning disorders (Irwanto et al., 2018), and encourage students to be more participative and motivated in learning in future lessons (Gani et al., 2022; Subari et al., 2022).
The average score for each learning cycle increased significantly from cycle I to cycle II. The way of learning in cycle I and II has similarities to the learning syntax of the PBL model. Low cognitive learning outcomes in cycle I made the model teacher and the LS team follow up for learning activities with

various instruments that would help the model teacher in carrying out the learning in cycle II. This is evidenced by the acquisition of average scores in cycles I and II that with the existence of learning variations by conducting good evaluations, good thinking, effective LS teamwork, can lead learning to improve significantly.

Implementation of PBL Model based on LS

The problem-based learning model based on lesson study is a learning activity that focuses on the process of finding information as detailed as possible by relying on various learning resources by involving all thinking activities systematically and logically to form a more meaningful learning experience (Duda et al., 2019; Surur et al., 2020). Previous research conducted by Kanellopoulou & Darra, 2019; Sholahuddin et al., 2021; Ernawati et al., 2022; Miftakhurrohmah et al., 2023, stated that the application of the PBL model based on LS can improve students' cognitive learning outcomes where this learning model requires students in their activities to provide ideas, ideas, creativity, and solutions, and the PBL model can guide students through learning syntax so that student learning can be well directed. The stages of the problem-based learning model based on lesson study are orientation/observation, question/conceptualize, investigation, conlcusion, and discussion. The implementation of the problem-based learning model based on lesson study is illustrated in the learning stages as follows.

Problem orientation stage for students. Learning in cycles I and II began with the division of groups and the introduction of general material that would be the topic of discussion. At this stage, the group was free to provide input in determining the problem formulation on the main topic given by the model teacher. After a brief discussion, the group then agreed on the use of the problem formulation that the group would work on through the problem solving process in further learning. The introduction of initial material with problem formulation activities is important at the beginning of learning to attract attention, readiness and motivate students to learn so that it facilitates the learning process in the next stages (Herpratiwi & Tohir, 2022; Hariri et al., 2020).

Organizing students to learn. After determining the formulation of the problem based on the topic of discussion, the student group continues in determining guiding questions based on the formulation of the problem that has been previously determined. At this stage, students with groups organize all preparations or determine the planning of the process of solving the topic of the problem that will be carried out during the learning process. It is important for students to organize and train themselves continuously in developing and composing high-level questions, so that by themselves the students are able to think broadly, directed, high knowledge insight, and increasing life capabilities (Noviyanti et al., 2019; Zhang & Chen, 2021). The guiding questions that have been set can help students be more focused, directed, and limit the scope of the problem so as not to expand so that it remains focused on the purpose of the problem formulation that has been made before so that it is useful for students in finding information to obtain answers.

Guiding individual or group experience. At this stage, the model teacher pays attention to each group's activities in working on problem-solving tasks. The teacher's activity at this stage is only as a tutor in helping direct students when they have difficulty in determining the steps to find sources of information or answers. Each group determines or formulates a hypothesis according to the problems they face in learning, for which purpose the group will search for answers through an investigative process using various learning resources or relevant references to produce new answer findings. Training students to formulate problems, hypothesize, and collect data can improve thinking skills and facilitate further learning that will be more flexible and gain more meaningful learning experiences (Hassan et al., 2014; Plotnikova & Strukov, 2019; Hsbollah & Hassan, 2022; Tian et al., 2022).

The stage of developing problems and producing work. The next activity in the learning process is to investigate the problem formulation that has been arranged questions to find accurate sources of answers. Investigation is a follow-up to the formulation of the problem to find out the truth through the process of finding answers. Learning activities that involve the investigation process will motivate students to be active in learning, skilled, brave, and show a positive attitude towards the surrounding environment. (Tekkol & Demirel, 2018).

The stage of analyzing and evaluating problem solving. After obtaining answers based on the investigation process, the group conducts a further stage, namely verifying the answers that will be summarized in outline. This stage aims to determine the final results in the form of concepts that are accurate, acceptable, and reasonable to convey to other groups through the discussion process. The verification process of new information is very important in building the level of understanding of the information they have received whether it can be accepted or rejected based on the studies that have been done before. (Tanjung et al., 2022; Lubis et al., 2022). This stage aims to convey all the information that has been created by the group to other groups through presentations, where the activity is carried out by one student appointed by his group to deliver presentation material to other groups. The

presentation process for cycle I and II was carried out differently, namely for cycle I it was carried out using the lecture method and the group listened to what was delivered. Presentation activities for cycle II were carried out with the addition of presentation media in the form of posters.

CONCLUSION

Based on the results of research and discussion, it can be concluded that through the calculation of the average comparison and calculation through N-Gain, the LS-based PBL model is effective and can improve students' cognitive learning outcomes, where it can be seen from the learning outcomes from cycle I to cycle II.

REFERENCES

1. Adnan, G., Zulfikar, T., Armia, M. S., Gade, S., & Walidin, W. (2021). Impacts of Inquiry Learning Model on Students' Cognitive and Critical Thinking Ability. Cypriot Journal of Educational Sciences, 16(3), 1290–1299. https://doi.org/10.18844/CJES.V16I3.5851
2. Apriyani, R., Ramalis, T. R., & Suwarma, I. R. (2019). Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning. Journal of Science Learning, 2(3), 85–91. https://doi.org/10.17509/jsl.v2i3.17559
3. Arono, Arsyad, S., Syahriman, Nadrah, & Villia, A. S. (2022). Exploring the effect of digital literacy skill and learning style of students on their meta-cognitive strategies in listening. International Journal of Instruction, 15(1), 527–546. https://doi.org/10.29333/iji.2022.15130a
4. Ayra, M., & Kösterelioğlu, İ. (2021). Effect of the Lesson Study Practice on Students' Academic Achievements in Life Sciences Course. Educational Policy Analysis and Strategic Research, 16(1), 249–270. https://doi.org/10.29329/epasr.2020.334.14
5. Bagassi, M., & Macchi, L. (2020). Creative Problem Solving as Overcoming a Misunderstanding. Frontiers in Education, 5(December), 1–10. https://doi.org/10.3389/feduc.2020.538202
6. Bayram, H., & Deveci, H. (2022). The Effect of Problem-Based Learning on Students' Entrepreneurship Level in Social Studies Course. International Journal of Contemporary Educational Research. https://doi.org/10.33200/ijcer.1056504
7. Das, S., Mandal, S. K. Das, & Basu, A. (2020). Identification of Cognitive Learning Complexity of Assessment Questions Using Multi-class Text Classification. Contemporary Educational Technology, 12(2), 1–14. https://doi.org/10.30935/cedtech/8341
8. Duda, H. J., Susilo, H., & Newcombe, P. (2019). Enhancing Different Ethnicity Science Process Skills: Problem-Based Learning through Practicum and Authentic Assessment. International Journal of Instruction, 12(1), 1207–1222. https://doi.org/10.29333/iji.2019.12177a
9. Ernawati, M. D. W., Sudarmin, Asrial, Damris, M., Haryanto, Nevriansyah, E., Fitriani, R., & Putri, W. A. (2022). How Scaffolding Integrated With Problem Based Learning Can Improve Creative Thinking in Chemistry? European Journal of Educational Research, 11(3), 1349–1361. https://doi.org/10.12973/eu-jer.11.3.1349
10. Evendi, E., Al Kusaeri, A. K., Pardi, M. H. H., Sucipto, L., Bayani, F., & Prayogi, S. (2022). Assessing students' critical thinking skills viewed from cognitive style: Study on implementation of problem-based e-learning model in mathematics courses. Eurasia Journal of Mathematics, Science and Technology Education, 18(7). https://doi.org/10.29333/ejmste/12161
11. Funa, A. A., & Prudente, M. S. (2021). Effectiveness of Problem-Based Learning on Secondary Students' Achievement in Science: A Meta-Analysis. International Journal of Instruction, 14(4), 69–84. https://doi.org/10.29333/iji.2021.1445a
12. Gani, M. A., Tumewu, W. A., & Wola, B. R. (2022). Motivasi Belajar Siswa Kelas VII SMP Anugerah Tondano pada Pembelajaran IPA di Era Pandemi Covid-19. SCIENING : Science Learning Journal, 3(1), 8–13. https://doi.org/10.53682/slj.v3i1.1845
13. Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving students' problem-solving skills using inquiry learning model combined with advance organizer. International Journal of Instruction, 13(4), 427–442. https://doi.org/10.29333/iji.2020.13427a
14. Hanif, M. (2020). The Development and Effectiveness of Motion Graphic Animation Videos to Improve Primary School Students' Sciences Learning Outcomes. International Journal of Instruction, 13(4), 247–266. https://doi.org/10.29333/iji.2020.13416a
15. Hariri, H., Karwan, D. H., Haenilah, E. Y., Rini, R., & Suparman, U. (2020). Motivation and Learning Strategies: Student Motivation Affects Student Learning Strategies. European Journal of Educational Research, 10(1), 39–49. https://doi.org/10.12973/EU-JER.10.1.39
16. Herpratiwi, & Tohir, A. (2022). Learning Interest and Discipline on Learning Motivation. International Journal of Education in Mathematics, Science and Technology, 10(2), 424–435. https://doi.org/10.46328/IJEMST.2096

17. Hsbollah, H. M., & Hassan, H. (2022). Creating Meaningful Learning Experiences with Active, Fun, and Technology Elements in The Problem-Based Learning Approach and Its Implications. Malaysian Journal of Learning and Instruction, 19(1), 147–181. https://doi.org/10.32890/mjli2022.19.1.6
18. Huong, L. T. T., Quynh, N. T. T., Ngoc, N. T., & Duc, N. M. (2020). Applying the Lesson Study Model in Developing Teaching Capability for Young Teachers in Vietnam. European Journal of Educational Research, 9(1), 331–349.
19. Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Sari, M. S. (2022). Promoting Students' Metacognitive Awareness and Cognitive Learning Outcomes in Science Education. International Journal of Evaluation and Research in Education, 11(1), 20–30. https://doi.org/10.11591/ijere.v11i1.22083
20. Irwanto, Saputro, A. D., Rohaeti, E., & Prodjosantoso, A. K. (2018). Promoting critical thinking and Problem Solving Skills of Preservice Elementary Teachers through Process-Oriented Guided-Inquiry Learning (POGIL). International Journal of Instruction, 11(4), 777–794. https://doi.org/10.12973/iji.2018.11449a
21. Isnaini, A., & Mulyono, M. (2019). Differences in Reflective Thinking Ability Between Creative Problem Solving and Discovery Learning Models Based on Gender. Journal of Education and Practice, 10(23), 2017–2020. https://doi.org/10.7176/jep/10-23-04
22. Kanellopoulou, E.-M., & Darra, M. (2019). The Implementation of the Lesson Study in Basic Teacher Education: A Research Review. Higher Education Studies, 9(3), 65. https://doi.org/10.5539/hes.v9n3p65
23. Kew, S. N., & Tasir, Z. (2021). Analysing Students' Cognitive Engagement in E-Learning Discussion Forums Through Content Analysis. Knowledge Management and E-Learning, 13(1), 39–57. https://doi.org/10.34105/j.kmel.2021.13.003
24. Khairani, R., & Aloysius, S. (2023). How does PBL Brainwriting Method Supplemented with Concept Mapping Effective to Improve Critical Thinking and Problem-Solving Ability ? Jurnal Penelitian Pendidikan IPA, 9(3), 1030–1038. https://doi.org/10.29303/jppipa.v9i3.3212
25. Khotimah, K., Hastuti, U. S., Ibrohim, & Suhadi. (2021). Developing Microbiology Digital Handout as Teaching Material to Improve the Student's Science Process Skills and Cognitive Learning Outcomes. Eurasian Journal of Educational Research, 95(95), 80–97. https://doi.org/10.14689/EJER.2021.95.5
26. Kim, J. Y., Choi, D. S., Sung, C. S., & Park, J. Y. (2018). The role of problem solving ability on innovative behavior and opportunity recognition in university students. Journal of Open Innovation: Technology, Market, and Complexity, 4(1). https://doi.org/10.1186/s40852-018-0085-4
27. Kivi, P. J., Hernández, R. M., Flores, J. L. E., Garay, J. P. P., & Fuster-Guillén, D. (2021). The Correlation Between Cognitive Ctyles and Written Corrective Feedback Preferences among Iranian and Turkish EFL Learners. Cypriot Journal of Educational Sciences, 16(2), 669–685. https://doi.org/10.18844/CJES.V16I2.5643
28. Kuisma, M., & Nokelainen, P. (2018). Effects of Progressive Inquiry on Cognitive and Affective Learning Outcomes in Adolescents' Geography Education. Frontline Learning Research, 6(2), 1–19. https://doi.org/10.14786/flr.v6i2.309
29. Laksmi, M. L., Sari, D. P., Rinanto, Y., & Sapartini, R. R. (2021). Implementation of Problem Based Learning to Increase Scientific Explanation Skill in Biology Learning about the Environment. Journal of Learning for Development, 8(3), 532–540. https://doi.org/10.56059/jl4d.v8i3.531
30. Lubis, S. P. W., Suryadarma, I. G. P., Paidi, & Yanto, B. E. (2022). The Effectiveness of Problem-based learning with Local Wisdom oriented to Socio-Scientific Issues. International Journal of Instruction, 15(2), 455–472. https://doi.org/10.29333/iji.2022.15225a
31. Mamahit, J. A., Aloysius, D. C., & Suwono, H. (2020). Efektivitas Model Project-Based Learning Terintegrasi STEM (PjBL-STEM) terhadap Keterampilan Berpikir Kreatif Siswa Kelas X. Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan, 5(9), 1284. https://doi.org/10.17977/jptpp.v5i9.14034
32. Matraeva, A. D., Rybakova, M. V., Vinichenko, M. V., Oseev, A. A., & Ljapunova, N. V. (2020). Development of Creativity of Students in Higher Educational Institutions: Assessment of Students and Experts. Universal Journal of Educational Research, 8(1), 8–16. https://doi.org/10.13189/ujer.2020.080102
33. Maulyda, M. A., Hidayati, V. R., Rosyidah, A. N. K., & Nurmawanti, I. (2019). Problem-solving ability of primary school teachers based on Polya's method in Mataram City. PYTHAGORAS: Jurnal Pendidikan Matematika, 14(2), 139–149. https://doi.org/https://doi.org/10.21831/pg.v14i2.28686

34. Miftakhurrohmah, N. L., Masykuri, M., Ariyani, S. R. D. A., & Noris, M. N. (2023). The Effect of Guided Inquiry-Based Excretion System E-Module to Improve Critical Thinking and ICT Literacy Skills for Students. Jurnal Penelitian Pendidikan IPA, 9(2), 681–689. https://doi.org/10.29303/jppipa.v9i2.2036
35. Noviyanti, N. I., Mukti, W. R., Yuliskurniawati, I. D., Mahanal, S., & Zubaidah, S. (2019). Students' Scientific Argumentation Skills Based on Differences in Academic Ability. Journal of Physics: Conference Series, 1241(1). https://doi.org/10.1088/1742-6596/1241/1/012034
36. Ogegbo, A. A., Gaigher, E., & Salagaram, T. (2019). Benefits and challenges of lesson study: A case of teaching physical sciences in South Africa. South African Journal of Education, 39(1), 1–9. https://doi.org/10.15700/saje.v39n1a1680
37. Permatasari, B. D., Gunarhadi, & Riyadi. (2019). The Influence of Problem Based Learning Towards Social Science Learning Outcomes Viewed from Learning Interest. International Journal of Evaluation and Research in Education, 8(1), 39–46. https://doi.org/10.11591/ijere.v8i1.15594
38. Plotnikova, N. F., & Strukov, E. N. (2019). Integration of teamwork and critical thinking skills in the process of teaching students. Cypriot Journal of Educational Sciences, 14(1), 1–10. https://doi.org/10.18844/cjes.v14i1.4031
39. Rahmawati, Y., Ramadhani, S. F., & Afrizal. (2020). Developing Students' Critical Thinking: A Steam Project for Chemistry Learning. Universal Journal of Educational Research, 8(1), 72–82. https://doi.org/10.13189/ujer.2020.080108
40. Richit, A., da Ponte, J. P., & Tomasi, A. P. (2021). Aspects of Professional Collaboration in a Lesson Study. International Electronic Journal of Mathematics Education, 16(2), em0637. https://doi.org/10.29333/iejme/10904
41. Saarinen, A. I. L., Lipsanen, J., Hintsanen, M., Huotilainen, M., & Keltikangas-Järvinen, L. (2021). The Use of Digital Technologies at School and Cognitive Learning Outcomes: A Population-Based Study in Finland. International Journal of Educational Psychology, 10(1), 1–26. https://doi.org/10.17583/IJEP.2021.4667
42. Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing Critical-Thinking Skills through the Collaboration of Jigsaw Model with Problem-Based Learning Model. International Journal of Instruction, 12(1), 1077–1094. https://doi.org/10.29333/iji.2019.12169a
43. Senisum, M., Susilo, H., Suwono, H., & Ibrohim. (2022). GIReSiMCo: A Learning Model to Scaffold Students' Science Process Skills and Biology Cognitive Learning Outcomes. Education Sciences, 12(4). https://doi.org/10.3390/educsci12040228
44. Sholahuddin, A., Susilowati, E., Prahani, B. K., & Erman, E. (2021). Using a Cognitive Style-Based Learning Strategy to Improve Students' Environmental Knowledge and Scientific Literacy. International Journal of Instruction, 14(4), 791–808. https://doi.org/10.29333/iji.2021.14445a
45. Sousa, M. J., & Costa, J. M. (2022). Discovering Entrepreneurship Competencies through Problem-Based Learning in Higher Education Students. Education Sciences, 12(3). https://doi.org/10.3390/educsci12030185
46. Subari, A., Chatri, M., Fadilah, M., & Vauzia. (2022). Development of E-Modules with a Guided Inquiry Approach on Ecology and Environmental Change Materials. Jurnal Penelitian Pendidikan IPA, 8(6), 2815–2826. https://doi.org/10.29303/jppipa.v8i6.2350
47. Surur, M., Degeng, I. N. S., Setyosari, P., & Kuswandi, D. (2020). The Effect of Problem-Based Learning Strategies and Cognitive Styles on Junior High School Students' Problem-Solving Abilities. International Journal of Instruction, 13(4), 35–48.
48. Sutiani, A., Situmorang, M., & Silalahi, A. (2021). Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills. International Journal of Instruction, 14(2), 117–138. https://doi.org/10.29333/iji.2021.1428a
49. Tanjung, S., Baharuddin, Ampera, D., Farihah, & Jahidin, I. (2022). Problem Based Learning (PBL) Model with Technological, Pedagogical, and Content Knowledge (TPACK) Approach. International Journal of Education in Mathematics, Science and Technology, 10(3), 740–752. https://doi.org/10.46328/ijemst.2510
50. Tekkol, I. A., & Demirel, M. (2018). An investigation of self-directed learning skills of undergraduate students. Frontiers in Psychology, 9(NOV), 1–14. https://doi.org/10.3389/fpsyg.2018.02324
51. Tian, M., Lu, G., & Li, L. (2022). Assessing the Quality of Undergraduate Education for International Students in China: A Perspective of Student Learning Experiences. ECNU Review of Education, 5(1), 65–88. https://doi.org/10.1177/20965311221075039
52. Tung, K. Y., & Alissa, A. (2021). Flipperentiated Learning in Biology Class to Improve Cognitive Learning Outcomes, Problem-Solving Skill, and Motivation. International Journal of Education and Literacy Studies, 9(1), 183. https://doi.org/10.7575/aiac.ijels.v.9n.1p.183

53. Wahman, M. L., Peplow, A., Kumar, R., & Refaei, B. (2020). Benefits of Using Lesson Study for SoTL, Cross-Disciplinary Research, and Assessment. International Journal for the Scholarship of Teaching and Learning, 14(1), 1–6. https://doi.org/10.20429/ijsotl.2020.140102
54. Wake, G., & Seleznyov, S. (2020). Curriculum design through lesson study. London Review of Education, 18(3), 467–479. https://doi.org/10.14324/LRE.18.3.10
55. Wang, Y.-O. (2021). Effects of Online Problem-Solving Instruction and Identification Attitude Toward Instructional Strategies on Students' Creativity. Frontiers in Psychology, 12(October), 1–6. https://doi.org/10.3389/fpsyg.2021.771128
56. Wola, B. R., Rungkat, J. A., & Harindah, G. M. D. (2023). Science Process Skills of Prospective Science Teachers' in Practicum Activity at the Laboratory. Jurnal Inovasi Pendidikan IPA, 9(1). https://doi.org/10.21831/jipi.v9i1.52974
57. Yıldırır, H. E. (2020). Secondary School Students' Initial and Changes in Cognitive Structures of Argument and Related Concepts. International Journal of Research in Education and Science, 6(2), 231–249.
58. Yulindar, A., Setiawan, A., & Liliawati, W. (2018). Enhancement of problem solving ability of high school students through learning with real engagement in active problem solving (REAPS) model on the concept of heat transfer. Journal of Physics: Conference Series, 1013(1). https://doi.org/10.1088/1742-6596/1013/1/012052
59. Zhang, G., & Chen, C. (2021). A Study on the Relationship Between Learning Motivation and Learning Effectiveness of Personnel Based on Innovation Capability. Frontiers in Psychology, 12(October), 1–6. https://doi.org/10.3389/fpsyg.2021.772904