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The Impact of Problem Based Learning with Mind Mapping on Learning Outcomes in Ecosystem Lesson

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Abstract: Education plays a critical role in shaping the cognitive, affective, and psychomotor development of students. In the 21st century, students are expected not only to acquire knowledge but also to develop the ability to think critically, solve problems, and apply concepts in real-life situations. For this reason, this study aims to determine the effect of applying the problem-based learning model assisted by mind mapping on student learning outcomes in ecosystem lesson. This research employed a quasi-experimental approach using the Pretest-Posttest Non-Equivalent Control Group Design, involving both control and experimental classes. The study population included all tenth-grade students at SMA Negeri 1 Biau. Through purposive sampling, four classes were selected, totaling 121 students. Learning outcomes data were collected using a test instrument comprising 30 multiple-choice questions. The data were analyzed using the Mann-Whitney statistical test at a significance level of 0.05. The analysis results revealed that the use of the problem-based learning model combined with mind mapping had a statistically significant impact on student learning outcomes, with a p-value less than 0.05 (0.000 < 0.05). Therefore, it can be concluded that the integration of mind mapping within the problem-based learning model has a positive influence on learning achievement. These findings suggest that this instructional approach is effective and can be implemented in lessons focused on ecosystem.

Keywords: Ecosystem; Learning outcomes; Mind-mapping; Problem based learning.

Introduction

Education plays a critical role in shaping the cognitive, affective, and psychomotor development of students (Silaban & Manalu, 2024). In the 21st century, students are expected not only to acquire knowledge but also to develop the ability to think critically, solve problems, and apply concepts in real-life situations (Astriani et al., 2020; Erina et al., 2025). Biology, as a subject that integrates various aspects of science and nature, offers many opportunities to develop these competencies (Murisqa & Nurmaliah, 2024). One of the essential topics in biology is ecosystems, which encompasses complex relationships between organisms and their environment. However, the teaching and learning of ecosystem concepts often face challenges, especially in fostering students' understanding and engagement (Asih & Wiyasa, 2023).

In SMA Negeri 1 Biau, the ecosystem lesson is considered one of the more difficult topics for students to grasp. This is due to the abstract nature of the content, the complexity of the interactions discussed, and the limited use of innovative learning models in the classroom. Traditional lecture-based methods that are still widely applied often lead to passive learning, where students merely receive information without active involvement. As a result, students tend to memorize facts rather than develop a deep conceptual

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understanding. This condition is reflected in students' low academic performance in the topic of ecosystems, as seen in their test results and classroom participation (Maker et al., 2015).

To address this issue, there is a growing need for teaching strategies that promote active, meaningful learning and critical thinking (Hwang et al., 2013). Problem-Based Learning (PBL) is one such strategy that has gained significant attention in recent years. PBL encourages students to engage with real-world problems, collaborate with peers, and construct their own understanding through inquiry and reflection. When students are exposed to problems that require analysis and solutions, they tend to be more motivated and involved in the learning process (Nuraini et al., 2023; Kundariati et al., 2025).

However, while PBL is effective in promoting problem-solving skills and conceptual learning, it can be challenging for students who struggle with organizing and connecting complex information (Chen et al., 2016). To overcome this limitation, mind mapping can be integrated as a visual tool to support the PBL process. Mind mapping helps students organize ideas, identify relationships among concepts, and retain information more effectively (Swari & Manuaba, 2022). The combination of PBL and mind mapping is expected to create a synergistic effect, enhancing students' learning outcomes through both active engagement and structured knowledge representation (Yew & Goh, 2016; Agustina & Joyoatmojo, 2024).

Previous studies have investigated the effectiveness of PBL in improving learning outcomes in science education. For example, research conducted by Liu et al. (2014) indicated that PBL enhances students' problem-solving abilities and deepens their understanding of scientific concepts. Similarly, studies by (Loyens et al. (2015) demonstrated that mind mapping improves memory retention and conceptual clarity. Despite the positive outcomes reported, few studies have examined the integrated use of PBL and mind mapping, especially in the context of high school biology education in Indonesia. Moreover, there is limited empirical evidence from rural or semi-urban schools such as SMA Negeri 1 Biau, where access to innovative pedagogical methods remains relatively low. The novelty of this research lies in the integration of two complementary instructional strategies PBL and mind mapping to enhance both cognitive engagement and content mastery (Ristiliana et al., 2022). Unlike prior studies that focused solely on either PBL or mind mapping, this research seeks to determine the combined effect of both strategies in improving learning outcomes (Wang, 2021).

Therefore, the objective of this study is to analyze whether the application of Problem-Based Learning with Mind Mapping significantly improves students' understanding of ecosystem concepts compared to traditional teaching methods. Specifically, the study will evaluate the effectiveness of this integrated approach in increasing students' academic performance, participation, and comprehension in biology classes. The findings of this research are expected to contribute to the development of innovative and effective teaching models that can be applied not only in SMA Negeri 1 Biau but also in other educational institutions facing similar challenges in science education.

Method

Time and Place of Research

This research was conducted from May to June 2024 at the Biology Laboratory, Faculty of Teacher Training and Education, Tadulako University.

Research Methods, Research Stages, and Data Analysis

The research design and methodology must be described in detail. This study employed an experimental approach using a Quasi-Experimental Design, which involved both an experimental group and a control group. The experimental group received treatment through the application of a problem-based learning model enhanced with mind mapping, whereas the control group was taught using traditional instructional methods. The specific design used was the Pretest-Posttest Quasi-Experimental Design with a Non-Equivalent Control Group, as illustrated in Table 1.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
E	O_1	X	O_2
C	O_3		O_4

Description:
E : Experiment
K : Control
O1 : Pretest score (before the application of problem-based learning assisted by mind mapping)
O2 : Posttest score (before the application of problem-based learning assisted by mind mapping)
O3 : Pretest score (before the application of problem based learning)
O4 : Posttest score (before the application of problem based learning)
X : Treatment

The research took place at SMA Negeri 1 Biau from May to July 2023, focusing on class X. The study's population encompassed 455 students from 10 class X sections of SMA Negeri 1 Biau (Table 2).

Table 2. Research population

Class	N	The average students' initial score
1	37	83
2	36	83
3	36	82
4	35	85
5	30	87
6	27	88
7	32	89
8	32	88
9	36	88
10	36	87
Total number of students	361	

The sampling technique applied in this study was purposive sampling, selecting classes that had identical or nearly similar average initial scores. Afterward, randomization was carried out to determine the final sample. A total of 121 students participated as the research sample, as shown in Table 3. Although six classes initially had comparable average pretest scores, only four were included in the study due to the remaining two being assigned to PPG students for teaching practice.

Table 3. Research sample

Class	N	The average students' initial score
Kontrol	30	89
	32	87
Eksperimen	27	88
	32	88
Total number of students	121	

This study utilized a written test as the primary instrument to assess student learning outcomes following the learning process. The assessment involved objective tests administered in the form of both pretest and posttest questions. Learning achievement was evaluated using the posttest, which consisted of 30 multiple-choice items, each offering five answer choices. Data collection was conducted by administering the pretest and posttest to both the control and experimental groups. A detailed overview of the data types and data collection methods used in this study is presented in Table 4.

Table 4. Data collection technique

Data type	Data source	Data collection method	Instrument	Data collection time
Initial score	Students	Objective test	Pretest	Before learning begins
Learning outcome	Students	Objective test	Posttest	After learning ends

Hypothesis testing in this study was conducted using the Mann-Whitney U test. The decision to accept or reject the null hypothesis (Ho) was based on the significance value obtained through analysis using SPSS version 26. The criteria for drawing conclusions were as follows: if the significance (Sig) value is greater than 0.05, then Ho is accepted, indicating that the differences in treatment did not have a significant effect on the response variables.

Result and Discussion

Comparison of Learning Outcomes Between the Experimental and Control Classes

The results and discussion are divided into two main sections. The first section presents a comparison of the pretest and posttest scores between the control and experimental groups, as illustrated in Figure 1. The second section highlights the results of inferential statistical testing. Together, these two components aim to provide a comprehensive understanding of the impact of applying problem-based learning supported by mind mapping in the context of ecosystem lessons.

Figure 1 illustrates the average pretest scores, with the control class scoring 49.92 and the experimental class scoring 50.03. These values indicate that both groups started with relatively equal initial abilities. However, after the learning intervention, the experimental class achieved an average posttest score of 63.42, which was noticeably higher than the control class's posttest average of 55.74 (Jones et al., 2012; Gao et al., 2022).

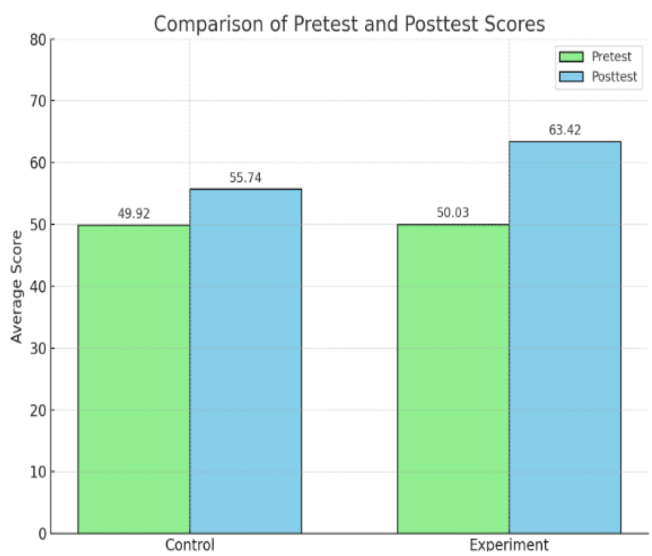

Figure 1. The comparison of pretest and posttest scores from both classes

Figure 1 does not display a significant difference between the pretest and posttest scores of the control and experimental groups. Therefore, to draw more accurate conclusions, further analysis through statistical testing is required, beginning with a normality test (Table 5) followed by a homogeneity test (Table 6).

The Effect of the Problem-Based Learning Model with Mind Mapping on Learning Outcomes

Table 5. Results of the normality test of learning outcomes

Class		Mean	df	Normality test*
Control	Pretest	49.83	61	0.000
	Posttest	55.65	61	0.000
Experiment	Pretest	50.14	58	0.001
	Posttest	63.53	58	0.087

*Kolmogorov-Smirnov, sig > 0,05 then the distribution is normal

Table 5 indicates that the learning outcome data in the control class do not follow a normal distribution. In the experimental class, only the posttest data are normally distributed, while the pretest data are not. Given this, non-parametric statistical analysis using the Mann-Whitney test was employed to evaluate the hypothesis regarding learning outcomes. The results of the Mann-Whitney test for the pretest are presented in Table 7, and those for the posttest are shown in Table 8.

Table 6. Homogeneity test results of learning outcomes

Aspect	Levene Statistic	df1	df2	Sig.
Learning outcome	1.55	3	238	0.20

*Levene, sig > 0,05 then the data is homogeneous

Table 7. Mann-Whitney U Test results for pretest scores

Class	N	Mean	Mann-Whitney Test
Control	62	61.73	Asymp Sig 0.81
Experiment	59	60.23	

*Sig < 0.05 then significantly different

Table 8. Mann-Whitney U Test results for posttest scores

Class	N	Mean	Mann-Whitney Test
Control	62	47.84	Asymp Sig 0.00
Experiment	59	74.80	

*Sig < 0.05 then significantly different

Discussion

The Levene's test results in Table 6 indicate a significance value of 0.204, which is greater than 0.05, suggesting that the average learning outcomes are homogeneous. However, although the data is homogeneous, the normality test results reveal that some data are not normally distributed. Therefore, further analysis was conducted using non-parametric tests.

Based on the results of the Mann-Whitney test presented in Table 7, the average pretest scores obtained a significance value of 0.810, which is greater than the threshold of 0.05. This result indicates that there was no statistically significant difference between the average pretest scores of students in the control and experimental classes. Therefore, it can be concluded that both groups of students began the study with similar academic abilities. This finding supports the assumption that the initial level of knowledge and understanding among students in both classes was equivalent before the application of the different learning models.

The comparable initial abilities of students in both control and experimental classes are supported by the pretest analysis results, which confirmed the absence of significant differences between the two groups. This similarity is essential as it ensures a fair comparison of learning outcomes after the implementation of different instructional strategies. In this study, the control class was taught using the conventional problem-based learning (PBL) model, while the experimental class was exposed to a PBL model integrated with mind mapping techniques. To assess the impact of these approaches, a post-test was administered at the end of the learning session to evaluate students' academic progress and the effectiveness of the mind mapping-based PBL strategy.

As shown in Table 8, the post-test analysis yielded a significance value of 0.000, which is well below the 0.05

threshold, indicating a statistically significant difference between the post-test scores of the control and experimental classes. This result provides strong evidence that the application of the mind mapping-based PBL model in the experimental class significantly influenced student learning outcomes in the topic of ecosystem. Consequently, the hypothesis that the learning model would produce different outcomes was accepted, and the null hypothesis (Ho), which assumed no difference, was rejected.

The analysis of post-test results further reinforces the conclusion that the mind mapping-assisted problem-based learning model had a positive and significant impact on student learning outcomes. With a significance value of 0.000, which surpasses the standard threshold of 0.05, it is evident that the average post-test score in the experimental class was considerably higher than that of the control class. This improvement can be attributed to the use of mind mapping, which is recognized as an effective tool for enhancing memory retention and facilitating long-term information storage. This claim is supported by Khairunnisa et al. (2022), who highlight the cognitive benefits of mind mapping in learning processes.

The integration of the problem-based learning model with mind mapping techniques not only enhances students' academic performance but also promotes greater involvement and collaboration among learners. This improvement is reflected in the active participation of students during group discussions, where they worked together to find solutions to assigned problems. In these discussions, students sought information from various sources, including textbooks and online materials, which they then organized and presented in the form of mind maps. This learning activity aligns with the findings of Areeisty et al. (2020) and Adodo (2013), who reported that mind mapping can significantly boost student performance. Additionally, Liu (2014) emphasized the effectiveness of mind mapping in enhancing the overall teaching and learning experience.

Wang (2021) demonstrates that implementing problem-based learning (PBL) strategies can significantly enhance various professional and academic attributes among pre-service teachers, including knowledge acquisition, active learning engagement, reflective thinking, and teamwork skills. Furthermore, PBL has been proven to outperform traditional teaching methods in improving learners' social and communication abilities, problem-solving competencies, and capacity for independent learning. This conclusion is echoed by Trullas et al. (2022), who confirmed that PBL does not negatively affect academic outcomes. In addition, research conducted by Salfina et al. (2021) highlights that the use of PBL models in combination with animated media can further strengthen students' science process skills. Moreover, Tseng et al. (2011) found that implementing PBL strategies can positively increase students' motivation to learn. According to Eppler (2006), mind mapping offers numerous benefits that make it a valuable tool in educational contexts. These advantages include its ease of use and understanding, the encouragement of creativity and individual expression, the ability to provide a concise hierarchical overview of information, and its flexibility in allowing content to be expanded or modified without limitations. Mind mapping is also characterized by its open structure, which supports the free flow of ideas and associations without requiring a rigid format. This format encourages both creative thinking and brainstorming. Research by Ristiliana (2022) supports these claims, showing that mind mapping can increase student engagement in learning activities. Additionally, Yang (2022) found that combining mind mapping with PBL can help students develop more integrated concept maps and construct a deeper and more comprehensive knowledge framework.

The use of a problem-based learning model supported by mind mapping techniques also contributes to the development of students' creativity. This is because the process of creating mind maps allows students to express their ideas freely through various shapes, colors, and visual representations, as illustrated in Figure 2. The artistic freedom in designing mind maps not only stimulates creativity but also enhances students' motivation to learn. As a result, this increased motivation contributes positively to learning outcomes. These findings are supported by Areeisty et al. (2020), who concluded that implementing PBL in combination with mind mapping is effective in improving students' enthusiasm and motivation to engage in learning activities.

According to the findings of Huda (2020) and Husna et al. (2013), the problem-based learning (PBL) model has a significantly stronger impact in enhancing students' attitudes of environmental care compared to conventional instructional methods. This indicates that the PBL model is particularly effective in instilling values related to environmental responsibility. Therefore, this model is highly recommended for implementation in learning materials concerning ecosystem, as it actively promotes students' awareness and sense of responsibility toward preserving the natural environment. Furthermore, the application of the PBL model has also been shown to enhance overall student academic performance. Dolder et al. (2012) found that students engaged in PBL environments tend to perform better due to the model's emphasis on problem-solving, active participation, and critical thinking. Supporting this, research by Günter and Alpat (2017) revealed a statistically significant difference in the academic achievement of students who were taught using the PBL model compared to those who were not. Students in PBL-oriented classrooms not only achieved higher learning outcomes but also demonstrated a deeper and more comprehensive understanding of the subject matter. This suggests that the PBL model is not only beneficial for skill development but also enhances conceptual understanding.

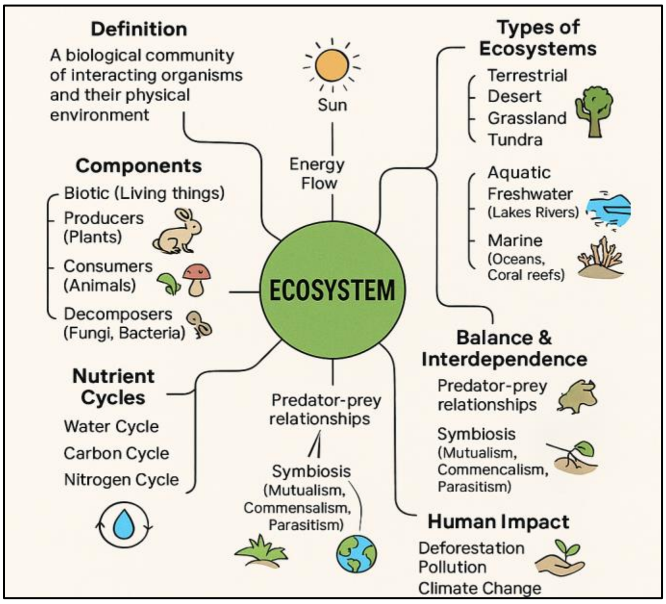

Figure 2. An example of Mind mapping created by students

Conclusion

Based on the findings and analysis of this study, the implementation of a problem-based learning (PBL) model supported by mind mapping has shown a positive influence on the learning outcomes of tenth-grade science students at SMA Negeri 1 Biau. These results indicate that the PBL approach, when integrated with mind mapping techniques, is suitable for teaching topics related to ecosystem. Moreover, the outcomes of this research serve as a valuable reference for educators and educational institutions, highlighting the importance of granting students the autonomy to explore and express their ideas. Providing such learning freedom encourages deeper engagement and maximizes students' potential in understanding complex subject matter.

Author Contributions

Conceptualization, Mohammad Jamhari and Yulia Windarsih; methodology, Mohammad Jamhari and Manap Trianto; formal analysis, Mohammad Jamhari, Yulia Windarsih, and Manap Trianto; writing—original draft preparation, Mohammad Jamhari and Manap Trianto; writing—review and editing, Mohammad Jamhari, Yulia Windarsih, and Manap Trianto.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Adodo, S. O. (2013). Effect of Mind-Mapping as a Self Regulated Learning Strategy on students' achievement in basic science and Technology. *Mediterranean Journal of Social Sciences*. https://doi.org/10.5901/mjss.2013.v4n6p163

Agustina, P. R., & Joyoatmojo, S. (2024). Penerapan Model Pembelajaran Problem Based Learning (PBL) Berbantuan Media Mind Mapping untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas XI Pemasaran 2 SMK Negeri 6 Surakarta. *Innovative: Journal Of Social Science Research*, 4(4), 12676-12687. https://doi.org/10.47668/edusaintek.v9i2.491

Areeisty, K., Hasanuddin, & Sarong, M. A. (2020). The implementation of problem-based learning with mind mapping to improve students' learning motivation. *Journal of Physics*, 1460, 012061. https://doi.org/10.1088/1742 6596/1460/1/012061

Asih, L. P. A. M., & Wiyasa, I. K. N. (2023). The Influence of the Mind Mapping Assisted PBL Model on the Critical Thinking Ability of Fifth Grade Elementary School Students. *Journal for Lesson and Learning Studies*, 6(2), 330-340.

Astriani, D., Susilo, H., Suwono, H., Lukiati, B., & Purnomo, A. (2020). Mind mapping in learning models: A tool to improve student metacognitive skills. *International Journal of Emerging Technologies in Learning (iJET)*, 15(6), 4-17.

Chen, C. H., Chou, Y. Y., & Huang, C. Y. (2016). An augmented-reality-based concept map to support mobile learning for science. *The Asia-Pacific Education Researcher*, 25, 567-578.

Dolder, C. R., Olin, J. L., & Alston, G. L. (2012). Prospective measurement of a Problem-Based Learning Course sequence. *The American Journal of Pharmaceutical Education*, 76(9), https://doi.org/10.5688/ajpe769179

Eppler, M. J. (2006). Information Visualization A comparison between concept maps, mind maps, conceptual diagrams, and visual knowledge construction and sharing. *Information Visualization*, 5, 202 – 210. https://doi.org/10.1057/palgrave.ivs.9500131

Erina, Z. E., Susilo, H., & Setiawan, D. (2025). Mind mapping assisted with picture media using learning ownership approach integrated with PjBL to increase students' collaboration skills and cognitive learning outcomes. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 11(1), 83-103.

Gao, X., Wang, L., Deng, J., Wan, C., & Mu, D. (2022). The effect of the problem-based learning teaching model combined with mind mapping on nursing teaching: A meta-analysis. *Nurse Education Today,* 111, 105306. https://doi.org/10.1016/j.nedt.2022.105306

Günter, T., & Alpat, S. K. (2017). The effects of problem based learning (PBL) on the academic achievement of students studying 'Electrochemistry.' Chemistry Education. *Research and Practice,* 18(1), 78–98. https://doi.org/10.1039/c6rp00176a

Huda, K. (2020). Modul pembelajaran SMA biologi kelas X: perubahan lingkungan. [Teaching Resource]. https://repositori.kemdikbud.go.id/22020/

Husna, S., Abdullah, A., & Nurmaliah, C. (2013). Penerapan model problem-based learning pada konsep perusakan dan pencemaran lingkungan untuk meningkatkan sikap peduli lingkungan siswa SMA Negeri 1 Sabang. *Jurnal Edubio Tropika*, 1(2), 97–100. https://jurnal.usk.ac.id/JET/article/view/5231

Hwang, G. J., Yang, L. H., & Wang, S. Y. (2013). A concept map-embedded educational computer game for improving students' learning performance in natural science courses. *Computers & Education*, 69, 121-130.

Jones, B. D., Ruff, C., Snyder, J. D., Petrich, B., & Koonce, C. (2012). The effects of mind mapping activities on students' motivation. *International Journal for the Scholarship of Teaching and Learning,* 6(1). https://doi.org/10.20429/ijsotl.2012.060105

Khairunnisa, Abdullah, Kharil, Hasanuddin, & Rahmatan, H. (2022). The Influence of Problem Based Learning Models combined with Flashcard Media on Creative Thinking Skills of Students. *Jurnal Penelitian Pendidikan IPA,* 8(1), 247–251. https://doi.org/10.29303/jppipa.v8i1.1154

Kundariati, M., Ibrohim, I., Rohman, F., & Nida, S. (2025). Navigating climate change education: a problem-oriented project-based learning in secondary schools. *Science Activities*, 1-15.

Liu, Y., Zhao,G., Ma, G., & Bo, Y.(2014). The effect of mind mapping on teaching and learning : A meta analysis. *Standard Journal of Education and Essay,* 2(2014), 17–31.

Loyens, S. M. M., Jones, S. H., Mikkers, J., & Van Gog, T. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction,* 38, 34 42.

Maker, C. J., Zimmerman, R., Gomez-Arizaga, M. P., Pease, R., & Burke, E. M. (2015). Developing real-life problem solving: Integrating the DISCOVER problem matrix, problem based learning, and thinking actively in a social context. In *Applied practice for educators of gifted and able learners,* 131-168. Rotterdam: SensePublishers.

Murisqa, L., & Nurmaliah, C. (2024). The Impact of Project Based Learning with Aquascapes on Metacognitive Skills and Learning Outcomes in Ecosystem Lesson. *Jurnal Penelitian Pendidikan IPA*, 10(12), 11070-11076.

Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of project based learning with steam approach model integrated science literacy in improving student learning outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1632-1640.

Ristiliana, R., Nurasmawi, N., Hartanto, D., Akhyar, A., & Yuliana, I. (2022). The Effect of Using Mind Mapping Strategy towards Students' Learning Activities. *AL-ISHLAH: Jurnal Pendidikan*, 14(3), 3807–3812. https://doi.org/10.35445/alishlah.v14i3.1671

Silaban, A. P. W., & Manalu, K. (2024). Development of a mindmap-based module to improve student learning outcomes in ecosystem biology learning material. *BIOINOVED: Jurnal Biologi-Inovasi Pendidikan*, 6(1), 48-55.

Swari, N. P. P., & Manuaba, I. B. S. (2022). Mind Mapping Berbasis Problem Based Learning sebagai Media Pembelajaran Menarik bagi Siswa Kelas V SD. *Journal for Lesson and Learning Studies*, 5(1), 117-126.

Trullàs, J. C., Blay, C., Sarri, E., & Pujol, R. (2022). Effectiveness of problem-based learning methodology in undergraduate medical education: a scoping review. *BMC Medical Education,* 22(1), 1 12. https://doi.org/10.1186/s12909-022-03154-8

Tseng, H. C., Chou, F. H., Wang, H. H., Ko, H. K., Jian, S. Y., & Weng, W. C. (2011). The effectiveness of problem-based learning and concept mapping among Taiwanese registered nursing students. *Nurse Education Today,* 31(8), e41–e46. https://doi.org/10.1016/j.nedt.2010.11.020

Wang, C. C. (2021). The process of implementing problem-based learning in a teacher education programme: an exploratory case study. *Cogent Education,* 8(1). https://doi.org/10.1080/2331186X.2021.1996870

Yang, K., Chen, H., Liu, C., Zhang, F., & Jiang, X. (2022). Effects of reflective learning based on visual mind mapping in the fundamentals of nursing course: A quasi-experimental study. *Nurse Education Today*, 119, 105566. https://doi.org/10.1016/j.nedt.2022.105566

Yew, E. H. J., & Goh, K. (2016). Problem-Based Learning : An overview of its process and impact on learning. *Health Professions Education,* 2(2), https://doi.org/10.1016/j.hpe.2016.01.004)