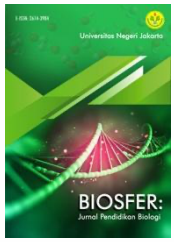
Biosfer: Jurnal Pendidikan Biologi, 18(1), 37-45 (2025)

Biosfer: Jurnal Pendidikan Biologi

Journal homepage: http://journal.unj.ac.id/unj/index.php/biosfer



Effects of the problem-based learning model assisted by mind mapping on the science learning outcomes of junior high school students

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ARTICLE INFO

Article history
Received: 03 July 2024
Revised: 21 November 2024
Accepted: 29 November 2024

Keywords:
Learning model
Learning outcome
Pbl
Science learning

ABSTRACT

Science learning is an effort to discover scientific truths through a series of thought processes. The demands of 21st-century science learning are learning that develops students' thinking skills. One learning model that is expected to train students' thinking skills is problem-based learning (PBL). This research aims to analyze the influence of the PBL learning model assisted by mind mapping on the science learning outcomes of class VII students at SMP Muhammadiyah 8 Surakarta for the 2022/2023 academic year. This research is a quasi-experimental research with a non-equivalent control group design. Samples were taken randomly, with 1 class as the control class and 1 class as the experimental class. The learning outcomes analyzed include cognitive, affective, and psychomotor learning outcomes. Data analysis was carried out using an independent sample t-test. Based on the research and data analysis results, there is a significant influence of the application of the PBL learning model assisted by mind mapping on students' science learning outcomes.

INTRODUCTION

Science is built based on scientific products, processes, and attitudes. Science learning is not just learning to memorize concepts but learning to discover things through a scientific method. The essence of science is a bridge for students to uncover and understand natural reality (Rusmana & Wahidah, 2016). Science learning, according to the essence of science, is learning that can develop competence in students, including attitudes in the form of curiosity about objects, natural phenomena, living creatures, and cause-and-effect relationships that give rise to new problems that can be solved through correct procedures and processes in the form of problem-solving procedures. Through the scientific method. Science learning provides a direct experience of how scientists discover products through facts, principles, theories, and laws (Indrawati & Nurpatri, 2022).

Teachers must teach according to the nature of the field of science being taught. Teachers' understanding of the nature of science is vital. It is expected to have the potential to make a positive contribution to the process and outcomes of science learning in schools. Understanding the nature of science is closely related to preparing learning tools, including determining the learning experiences that students must have, selecting learning strategies, using learning media, and assessing learning processes and outcomes (Sudarisman, 2015). One learning model suitable to science's character and nature is Problem-Based Learning (PBL).

PBL is a cutting-edge teaching approach that allows students to set the stage for more engaged learning. For kids to learn about difficulties and develop problem-solving abilities in a question, PBS is a learning model that involves problem-solving in pupils through the steps of the scientific method. PBL features learning that starts with asking questions, typically with a real-world context, learning authentically, and active groups asking questions and providing answers (Sulistia & Anshor, 2023). The PBL learning model has the following characteristics: (1) the beginning of learning is a problem point; (2) the problem is related to an actual situation; (3) the problem gives rise to many points of view; (4) problems provide challenges to new knowledge, behavior and student competencies; (5) prioritizing independent learning; (6) utilize various sources; (7) learning is cooperative, collaborative and communicative; (8) develop problem-solving abilities; and (9) the end of learning in the form of elaboration and synthesis (Agustin, 2021).

Many studies have been conducted related to applying the PBL learning model. Setyaningsih et al., (2022) stated that the PBL learning model is carried out systematically by building student skills through problem-solving, identification, and solutions provided in solving problems. According to Dharma et al. (2020) PBL, it also has advantages that can involve students in the process of learning according to real life, not only focusing on the problem-solving process in finding solutions but also taking responsibility in developing other skills. The results Nurtamara & Widyastuti (2023) show that PBL can be used as an alternative to help students improve their evidence-based argument skills. In all three aspects of the evidence-based argument, namely claims, evidence, and connection claims to evidence, there has been a significant increase.

One of the stages of the PBL learning model is developing and presenting the work results. This stage will run well with the proper methods and media. One method that can be used to implement the PBL learning model is mind mapping. Mind mapping is a visual technique used to organize information and assist students in understanding and remembering the information provided(Astiningtyas et al., 2023). Mind mapping Muharam et al. (2020) is a route map that facilitates memory and makes it possible to organize facts and thoughts; thus, the brain's natural work is involved from the start. This means that remembering information is easier and more reliable than traditional note-taking techniques. The use of mind maps Dewi (2019) can improve student learning outcomes. That is because a mind map is a media that can unite concepts so that they can easily understand the information, especially with a high level of conceptual complexity. Based on the result of the research, it was Dewi (2019) concluded that mind map learning media can improve student learning outcomes. This is because mind maps can help students in learning that requires a lot of understanding of concepts.

Combining the PBL learning model with the mind map strategy is expected to complement each other because the results of student learning using the problem-based learning model can be expressed as a mind map. Research conducted by Karo-Karo et al. (2017) shows that using PBL with mind mapping significantly affects students' creative thinking skills and learning outcomes. Areeisty et al., (2020) stated that students can encounter real-world issues in the form of inquiries about the

subject matter and natural phenomena when PBL is implemented using mind mapping. To encourage children to learn, real-world situations that incorporate facts and the natural world (a natural laboratory) might be used. Students' learning outcomes will be impacted by their high level of motivation. Students can apply the principles to real-world situations, thanks to the PBL learning paradigm. According to Yusniza et al. (2023) PBL is much more successful when combined with mind mapping, which makes conceptual understanding easier for students.

Observations were made on the science learning process at SMP Muhammadiyah 8 Surakarta. The initial observations show that teachers' learning models are less varied, so students' science learning outcomes are low. Students need to be more actively involved in learning. Teachers more often use the lecture method using PowerPoint media. Another problem is that students need to be more enthusiastic about learning. An inappropriate selection of learning models and media can cause this. Therefore, this research seeks to analyze the role of the PBL learning model combined with mind mapping in increasing student motivation and learning outcomes. This research aims to analyze the effect of implementing the PBL learning model assisted by mind mapping on students' science learning outcomes.

METHODS

Research Design

This research is quasi-experimental with the independent variable, namely the learning model, while the dependent variable is the students' science learning outcomes. The design of this research is a non-equivalent control group design. The description of the research design is shown in Table 1.

Table 1
Nonequivalent Control Group Design

Group	Pretest	Independent Variable	Posttest
Experiment	O_1	X_E	O_2
Control	O_2	X_K	O_4

Note:
O_1: Pretest of experiment group (PBL assisted with mind mapping)
O_2: Post-test of experiment group (PBL assisted with mind mapping)
O_3: Pretest of control group (conventional learning)
O_4: Post-test of control group (conventional learning)
X_E: PBL assisted with mind mapping
X_K: Conventional learning

Population and Samples

The population in this study were all class VII students at SMP Muhammadiyah 8 Surakarta, totaling 135 students and divided into five classes. Samples were taken from 2 classes randomly. One class is the control class, and one class is the experimental class. Sampling was carried out using the cluster random sampling technique.

Instrument

The data in this research are students' science learning outcomes, including cognitive, affective, and psychomotor learning outcomes. Cognitive learning outcomes are obtained based on pretest and posttest scores, while affective and psychomotor learning outcomes are obtained based on observation results. Data collection instruments include tests, observation, and documentation. All instruments have undergone expert validation and have been tested for item validity.

Procedure

The research implementation procedure is divided into two stages namely preparation, implementation and data collection. The preparation stage involves preparing proposals and research instruments, including validating and requesting research permits. The implementation and data collection stages were completed by applying the learning model to the control and experimental classes. The experimental class was given conventional learning treatment, while the experimental class was given PBL treatment assisted by mind mapping in the experimental class. At this stage, data

on cognitive learning outcomes (based on pretest and post-test scores), affective (based on questionnaire results), and psychomotor (based on observation results) are also taken.

Data Analysis Techniques

Data analysis was carried out using descriptive analysis techniques and quantitative analysis. Descriptive analysis was done to analyze data on affective and psychomotor learning outcomes. Data on cognitive, affective, and psychomotor learning outcomes were analyzed using percentages and then categorized into low, medium, and high categories. Quantitative analysis is carried out in two stages: testing prerequisites for analysis and hypothesis testing. Prerequisite analysis tests were carried out using normality tests and homogeneity tests. Meanwhile, hypothesis testing was carried out using the independent sample t-test.

RESULTS AND DISCUSSION

This research aims to analyze the effect of using the PBL learning model assisted by mind mapping on students' science learning outcomes. The research used two classes: the control class (conventional learning) and the experimental class (PBL assisted by mind mapping). Learning outcome data is obtained from tests, questionnaires, and observation sheets.

1. Students' Science Cognitive Learning Outcomes through the Application of PBL Learning Model Assisted by Mind Mapping

Data on cognitive learning outcomes were obtained from the pretest and posttest results after implementing the PBL learning model assisted by mind mapping. A description of this research data is presented in Table 2.

Table 2

Students' Science Cognitive Learning Outcomes Through the Application of PBL Learning Model Assisted by Mind Mapping

Descriptive	Control Class		Experiment Class	
	Pretest	Postest	Pretest	Postest
N	19.00	19.00	22.00	22.00
Max	70.00	90.00	80.00	90.00
Min	30.00	20.00	10.00	50.00
Mean	48.42	63.68	48.64	74.09
SD	11.67	11.00	14.89	10.54

Based on the data in Table 2, the pretest and posttest scores were then categorized into low, medium, and high learning outcome categories. Figure 1 compares the learning outcome categories for the control class and the experimental class.

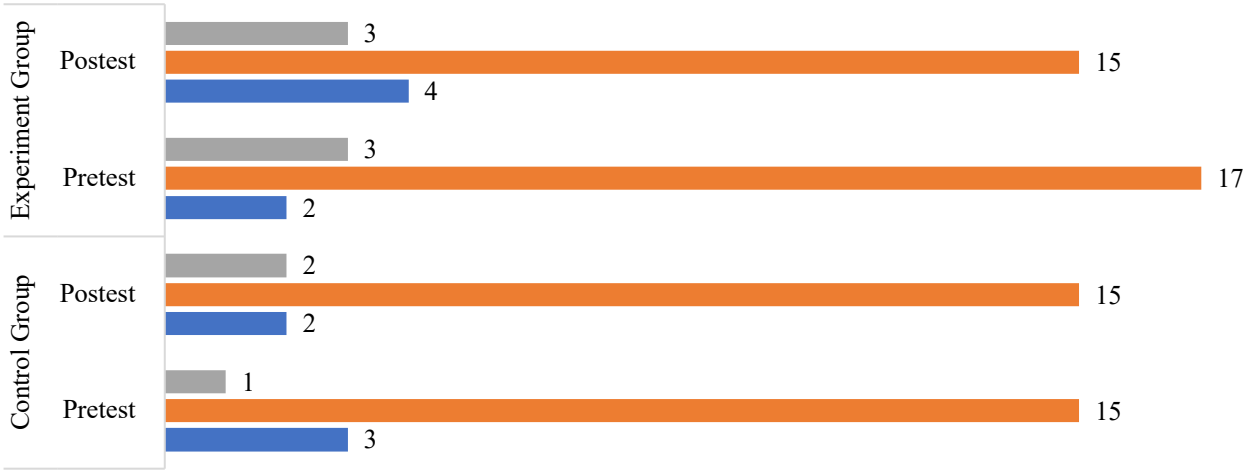

Figure 1. Comparison of Cognitive Learning Outcome Categories for the Control and Experimental Class

The cognitive learning result data is then tested for prerequisite analysis. Prerequisite analysis tests include normality tests and homogeneity tests. The results of the normality test show that all data groups are normally distributed with a significance value of more than 0.05. Meanwhile, the homogeneity test shows that the data is distributed the same or homogeneous. Hypothesis testing was carried out using the independent sample t-test. Hypothesis testing was carried out to determine the average difference in cognitive learning outcomes between the control class and the experimental class. The results of the hypothesis test are shown in Table 3.

Table 3
Result of Independent Sample t-Test

Class	Mean	Significance Value	Information
Control	63.68	0.02	Significantly different
Experiment	74.09		

Based on Table 3, it is known that the significance value is 0.02, which indicates that there is a significant difference between the cognitive learning outcomes of the control class and the experimental class. The result shows that the application of the PBL learning model assisted by mind mapping affects students' cognitive learning outcomes. The PBL learning model, according to Aslam et al. (2021), improves the cognitive ability of each student to produce students who are independent and have thinking skills. PBL is a student-centred learning model that presents problems, questions, investigations, and discussions between teachers and students on basic competency specifications, characteristics, and procedures for concrete construction. In this model, the teacher acts as a facilitator to stimulate students to learn to solve problems.

Raharjo et al. (2018) claim that PBL is centered on student activities that are based on a constructivist perspective, where students build their knowledge through meaningful learning. PBL exercises start with an introduction to the topic, after which students must solve the challenges. Pupils must actively study, look for knowledge in books or on the internet, converse with friends, and practice with natural items on their own or in groups. To make learning more efficient and significant, students not only practice reading the assigned task sheet but also evaluate the first issue that comes up and then search for solutions.

The efficacy of the PBL model necessitates considerable time and preparation for implementation; students are also unaccustomed to this approach, having previously relied solely on note-taking, passive listening, and rote memorization of the material presented by the instructor. Students sometimes encounter numerous challenges due to the multitude of concepts that must be memorized, encompassing both information and images. Therefore, it is essential to employ an appropriate technique to address the deficiencies of the PBL paradigm and facilitate students' retention of learning content, namely through mind mapping. A mind map is a pedagogical technique that enhances cognitive development and utilizes all student competencies, assisting both students and educators in the classroom by condensing information and articulating difficulties for presentation and retention (Devyana Sukma Dewi & Bayu Sangka, 2022).

The PBL learning approach, augmented by mind mapping, enables students to engage in independent learning with appropriate references, fostering creativity and critical thinking through the equilibrium of left and right brain functions. This paradigm can foster the development of a growth mentality and is pertinent to education in the context of the Fourth Industrial Revolution, characterized by the 4Cs and the Society 5.0 period. This model will enhance students' abilities. (a) identify issues and resolutions; (b) conduct individual and collective inquiries; (c) establish collaborative efforts; (d) analyze and assess problem-solving strategies; (e) seek pertinent references; (f) engage in group communication; (g) deliver presentations; and (h) summarize policies (Siswati et al., 2021). Research conducted by Anratriningrum et al. (2020) states that students' cognitive learning outcomes can be improved by implementing the PBL model assisted by mind mapping because there are significant improvements in understanding concepts and problem-solving activities. Mind mapping makes problem-solving activities more direct and efficient. The help of a mind map in PBL can strengthen students' mastery of concepts.

2. Students' Science Affective Learning Outcomes through the Application of PBL Learning Model Assisted by Mind Mapping

Affective learning outcomes are evidenced by behaviors reflecting awareness, interest, attention, concern, and responsibility; the capacity to listen and engage in interactions with others; and the ability to exhibit attitudinal characteristics or values pertinent to the assessment context and discipline. Data on affective learning outcomes were obtained from observations during the learning process. A description of affective learning outcome data is presented in Table 4.

Table 4
Students' Science Affective Learning Outcomes Through the Application of PBL Learning Model Assisted by Mind Mapping

Descriptives	Control Group	Experimental Group
N	19.00	22.00
Max	91.67	100.00
Min	66.67	91.67
Mean	81.58	95.45
SD	7.124	4.145

Based on the data in Table 4, affective learning outcomes were then categorized into low, medium, and high learning outcome categories. Figure 2 compares the affective learning outcome categories for the control class and the experimental class.

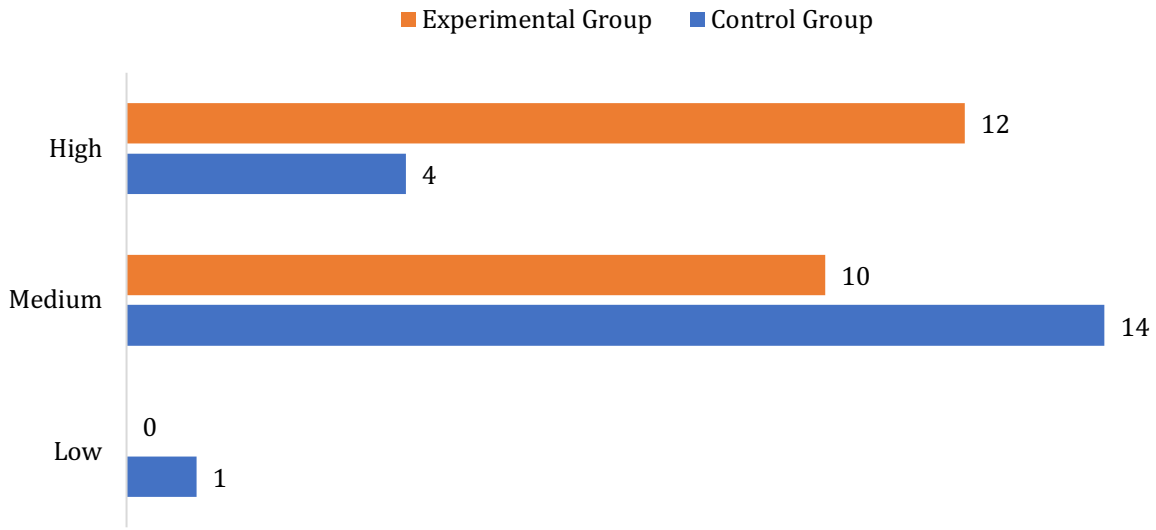

Figure 2. Comparison of Affective Learning Outcome Categories for the Control and Experimental Class

Affective learning outcomes are divided into two aspects, namely spiritual and social attitudes. A spiritual attitude includes receiving, implementing, and appreciating the religion. In contrast, with a social attitude, students can show off honest, disciplined, decorous, self-confident, caring, and responsible behaviours when interacting with family, friends, teachers, neighbours, and the state (Nuryati et al., 2018). The effective learning outcomes studied include aspects of discipline, honesty, cooperation, and responsibility. Based on Table 4, the average affective learning outcome for the control class is 81.58, while the experimental class is 95.45. By applying the PBL learning model, students can develop their mastery of knowledge through a responsible problem-solving process. All students are responsible for the problem-solving process carried out by their group.

According to Cerkez et al. (2023), the utilization of a mind map positively influences student learning. It facilitates enduring learning retention; it enhances memory, conserves time, extends students' attention and focus, and is enjoyable and motivating due to the selection of easily memorable and rapidly learned keywords. Moreover, mind maps can be employed to assess prior knowledge, identify erroneous and inadequate understanding, and enhance the retention of information and

concepts along with their interconnections. Mind mapping can offer educators insights into students' cognitive frameworks and the evolution of these frameworks. Furthermore, educators must be proficient in instructing the mind map approach and integrating mind maps into their curricula. It is essential to ascertain the types of information that can be represented through mind maps and included in the curriculum of the books at the conclusion of each requisite segment. To achieve this, collaboration with the relevant authorities can be initiated to deliver awareness and practical training to educators. To expand the use and practice duration of the mind map approach, it is initially imparted to educators, who then instruct pupils, hence facilitating its application across all subjects. Conducting research will yield results within a broader context.

PBL learning model, according to Yusniza et al. (2023), can enhance student learning outcomes and have a more significant positive impact on critical thinking, analysis, and evaluation than traditional learning. Implementing PBL combined with mind mapping can increase student competence, foster a positive attitude towards learning experiences, and enhance student performance.

3. Students' Science Psychomotor Learning Outcomes through the Application of PBL Learning Model Assisted by Mind Mapping

Psychomotor learning outcomes relate to motor skills, which involve the manipulation of objects or activities that require coordination of nerves and bodies. Psychomotor learning outcomes were obtained based on observations of students' skills in presenting discussion results. Aspects assessed include systematic presentation, use of language, clarity of presentation, communicativeness, and correctness of concepts. A description of psychomotor learning outcome data is presented in Table 5.

Table 5
Students' Science Psychomotor Learning Outcomes Through the Application of PBL Learning Model Assisted by Mind Mapping

Descriptives	Control Group	Experimental Group
N	19.00	22.00
Max	72.00	76.00
Min	52.00	60.00
Mean	56.85	66.00
SD	4.12	6.95

Based on the data in Table 5, psychomotor learning outcomes were then categorized into low, medium, and high learning outcome categories. Figure 3 compares the psychomotor learning outcome categories for the control class and the experimental class.

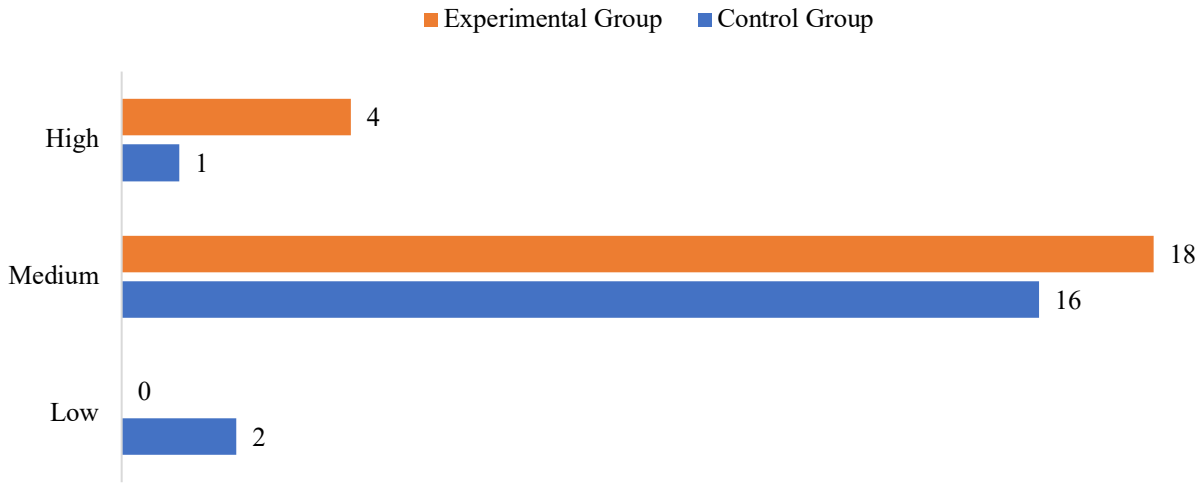

Figure 3. Comparison of Psychomotor Learning Outcome Categories for the Control and Experimental Class

The learning outcomes about skills and the capacity for action are referred to as the psychomotor domain. The psychomotor domain pertains to the acquisition of skills and the capacity for action. There are five psychomotor domains: imitation, manipulation, precision, articulation, and naturalization. The process skills cultivated for discussing Indonesian language themes involve the utilization of specific competencies: Students are provided with a comprehensive overview of the material to be presented. Asking entails that students have the option to inquire with the teacher regarding clarifications of the material or challenging aspects relating to the subject matter being presented. Exploring entails that students are encouraged to investigate to acquire a fresh understanding of the subject matter to be addressed. In this context, communication entails students presenting their research findings to peers, facilitating interaction between students and others, including educators (Aidah, 2022). Psychomotor learning outcomes in this research are seen from students' skills in presenting discussion results. The use of PBL, assisted by mind mapping, encourages students to analyze, express ideas, and explain statements and opinions expressed to strengthen group arguments.

CONCLUSION

Based on the research results and data analysis, the application of the PBL learning model assisted by mind maps has a significant effect on student learning outcomes. The average cognitive, affective, and psychomotor learning outcomes for the experimental class were higher than those for the control class.

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