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The Influence of Problem-Based Learning Models on Student Learning Outcomes on Dynamic Fluid Material

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ABSTRACT

Thus studying physics is very important as it relates to real life. However, based on the results of a survey that has been carried out in a high school, it is known that student learning outcomes are less / low, this is due to difficulties in understanding fundamental physics concepts, limitations in solving physics problems, and lack of connections between these concepts. Therefore, the purpose of this study is to analyze how the implementation of the application of the PBL model for the learning outcomes of dynamic fluid material students. The method applied in this study is quantitative Quasi Experiment using nonequivalent control group design. From the results of research that has been carried out, it can be concluded that the PBL learning model has the potential to improve physical learning outcomes, especially in the context of Dynamic Fluid material. The implications of this research can be used as a basis to recommend the application of the Problem Based Learning model in physics learning to improve the effectiveness and efficiency of the concept understanding process at the relevant educational level. Further research can be conducted to explore specific aspects of this learning model that exert the most significant impact on understanding physics concepts.

Keywords : Physics, Problem Based Learning, Learning Outcomes

INTRODUCTION

The understanding of science has indisputable relevance in the development of man and modern society. Science is the foundation of man's understanding of the universe from smallest to greatest (Kotseva et al., 2022). An understanding of science can explain natural phenomena, understand the principles that govern the universe, and develop technologies that improve the quality of life. Without an understanding of science, many of the technologies we enjoy today would not be possible, from electronic devices to medical technology (Sari et al., 2023). Physics is a science that has implications for studying the properties of the universe and the natural phenomena that occur in it, from very small to very large scales.

Physics is a branch of science that studies the properties of the universe and the natural phenomena that occur in it, from very small to very large scales. The importance of understanding the relationship between physics and other sciences can be seen from several aspects. This provided the foundation for many other branches of science (Falah & Jufrida, 2024). Physical principles, such as the laws of motion, energy, and force, form the basis for our understanding of chemistry, biology, and other sciences. In addition, understanding the links of physics in science helps in the development of technology (Irfandi et al., 2023). Many modern technologies, from computers to airplanes, are based on fundamental principles of physics. For example, an understanding of the electromagnetic principle helped in the development of telecommunications and semiconductor technology. Similarly, an understanding of fluid mechanics helps in the design of airplanes and automobiles. Furthermore, physics plays an important role in solving real-world problems (Gunawan et al., 2019; Haetami et al., 2023;

Irawan et al., 2022). Physical concepts are used in understanding and designing solutions to various global challenges, such as renewable energy, climate change, and public health. For example, an understanding of the properties of energy and matter is used in developing technologies with renewable energy e.g. solar panels and wind turbines.

Thus studying physics is very important as it relates to real life (Burlachenko, 2020; Marcinauskas et al., 2024). However, the results of surveys that have been carried out in a high school are known to be low / low student learning outcomes, this is due to difficulties in understanding fundamental physics concepts, limitations in solving physics problems, and lack of connections between these concepts. They also experience limitations in laboratory skills and lack of motivation and confidence in studying physics. In addition, low levels of metacognitive skills can also be an obstacle, as students may not be able to identify and overcome difficulties in their understanding of physical material. Given that physics is the cornerstone for much modern science and technology, and has far-reaching implications in everyday life, it is important for teachers and the education system to pay special attention in helping students who have low learning outcomes in physics (Sakliressy et al., 2021). By improving students' understanding and skills in physics, they will be better prepared for real-world challenges and can better contribute to an increasingly connected society with science and technology.

Some other factors that influence the understanding of low learning outcomes involve the complexity of learning materials, teaching methods and models applied, and individual characteristics of students (Komikesari et al., 2020). Understanding physics concepts requires strong concept integrity, that is, the ability to associate, organize, and generalize the physics concepts studied. Understanding concepts is not only limited to the ability to remember facts or formulas, but involves the interpretation, integration, and application of these concepts in different situations (Susilawati et al., 2021). At a basic level, concept understanding reflects the clarity of the concept, whereas at a higher level, it involves the ability to understand the structure of the concept in depth and relate it to a broader context.

An easy-to-understand understanding of physics often occurs when physics concepts are applied in the context of real problems relevant to everyday life. When students are faced with concrete problems that they can identify in everyday life, they are more likely to be actively involved in learning and understand physics concepts better (Kanyesigye et al., 2023). For example, when students learn about Newton's laws of motion, they can understand them better if given real cases about the motion of cars on the highway or about the motion of objects on slippery surfaces. By using a real problem-based learning approach, students can see the interrelation of physics concepts in their daily life situations, so they are more motivated to learn it. In addition, PBL with real problems can motivate students to develop problem-solving, analysis, and critical thinking skills that are essential in understanding and applying physics concepts(Santyasa et al., 2021).

The research on Problem Based Learning (PBL) was conducted by (Wijayanto et al., 2020) with experimental methods at universities in Turkey. The experimental group applied PBL-based learning, while the control group applied traditional learning methods. The results proved that students learning with the PBL model produced significantly higher scores in understanding fluid concepts compared to the control group. In addition, students in the experimental group also showed better problem-solving skills in a fluid context.

Other research conducted by (Permata Sari et al., 2022) at a university in South Korea with a pseudo-experimental design. The experimental group applied PBL-based learning, while the control group applied traditional learning approaches. The results proved that students who studied with the PBL approach showed significant improvements in fluid concept understanding and problem-solving skills compared to the control group. The experimental group also showed higher levels of satisfaction with their learning.

From the background already mentioned, the purpose of this study is to analyze how the implementation of the application of the PBL model for the learning outcomes of dynamic fluid material students. By understanding the impact of PBL models in the context of physics learning, we can then identify more effective learning strategies to help students understand complex physics concepts and improve their ability to solve real-world physics problems.

RESEARCH METHODS

The method used in this study is quantitative Quasi Experiment with a form of nonequivalent control group design. This study was conducted in November 2023 with a population of 344 students with a sample of 31 students in grade XI-1 as a control class and 30 in class XI-2 as an experimental class at SMA Negeri 22 Central Maluku.

Data collection in this study used instrument postes. To obtain data on understanding the concepts of students, tests in the form of essay questions with Newton's Laws are used. From the question instrument, data in the form of written argumentation is obtained. The problems presented amounted to 5 questions related to the acceleration of objects accompanied by springs, the amount of rope tension of an object, the speed of a rocket and rocket thrust. spring as well as its normal force. This already covers three main materials, namely Dynamic Fluid Matter.

The results of students' answers are analyzed with question item analysis techniques used to measure validity, reliability, discriminating power, and the level of difficulty of question items, namely by using the Anates application. From the results of limited tests conducted in class XI with a sample of 30 learners, it can be known as in table 1. Based on the validity test criteria according to Arikunto (2010: 211), in table 1 it was found that the 5 questions used were said to be valid with medium and high significance. The reliability test for this question obtained an r value of 0.51. This value belongs to the medium category. Meanwhile, from the results of the discriminating power test, it was found that the questions were well received, but there were some questions that still needed to be improved. The difficulty level of the question is the difficult and medium categories.

Table 1. Question point analysis

Question No.	Reliability	Validity	Information	Level of Difficulty	Differentiating Power
1	0,54	0,710	Very valid	Keep	0,37
2		0,564	Valid	Keep	0,31
3		0,701	Very valid	Difficult	0,59
4		0,432	Quite Valid	Difficult	0,41
5		0,498	Quite Valid	Keep	0,34

Data were analyzed using statistical tests including Kolmogorov siminov normality test, homogeneity test and independent t test with the help of SPSS software. An independent t-test is carried out with the aim of analyzing the effects of the application of PBL. The H0 of this study is both the mean of the control class and the experimental class are identical (the same), while Ha is both the mean of the control class and the experimental class are not identical (different). The decision-making criterion is reject H0 if the significance < 0.05.

RESULTS AND DISCUSSION

At the problem introduction stage, students are given background on the importance of efficient water use in the context of garden irrigation. They were introduced to the concept of fluids and how this concept relates to the flow of water in an irrigation system. Then the problem identification stage, students are given concrete problems, for example, a garden has various types of plants with different water needs. How to design an efficient irrigation system to meet the water needs of each plant without experiencing water wastage? Furthermore, at the concept learning stage, students are given material on the basic principles of fluids related to water flow, such as pressure, discharge, and Bernoulli's law. They also studied how to measure water requirements for each type of crop and the factors that affect water distribution in irrigation systems. Here the application of the concept is that students are asked to design an efficient irrigation system for a given garden, taking into account the water needs of each plant. They use learned concepts to calculate the required pressure, required water discharge, and water flow regulation to meet the needs of each plant. Furthermore, in the problem-solving stage, students work in groups to design optimal solutions. They analyze the efficiency of the irrigation system they designed, evaluate possible constraints or problems that may arise, and devise strategies to address those problems. Finally, in the presentation and discussion stage, each group presented their irrigation system design and explained the physics concepts they applied. Discussions were held to evaluate the advantages and disadvantages of each design, as well as improve solutions based on feedback from classmates and teachers.

From the results of the research that has been carried out, data on students' answers to questions about Newton's Laws were obtained. Figure 1 shows an example of Newton's Law III that must be answered by learners.

An example of a Real Problem: An urban park is experiencing water shortage problems due to an inefficient irrigation system. The plants in the garden are experiencing drought and stunted growth. How to redesign irrigation systems that allow for more efficient use of water and meet the water needs of each crop without wastage?

Figure 1. Examples of Dynamic Fluid problems

The distribution of the mean postest value of learning outcomes of SMA Negeri 22 Central Maluku students can be described and observed in more detail in table 2. From the results obtained, it can be where the mean of the experimental class is higher than the control class, which is 81.5 versus 65.5. This shows that the experimental class has good learning outcome data compared to the control class. In addition, the median score of the experimental class was also higher than that of the control class, which was 75.00 compared to 60.50. This proves that most students in the experimental class have scores that determine the mean, but some students have quite varied scores.

Based on table 2, it can be proved that the variance and standard deviation values of the experimental class are lower than those of the control class, namely 8.71 and 4.23 compared to 59.64 and 7.72. This proves that the experimental class has a tight distribution of values compared to the control class. In other words, the experimental class had consistency with high learning outcomes compared to the control class.

Based on table 2, it can also be proven that the minimum and maximum values of the experimental class are higher than the control class, namely 72.00 and 86.00 compared to 45.00 and 85.00. This proves that the experimental class has a narrower range of values compared to the control class. In other words, the experimental class has a higher uniformity of learning outcomes compared to the control class. Based on the results of the descriptive analysis, it can be concluded that the experimental class has a better understanding of concepts, more consistent, and more uniform than the control class.

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Table 2. Discriptive Statistics Results of Student Understanding

	Control Class	Experimental Class
Mean	65.5	81.5
Median	60.50	75.00
Variance	8.71	4.23
Std. Deviation	07.82	03.05
Minimum	46.00	73.00
Maximum	82.00	88.00

Table 3. Statistical Test Results Data

Class	Normality Test (Sig.)	Homogeneity Test (Sig.)	T Test (Sig.)
Control	0.143	0.124	0.007
Experiment	0.842		

From **table.3** it can be proven where the results of the normality test calculation with Kolmogorov Siminov show that the posttest value of the control class obtained a significance value of 0.143, while the significance value of the experimental class was 0.842. Because it is more than 0.05, it can be said that the data from both classes are distributed normally. In the output of the homogeneity test results, a significance value of 0.124 is obtained, so the data variance can be said to be homogeneous.

The results of the t test showed that the understanding of students was analyzed through an independent t-test with equal variance assumed, obtained a significance value of 0.007. Since $p < 0.05$, so H0 is rejected, or the two variations are completely different. That is, the mean for the learning outcomes of control classes and experiments is different. If based on the mean of both classes, the experimental class has a higher mean than the control class. That is, there are significant differences in student learning outcomes after applying the Quantum Teaching model learning with those that are not implemented with the Quantum Teaching model.

This study was conducted to evaluate the influence of PBL learning models on learning outcomes, especially for Dynamic Fluid material. The research design used was a Quasi Experiment involving two groups, an experimental group that received learning using the PBL model and a control group that received learning using a conventional model. Data collection was carried out through pre-test and post-test in both groups.

The results of data analysis showed that there was a significant improvement in understanding the concept of Dynamic Fluid material physics in the experimental group using the PBL model. This is reflected in the statistically higher post-test scores compared to pre-test scores. On the other hand, the control group that received conventional learning also increased, but this increase was not as large as the experimental group.

In particular, certain aspects of Newton's laws, are better understood by learners who follow learning with the PBL model. Statistical analysis using intergroup difference tests showed significant differences at certain levels of confidence. By using the Problem Based Learning (PBL) approach in fluid materials, students not only understand the physics concepts underlying fluid flow, but also apply them in real contexts relevant to everyday life.

Problem-Based Learning (PBL) has been shown to be effective in improving student learning outcomes through several different mechanisms. First of all, PBL puts students in demanding situations to solve complex and meaningful problems. Thus, students are actively involved in the learning process, which allows them to develop in-depth and relevant problem-solving skills. In addition, in the context of PBL, students are given the opportunity to study independently, which allows them to develop independence in learning and increases their intrinsic motivation. Through collaborative processes in PBL, students also learn to work in teams, share ideas, and discuss various problem-solving approaches, which can enhance their understanding of the concepts involved. In addition, PBL places emphasis on the application of theoretical concepts in the context of real-world problems, allowing students to see the relevance and practical application of what they are learning. By experiencing meaningful and contextual learning, students tend to retain and transfer the knowledge they gain to new situations, which in turn improves their overall learning outcomes. Therefore, through a structured and problem-oriented approach, PBL not only enhances understanding of concepts, but also helps students develop critical, creative, and collaborative skills that are essential in their preparation for the future.

CONCLUSION

Based on the results of research that has been done, it can be concluded that the Problem Based Learning learning model has the potential to improve physical learning outcomes, especially in the context of Dynamic Fluid material. The implications of this research can be used as a basis to recommend the application of the Problem Based Learning model in physics learning to improve the effectiveness and efficiency of the concept understanding process at the relevant educational level. Further research can be conducted to explore specific aspects of this learning model that exert the most significant impact on understanding physics concepts.

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