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The Effect of the Problem Based Learning (PBL) Learning Model on the Understanding of Mathematical Concepts in Time Unit Materials

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ABSTRACT

This study aims to analyze the effect of the use of the Problem Based Learning (PBL) learning model on the understanding of mathematical concepts in the time unit material of grade 4 students of SDN 01 Padangsidimpuan City, North Sumatra, Indonesia. This study uses a quantitative method with a quasi-experimental design involving Randomized Control Group Only Design through pretest and posttest. The research sample consisted of 45 students who were divided into two groups, namely the experimental group and the control group. The experimental group received learning using the PBL model, while the control group used conventional methods. The research instrument in the form of a test of understanding of mathematical concepts was given before and after treatment. Data analysis was carried out using a t-test to see significant differences between pretest and posttest results. The results showed that students who participated in learning with the PBL model experienced a significant increase in conceptual understanding compared to the control group. The average score of the posttest of the experimental group was higher than the pretest score, showing the effectiveness of the application of PBL in improving students' understanding of mathematical concepts, especially in the unit of time material. Thus, the use of the PBL learning model can be used as an alternative in improving the quality of mathematics learning at the elementary school level.

INTRODUCTION

One of the main advantages of the PBL learning model is its ability to increase students' sense of curiosity. When faced with a problem, students will naturally be encouraged to find out more about the problem, as well as find the most appropriate solution. This is a very important process in building analytical skills and critical thinking skills, which are one of the main goals of modern education. In addition, this curiosity can also encourage students to be more actively involved in the learning process, so that they will more easily absorb and remember the material taught (Siregar, 2016). In PBL, students are also taught to work collaboratively in groups. This collaboration is important because in many cases, real-life problems cannot be solved individually. By working together, students can share ideas, discuss, and help each other in solving problems. This collaborative process not only

improves students' communication and cooperation skills, but also helps them to better understand different perspectives and approaches in solving problems (Siregar, 2016). The implementation of PBL is also particularly relevant in the context of education in Indonesia, where the 2013 curriculum emphasizes the importance of student-centered education and the development of 21st-century skills, such as critical thinking, creativity, communication, and collaboration. By using PBL, teachers can help students to develop these skills, as well as prepare them for success in an increasingly complex and global world (Siregar, 2016).

In addition, the PBL learning model also allows teachers to act as facilitators and mediators in the learning process. As facilitators, teachers provide the support and guidance needed by students in solving problems. They are no longer the only source of information, but rather help students to find their own answers through exploration and research. This is very important in building students' independence in learning, which will ultimately make them better prepared to face future challenges (Siregar, 2016). The learning process that actively engages students, either individually or in groups, will become more meaningful because students have more hands-on experience in learning. This experience is important in forming a deeper understanding of the material being studied. When students experience a learning process that involves them directly, they not only memorize information, but also understand how it can be applied in real-world situations (Siregar, 2016).

In addition, PBL also takes a long time to prepare, both from the teacher and student side. Teachers need to design relevant and challenging problems, as well as ensure that students have enough resources to solve those problems. This process requires careful planning and a longer time compared to traditional teacher-centered learning methods. In some cases, the time it takes to resolve a single problem in PBL may take longer than expected, especially if the student needs additional guidance in the problem-solving process. Another drawback is that if students don't understand why the problem at hand is important to solve, they may lose motivation to learn. In PBL, it is very important for teachers to explain the relevance of the problems presented in the context of learning. If students feel that the problem is irrelevant or uninteresting to them, then they may not be motivated to seek solutions or actively engage in the learning process. Therefore, the selection of the right problem is a crucial factor in the successful implementation of PBL in the classroom.

Considering these advantages and disadvantages, PBL remains one of the most effective learning models in increasing student engagement and understanding. Although it has its challenges in terms of its preparation and implementation, the benefits offered by PBL in terms of the development of critical and analytical thinking skills and student learning responsibilities make them feasible for adoption in the context of modern education. Teachers need to understand how to implement PBL appropriately, as well as provide adequate support to students so that they can achieve success in this problem-based learning process. Understanding of mathematics concepts must be taught from the time students are in elementary school. Understanding concepts is an important factor in learning activities. Understanding concepts is the basic goal of learning mathematics. When students already understand the concept of mathematics, they will easily solve problems in mathematics lessons. The understanding of mathematics concepts for elementary school students is inseparable from the role of teachers. Teachers must be able to convey mathematical concepts in a good and interesting way. Teachers must also be able to build an understanding of concepts to students. Concept understanding activities for students are not always carried out in the classroom. Students are able to understand mathematical concepts through daily

activities. Experience in daily activities is able to make elementary school students acquire a variety of new information that allows them to see patterns, relationships between various knowledge. Currently, many teachers teach mathematics only by delivering material to students so that students are only able to solve mathematical problems without understanding the solution. Students find it difficult to solve mathematical problems competently if students do not have the right understanding of concepts.

The role of teachers is crucial in this process. Teachers are not only presenters of information, but also facilitators who help students build and develop their understanding of mathematical concepts. An effective teacher is one who is able to teach mathematics in a way that is engaging, contextual, and relevant to the student's experience. It helps students connect abstract mathematical concepts to concrete situations they experience on a daily basis. Unfortunately, there are still many teachers who teach mathematics in the traditional way, where the focus is more on delivering material and solving problems without paying attention to students' deep understanding. As a result, students may only be able to follow the problem-solving procedure without really understanding what they are doing. This causes students to struggle when faced with math problems that require a deeper understanding or on problems that are slightly different from what they are used to.

Understanding concepts has an important role in mathematical knowledge. A concept is a basic unit of cognition that is formed through a scheme of knowledge, a pattern of connections used to group objects into a category. (Fichte, 2015:13) defines a concept as an intuition that is the basis for a passive activity to be active. The emphasis on concepts can make students to acquire permanent concepts obtained through experience so that students are able to connect one concept with another (Ansari, 2016:38). Understanding a mathematical concept also allows students to understand new information that can be used for decision-making, problem solving, generalizing, reflecting and drawing conclusions (Churchill, 2017:39). Understanding a concept can be done through an interesting design of learning activities. According to Dienes (Ansari, 2016), the teaching of mathematical concepts is carried out through six stages, namely free play, games, the exploration of common traits, presentation, embodiment, and formalization. Understanding concepts in mathematics plays an important role in mastering in-depth mathematical knowledge. The concept itself can be interpreted as a basic unit of cognition that is formed through a knowledge scheme that serves to group objects into certain categories. Fichte (2015:13) defines the concept as an intuition that is the basis for transforming activities that were initially passive into active. By emphasizing concept understanding, students will be able to acquire permanent knowledge through learning experiences, so that they can connect one concept to another more effectively (Ansari, 2016:38). Understanding mathematical concepts also provides opportunities for students to understand and process new information that is relevant to decision-making, problem solving, as well as generalization, reflection, and conclusion making (Churchill, 2017:39).

To create a deep understanding of concepts, an interesting and contextual design of learning activities is needed. According to Dienes (in Ansari, 2016), the process of teaching mathematical concepts should be carried out through six systematic stages, namely free play, games, mutual nature exploration, presentation, embodiment, and formalization. Each stage has its own function in helping students understand concepts in a more intuitive and fun way. In the free play stage, students are given the freedom to explore and interact with

mathematical objects without certain restrictions. This stimulates students' curiosity and interest in the concepts to be learned**.**

METHODE

In this study, a quantitative research method was used with a pretest and postest design. Quantitative research is research that is based on assumptions, then variables are determined, and then analyzed using valid research methods, especially in quantitative research. This research method translates data into numbers to analyze the findings. Quantitative research can be descriptive, correlational, and associative based on the relationships between its variables. Sunawan et al. (2017) Quantitative research can be defined as a process of finding knowledge by using data in the form of numbers as a tool to analyze information about what you want to know. In this study, a quantitative research method with a pretest and posttest design was used. The quantitative research method is based on systematic assumptions and measurements, where variables are determined and statistically analyzed to produce reliable findings. This study converts data into numbers, which are then analyzed to gain a deeper understanding of the phenomenon being studied.

As part of the methodology, the pretest-posttest design is very useful for measuring the effectiveness of the intervention or treatment given. In this context, a pretest is conducted before the intervention to evaluate the participants' initial condition, while a posttest is conducted after the intervention to assess the changes or developments that occur. In this way, the researcher can identify whether the intervention applied has a significant influence on the variables being studied. Quantitative research can be descriptive, correlational, or associative, depending on the relationship between the variables being analyzed. According to Sunawan et al. (2017), quantitative research is the process of finding knowledge that relies on numerical data as a tool to examine information related to the phenomenon that is to be known. With this approach, researchers can produce objective and measurable data, as well as make it possible to conduct in-depth analysis using a variety of statistical methods. The application of quantitative research design in this context is expected to provide clearer insights into the effectiveness of the learning methods applied and their impact on students' understanding of mathematical concepts. Through the analysis of the data obtained, researchers can draw valid and relevant conclusions for the development of future learning methods.

The population of this study is students of SDN 01 Padangsidimpuan City. The sample used was all students in grade 4 of SDN 01 Padangsidimpuan City, North Sumatra, Indonesia with a total of 45 students. The data collection technique is carried out by holding written tests (Pretest and Postest) by providing test questions that are developed to measure understanding of mathematical concepts of time unit material. This test will be carried out before and after the implementation of the PBL model. The Independent (independent) variable of this study is the Problem Based Learning learning model, the dependent variable (bound) in this study is the understanding of the concept of time units. The material in this study is the unit of time for class 4 even semester. This research instrument is an essay-shaped test of 10 questions to measure the ability to understand concepts given at the beginning of the meeting and at the end of the meeting.

RESULT AND DISCUSSION

Data Uji Deskriptif Pretest dan Posttest

The Pretest results measured to measure students' initial concept understanding before using the Problem Based Learning (PBL) learning model obtained a minimum score of 40 and a kasimum score of 80 with an average score of 60.7. The following is the data of the Pretest results using excel:

Table 1. Pretest Results

Data Description	Sum
Maximum Value	80
Minimum Score	40
Mean	60,7
Median	60
Mode	70
Standard Deviation	10,63

The posttest results that have been carried out after using the *Problem Based Learning* (PBL) learning model with a minimum score of 80 and a kasimum score of 100 with an average score of 87.8, the following is the data of *the Posttest* results using excel:

Table 2. Posttest Results

Data Description	Sum
Maximum Value	100
Minimum Score	80
Mean	87,8
Median	90
Mode	80
Standard Deviation	8,41

Paired Samples Test				
Paired Differences	Mean	Hours of deviation	Std. Error Mean	95% Confidence Interval of the Difference
				Lower
Pair 1				
Pretest -	27.174	8.606	1.269	-29.729

Paired Samples Test				
Posttest				
t	-21.416			**Df**: 45

Explanation:
Mean: The average difference between pretest and posttest scores.
Std. Deviation: The standard deviation of the difference.
Std. Error Mean: Average standard error.
Confidence Interval: A 95% confidence interval for average differences.
t: The value t of the paired samples test.
Df: Degree of freedom.
Sig. (2-tailed): The significance value of the test that indicates whether the difference is significant.

Discussion

Based on the analysis with the t-test, it can be seen that after the learning model is carried out, there is an influence where the result of sig (2-tailed) is < 001 where Ho is rejected and Ha is accepted, which means that there is an average difference between the learning outcomes of the Pretest and Posttest which means that there is an influence of the use of the learning model in improving concept understanding. Based on the analysis with a t-test, the results of the study showed that after the application of a certain learning model, there was a significant influence on students' understanding of concepts. This significant result is indicated by the 2-tailed significance value (sig) obtained, which is less than 0.001. With these results, the zero (Ho) hypothesis is rejected and the alternative hypothesis (Ha) is accepted. This means that there is a significant average difference between student learning outcomes on the pretest and posttest. In this context, the use of applied learning models has proven to be effective in improving students' understanding of mathematical concepts. The effectiveness of the learning model can be measured from the improvement in student learning outcomes that are clearly visible between the two measurements made. The application of innovative and interactive learning models can encourage students to be more actively involved in the learning process. This is important, given that many previous studies have shown that active student involvement is key to gaining a deep understanding. Therefore, the results of this study are proof that the learning model applied not only has a positive effect on concept understanding, but can also increase students' motivation to learn.

In addition, these findings suggest that student-focused education with an active learning approach can result in positive changes in the way students understand subject matter. Basically, an effective learning model must be able to stimulate students' curiosity and interest. In this case, the role of the teacher as a facilitator is very important to guide students in the learning process. In this way, students not only receive information, but also engage in more in-depth discussions and exploration of concepts. Therefore, the improvement of understanding of mathematical concepts depends not only on the quality of the material taught, but also on the teaching strategies used. The application of a problem-

based learning approach, for example, can help students relate math concepts to their daily lives. This is important to help students see the relevance of the material they are learning to the real-life situation they are facing. Thus, students not only learn to pass exams, but also to understand and apply their knowledge in a broader context.

Further, this significant improvement in understanding of concepts can contribute to the development of students' critical thinking skills. This critical thinking skill is especially important in today's information age, where students are required to analyze and evaluate the various information they receive. In this context, an interactive and participatory learning model can provide a space for students to practice these critical thinking skills. By allowing students to discuss and work together in solving problems, they will learn to present arguments, consider different points of view, and reach agreement. This significant increase in learning outcomes is not only seen in grades, but also in students' attitudes towards mathematics subjects. Students who previously found it difficult to understand math concepts began to show greater interest and a higher sense of confidence in solving math problems. This is a sign that they are starting to build a strong foundation for future math learning.

In addition, the results of this study also show the importance of conducting a continuous evaluation of the teaching methods used. Teachers need to continually adapt and refine their approach to suit the needs and characteristics of students. The implementation of the right learning model not only impacts short-term learning outcomes, but can also affect students' motivation to learn in the long run. With increased understanding of concepts, students will also be better prepared to take on academic challenges at a higher level. This research also provides insight for educators and policy makers in designing better teacher training programs. Training that focuses on developing innovative learning strategies can be the first step to improving the overall quality of education. Thus, this research not only contributes to the understanding of concepts in the classroom, but also has broader implications for education reform in Indonesia.

Overall, the results of this study show that the application of the right learning model can have a significant impact on improving students' understanding of concepts. It is hoped that these findings will encourage more schools to adopt a more active and participatory approach to learning. With changes in teaching methods, it is hoped that students will be better prepared to face future challenges. A quality education should be able to equip students with the skills they need to succeed in life. Therefore, it is important for educators to continue to seek out and implement effective strategies in the teaching and learning process. Through this research, we can see that with the right efforts, mathematics education can become more interesting and beneficial for students. Given the importance of understanding concepts in mathematics education, this research also paves the way for further research that can explore a range of other learning models that can be applied. With collaboration between teachers, students, and educational institutions, we can create a more effective and enjoyable learning environment. The results of this research are expected to be a reference for educators in designing a better learning experience for students.

A better future of mathematics education can be achieved by implementing innovative and evidence-based learning models. The research also emphasizes the need for support from all parties, including parents and communities, to create a conducive learning environment. With the active participation of parents and the community, students will feel more motivated to learn and understand the math concepts they are learning. This also

reflects the importance of inclusive and community-based education. When all elements in the education ecosystem work together, the results achieved will be more optimal. In conclusion, this study not only provides an overview of the effectiveness of the learning models applied, but also provides hope for a better future of mathematics education. With the positive results of this study, it is hoped that more researchers and educators will be interested in delving deeper into various learning methods and models that can improve students' understanding of mathematics concepts in Indonesia.

The results of this study are supported by the results of research conducted by (Asnila et al., 2016) which states that there is an influence of *the Problem Based Learning* (PBL) learning model on students' ability to understand mathematical concepts, namely the ability to understand mathematical concepts in experimental classes using *the Problem Based Learning* learning model(PBL) is better than the ability to understand mathematical concepts in a control class that uses conventional learning. Supportive learning models will affect students' ability to understand mathematical concepts, this is in accordance with the results of research conducted by (Fitaloka et al., 2022) there is an influence of *the Problem Based Learning* (PBL) learning model with a metacognitive approach to critical thinking skills and understanding of mathematical concepts.

The results of this study are in line with previous research conducted by Asnila et al. (2016), which found a significant influence of the Problem Based Learning (PBL) learning model on students' ability to understand mathematical concepts. The study showed that students who were taught using the PBL model had a better understanding of mathematical concepts compared to students who followed conventional learning. This indicates that a more interactive learning model that focuses on real problems is able to increase student involvement in the learning process. By using the PBL approach, students not only learn about theory, but also how to apply mathematical concepts in relevant and contextual situations. This allows students to build stronger connections between the concepts learned and their use in the real world, thus facilitating a deeper understanding. Research conducted by Fitaloka et al. (2022) also supports these findings by showing that the application of the PBL learning model combined with a metacognitive approach has a positive effect on students' critical thinking skills and understanding of mathematical concepts. The metacognitive approach helps students to be more aware of their own thought processes, so they can identify the most effective strategies for solving problems. Thus, students not only learn to remember information, but also learn how to think critically and reflectively. The integration between PBL and metacognition allows students to take greater responsibility for their learning process, motivates them to engage more actively, and encourages them to explore more about mathematical concepts.

Furthermore, this study provides important insights into the importance of choosing the right learning model in improving students' understanding of concepts. The PBL model not only makes learning more engaging, but it also equips students with the necessary skills to think critically and solve problems. This is especially important in today's information age, where students are faced with a variety of challenges that require good analytical skills. Therefore, teachers need to consider implementing innovative learning models such as PBL in their curriculum to improve student learning outcomes. The implementation of the PBL model in mathematics learning can also increase students' motivation and interest in the subject. When students are given the opportunity to work in groups and solve problems relevant to their lives, they will be more motivated to learn. This is important to help students

feel more connected to the subject matter and see its relevance. In addition, collaboration in groups can also improve students' social skills, which are an important part of their personal development. Thus, the application of the right learning model not only has an impact on the understanding of mathematical concepts, but also on other aspects of student development.

The results of this study show that it is important for educators to adapt and develop teaching strategies that suit the needs of students. The use of varied learning models can help students to better understand and apply mathematical concepts in various contexts. Therefore, it is important for teachers to continuously improve their ability to apply various learning models, including PBL and metacognitive approaches, in order to create a more effective and enjoyable learning environment for students. Finally, the results of this study are expected to encourage more research and exploration regarding the application of innovative learning models in mathematics education. Thus, we can continue to improve the quality of education in Indonesia and ensure that students have a rewarding and relevant learning experience.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the application of the Problem Based Learning (PBL) learning model has a significant positive impact on students' understanding of the concept of time unit material in grade 4 of SDN 01 Padangsidimpuan City, North Sumatra, Indonesia. The results of the analysis showed a clear improvement between student learning outcomes before and after the application of this model, with the t-test yielding a sig (2-tailed) value indicating that $p < 0.001$. This confirms that the zero (Ho) hypothesis is rejected and the alternative hypothesis (Ha) is accepted, suggesting that the use of the PBL model is indeed influential in improving students' understanding of concepts. The PBL model gives students the opportunity to take an active role in the learning process. In the context of mathematics learning, students are encouraged to face real problems related to the unit of time, so that they not only memorize but also understand and are able to apply the concept in their daily lives. Thus, this learning model not only improves students' learning outcomes, but also facilitates the development of their critical and analytical thinking skills.

From the results of this study, it is suggested that teachers apply the PBL model in mathematics learning more broadly, especially in materials related to daily life. In addition, teachers are also expected to design problems that are relevant and interesting for students, so that the learning process becomes more interesting and meaningful. The use of varied learning media can also help students in understanding the concepts being taught. It is also important for teachers to provide sufficient guidance during the PBL learning process, so that students feel supported and motivated to actively participate. Teachers need to facilitate group discussions, encourage students to share ideas with each other, and provide constructive feedback. Thus, students will feel more confident in expressing opinions and learning from each other. In addition, it is recommended that further research be conducted to explore the effectiveness of the PBL model in other learning contexts or in different math materials. This aims to get a more comprehensive picture of the influence of PBL in mathematics education. Further research may also include long-term measurements of students' conceptual understanding to see if the application of the PBL model can have a sustainable impact.

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