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The Influence of the PBL Model to Student Learning Outcomes on Heat and its Transfer Concepts

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Abstract: This research aims to determine the influence of the Problem-Based Learning (PBL) model to student learning outcomes on heat and transfer concepts by using experimental research, with the research design being One Group Pretest-Posttest Design. The population of this study was class VII students of SMP Negeri 5 Gorontalo. The sample consists of 3 classes, namely experimental class, replication 1, and replication 2, with the sampling technique being Cluster Random Sampling. The instrument of research used was a learning outcomes test in the form of a pretest-posttest to see student learning outcomes. Then, the data was analyzed using descriptive and inferential statistics, including normality tests, hypothesis tests, and n-gain analysis. The average score for class VII students is greater than the Criteria for Achieving Learning Goals, shown by an average score for the experimental class of 82.25, replication 1 of 79.94, and replication 2 of 79.04, compared to the Criteria for Achieving Learning Goals of 70. Based on the hypothesis testing criteria for the class, experimental T_{count} 7.036 is greater than T_{table} 2.035, replication 1 T_{count} 6.684 is greater than T_{table} 2.035, and replication 2 T_{count} 5.824 is greater than T_{table} 2.035 so it stated T_{count} is more prominent than T_{table}. This can be interpreted that the PBL model influences student learning outcomes.

Keywords: Heat; PBL model; Student learning outcomes

Introduction

The world of education often experiences changes according to the dynamics of human civilization. More than the education and teaching styles of the past were needed to sustain learning according to the student's needs (Rasul et al., 2023; Shehata et al., 2024; Bahtiar et al., 2023). Therefore, teacher roles and strategies are required for changes in learning. Teachers must present innovative learning with various curriculum updates, techniques, methods, media, and new technology that are more meaningful, useful, and impact learning (Zunidar, 2019; Timotheou et al., 2023; Ng et al., 2023; Tsui et al., 2024; Matalka et al., 2024).

Innovative learning fosters a student-centered approach, where the educational process is organized and tailored to facilitate student learning, focusing on comprehending the students' context (Buhungo et al., 2023; Duan et al., 2024; Järvenoja et al., 2015). This approach is active learning, where the teacher creates an environment that encourages students to actively ask questions and share their opinions (Duong, 2023; Muhali, 2019; Ghazi & Matansh, 2023). Innovative learning models that enhance critical thinking, creativity, and problem-solving are essential components in supporting science education (Zulyusri et al., 2023; Wicaksono, 2020; Hikmah et al., 2023; Suyatmo et al., 2023; Sucilestari et al., 2023).

Science is the study of natural phenomena, encompassing both living and non-living entities. This knowledge is acquired and expanded through research conducted by scientists who seek to understand these

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phenomena and apply their findings to technology and daily life (Fahrudin & Saputro, 2023; Samosir et al., 2023). Science has been studied since receiving education in elementary school. Still, many students need help learning and understanding science concepts, resulting in low learning outcomes, including difficulty solving problems related to science concepts. An innovative approach that can address difficulties in comprehending science concepts and enhance learning outcomes is the Problem-Based Learning (PBL) model. PBL is a learning model focused on structured learning experiences, including investigation and solving contextual problems (Suharyat et al., 2023; Asrizal et al., 2023; Afnan et al., 2023; Simanjuntak et al., 2020; Hung, 2019; Kwan, 2009). Teachers must be innovative and creative in choosing and developing learning methods as time passes. The aim is for the Learning to be implemented to be effective, meet learning needs, and maximize the potential for learning outcomes (Bilyk et al., 2023; Cahyani et al., 2023; Teater, 2011).

Learning outcomes in science subjects can be achieved if the teacher uses learning models appropriate to the learning material and can increase student learning activity (Rahayu et al., 2018; Irviana, 2020). Student learning outcomes cannot be achieved or are classified as low because students are still too passive in the learning process, student participation needs to be improved, and learning models attractive to students need to be used. So, as educators, teachers play a very important role in improving the quality of student learning outcomes in the classroom through various active learning processes (Rossi et al., 2021; Niemi et al., 2016).

The results of interviews at Junior High School in SMP Negeri 5 Gorontalo with the science teacher in class VII state that the science learning process, especially on the Heat concepts, still needs to be learned using the PBL model. In the science topic of Heat and its Transfer, student learning outcomes are generally low due to a lack of understanding of the material, minimal active participation, and insufficient attention during the learning process.

The solution to the problem above is using the PBL model, which seeks to increase students' knowledge and understanding to influence student learning outcomes in heat and its transfer concepts. There are still students who need help understanding the material. By being actively, students improve their critical thinking skills in solving problems. Thus, it is important to use the PBL model on heat and its transfer concepts so that students can understand the material's content. Given the background described above, the researcher is motivated to pursue this study on the influence of the PBL model on student learning outcomes on heat and its transfer concepts.

Method

The type of research is experimental, and the research design used is One Group Pretest-Posttest. The steps taken in the experimental study were: giving a pretest to the three classes; providing the same treatment to all three classes using the PBL model; and giving a posttest to all three classes. The research population was class VII students of Junior High School in SMP Negeri 5 Gorontalo for the 2023/2024 academic year. The selected samples were class VII-A as the experimental class, class VII-B as the replication 1, and class VII-D as the replication 2. The replication class was a repetition of the experiment to ensure the student learning results' consistency (Abdjul et al., 2022). The flowchart of research steps from random assignment until posttest in Figure 1. The number of students in each sample group consisted of 34 people, with the sample group selected using cluster random sampling techniques.

This research uses a learning outcomes test, which is an essay with 10 questions covering the cognitive domain from levels C2 to C6. The aim is to determine student learning outcomes. The scores from the learning outcomes tests were analyzed using normality tests, hypothesis tests, and n-gain analysis to assess the impact of the PBL model on students' understanding of heat and its transfer concepts.

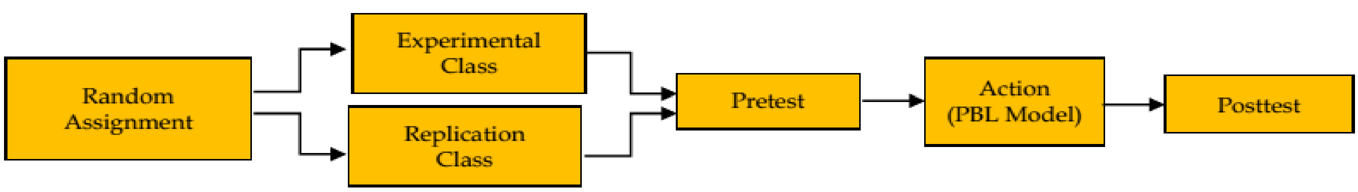

Figure 1. The flowchart of the research

Result and Discussion

The average student learning outcomes are shown in Table 1, showing a difference between the average Pretest-Posttest scores for each class, both experimental classes, replication 1 and replication 2 are 82.25, 79.94, and 79.04 respectively, greater compared to the Criteria for Achieving Learning Goals of 70. The average posttest exceeds the Pretest learning outcomes. Achievement of learning objectives from the learning outcomes obtained by students. Success is linked to the grades students achieve, their ability to absorb information, and their learning outcomes following participation in the teaching and learning process. One of determined in student learning outcomes, namely the learning process using the PBL model (Lagarusu et al., 2023).

Table 1. Average Student Learning Outcomes

Class	Average	
	Pretest	Posttest
Experimental	45.00	82.25
Replication 1	42.65	79.94
Replication 2	40.34	79.04

The results of students' tests are used to determine their cognitive domain learning outcomes. Figure 2 shows the average achievement of each student's cognitive domain from cognitive level C2 to C6.

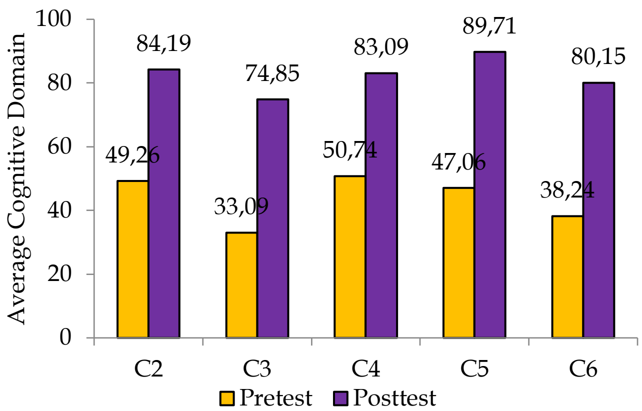

Figure 2. Average learning results in the cognitive domain of the experimental class

Figure 2 is the results of the achievement of cognitive levels C2 to C6 determined by using range value from pretest-posttest. It shows that for cognitive level C2, there was an increase of 34.93. At the cognitive level, C3 experienced a rise of 41.76, cognitive domain C4 of 32.35, C5 of 42.64, and C6 of 41.91. So, a higher increase occurred at the cognitive level of C5 compared to C6. This aligns with research by Ayunda et al. (2022) that students can solve questions with a higher C5 cognitive level than C4 and C6 cognitive domains because C5 level questions require students to express opinions through examining and criticizing. The average results of students' cognitive achievements from C2 to C6 for class in replication 1 are shown in Figure 3.

Learning results in the Cognitive Domain of the replication 1 determined by using range value of pretest and posttest in the Figure 3, the average calculation result for each achievement of cognitive levels C2 to C6 for cognitive level C2 was an increase of 37.32. C3 cognitive level increased by 38.68; cognitive domain C4 of 36.4; C5 of 31.62; and C6 of 41.91. So, in replication 1, a higher increase occurred at cognitive level C6 and cognitive level C2 had a greater increase than C4 and C5. The average results for each cognitive level achievement in replication 2 are shown in Figure 4.

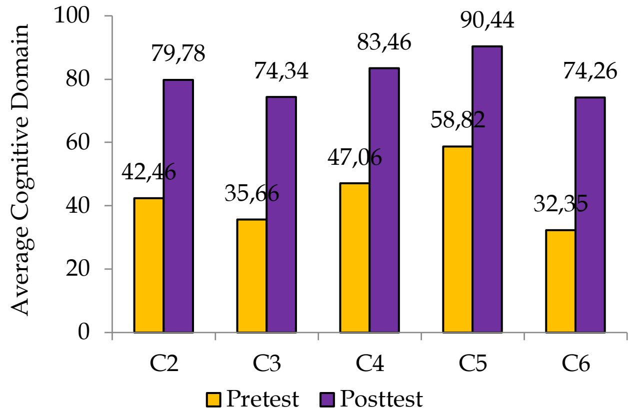

Figure 3. Average learning results in the cognitive domain of the replication 1

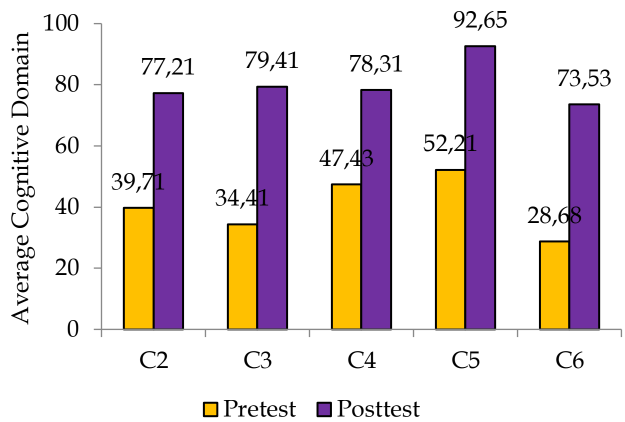

Figure 4. Average learning results in the cognitive domain of the replication 2

Based on Figure 4, replication 2 for cognitive level C2 saw an increase of 37.5. C3's cognitive level increased by 45; cognitive domain C4 was 30.88; C5 by 40.44; and C6 by 44.85. So, in replication 2, a higher increase occurred at cognitive level C3 compared to C4 to C6. This is in line with research conducted by Imaculata et al. (2021), showing that after being given treatment, the average score at cognitive level C3 has increased because, with the help of teachers, students can train themselves to use the concepts they have learned through Experimental activities in answering calculation questions. At the C3 level, there is the ability to apply, connect, calculate, and use formula-related concepts of heat and quantitatively calculate quantities from principles, concepts, or laws (Hurulean et al., 2022).

The data normality test aims to determine if the data follows a normal distribution. In this research, the Kolmogorov-Smirnov test formula was used with Microsoft Excel in Table 2.

Table 2. Results of Data Normality Testing

Class	F_i	K	Status
Experimental	0.482	0.232	Normally distributed
Replication 1	0.482	0.232	Normally distributed
Replication 2	0.482	0.232	Normally distributed

Table 2 presents the outcomes of data normality testing: $Fi \geq K$ for the significance level $a = 0.05$. Therefore, it can be inferred that the research data for the experimental class, replication 1 and replication 2, exhibit normal distribution.

Hypothesis testing aims to determine whether the PBL model influences student learning outcomes. Table 3 shows the hypothesis testing results.

Table 3. Results of Hypothesis Testing

Class	T_{count}	T_{table}	Status
Experimental	7.036	2.035	H_a Received
Replication 1	6.684	2.035	H_a Received
Replication 2	5.824	2.035	H_a Received

According to Table 3, the hypothesis testing results indicate that in the three classes, the T_{count} value exceeds the T_{table} value at the $\alpha = 0.05$ significance level. Therefore, the alternative hypothesis (*Ha*) is accepted, and the null hypothesis (*Ho*) is rejected, suggesting that the PBL model significantly influences student learning outcomes.

The n-gain test aims to see improvements in student learning outcomes through pretest and posttest in Table 4.

Table 4. Results of N-Gain Test

Class	N-gain	Criteria
Experimental	0.70	Medium
Replication 1	0.66	Medium
Replication 2	0.66	Medium

Table 4 shows the N-gain obtained for experimental class is 0.70 or is included in the medium criteria. Replication class 1 and replication 2 are 0.66 or included in the medium criteria. The increase in learning outcomes in each sample group has medium criteria.

The data on learning outcomes demonstrate an improvement following the treatment. This improvement is corroborated by observations of the science teacher's implementation of learning in Grade VII classrooms. Figure 5 presents the results of observations of learning implementation across the three sample groups.

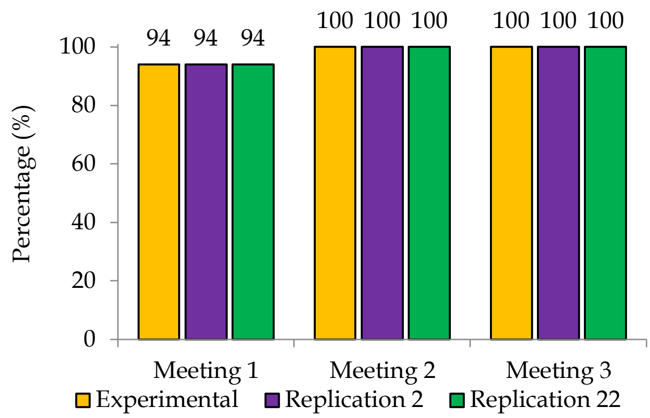

Figure 5. Percentage of learning implementation

Based on Figure 5, the percentage of observations of implementing the PBL model shows that implementing learning at meetings 2 and 3 is better than meeting 1. This can be seen from the large percentage at meeting 2 and meeting 3, which shows that it is higher than at meeting 1. The percentage results show that the implementation of the PBL model has a very good category in the learning process.

The results of the calculation of learning implementation, one stage was not implemented at meeting 1 in each class. In the fourth stage of the PBL model, namely developing and presenting results, students could not produce the results of discussions using various internet, books, and other reading sources. The obstacles experienced at this stage are that students need help finding information or additional reading sources from the internet because some students need to bring cell phones to school or have an internet connection to access various information. Therefore, at the next meeting, the researcher distributed teaching materials to help students find information related to learning materials.

When carrying out research, there needed to be more in the learning implementation process. One of the shortcomings that causes the learning process to be less than optimal at the initial learning meeting is that some students need help to search for information sources, such as the Internet. However, in general, researchers can use the PBL model very well because students are very enthusiastic and active in participating in the learning process; for example, group collaboration is very good, discussions take place quite well, and students can express their opinions during learning activities or ask questions when encountered difficulties when conducting experiments. Implementing the PBL model is an innovative learning strategy that requires students to think at a higher level or be creative, skilled, and innovative (Supartin et al., 2022).

Conclusion

Based on research using experimental research methods using experimental classes, replication 1 and replication 2 show that the PBL model on heat and its transfer concepts can influence student learning outcomes. This is demonstrated by the results of the hypothesis test where for the experimental class, T_{count} 7.036 is greater than T_{table} 2.035, for replication 1, T_{count} 6.684 is greater than T_{table} 2.035 and for replication 2, T_{count} 5.824 is greater than T_{table} 2.035. The hypothesis testing for each class is T_{count} greater than T_{table}. This means that the PBL model influences student learning outcomes.

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Author Contributions
Sri Maulina Otoluwa: Conceptualization, methodology; Ritin Uloli: Writing—original draft preparation; Tirtawaty Abdjul: Validation; Mursalin: Methodology; Abdul Haris Odja: Curation; Nova Elysia Ntobuo: Writing—review and editing, formal analysis.

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Conflicts of Interest
The authors declare no conflict of interest.

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