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The Influence of the PBL Model on Temperature and Expansion Topics on Student Learning Outcomes

Halisa Assagaf[1], Mursalin[1], Tirtawaty Abdjul[1*], Nova Elysia Ntobuo[1], Trisnawaty Junus Buhungo[2], Citron S. Payu[1]

[1]Science Education Study Program, Universitas Negeri Gorontalo, Gorontalo, Indonesia.
[2]Physics Education Study Program, Universitas Negeri Gorontalo, Gorontalo, Indonesia.
[*]e-mail: tirtawaty@ung.ac.id

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Abstract: The Problem-Based Learning (PBL) model is a student-centered learning strategy that requires students to be skilled and sensitive in solving problems in the surrounding environment. This research aims to determine the effect of the PBL model on temperature and expansion topics on student learning outcomes. This research is experimental research, with the research design being One Group Pre-test and Post-test Design. The population of this research was class VII students of SMP Negeri 11 Gorontalo. The sample consists of 3 classes: experimental class, replication 1, and replication class 2. The data collection instruments used are validation sheets, observation sheets, and pre-test and post-test question sheets to see student learning outcomes; then, the data is analyzed using descriptive statistics and statistics. Inferential, which includes normality testing, hypothesis testing, and n-gain analysis. The results of the research show that the results of the hypothesis test are that for the experimental class, the t-count is 7.513 greater than t-table 1.697; for replication class 1, t-count 4.679 is more significant than t-table 1.720, and for replication class 2, t-count 2.080 is more important than t-table 1.729. It can be concluded that the hypothesis testing in each class is t-count greater than t-table; this can be interpreted as the influence of the PBL model on temperature and expansion topics on student learning outcomes.

Keywords: Expansion; PBL Model; Student Learning Outcomes; Temperature.

Introduction

Education, an essential component in human life, plays a significant role in influencing everyday human attitudes and actions [1], [2]. Humans will achieve everything that is their goal in life because since humans are born in a state of helplessness and standing alone, the help of other people is needed to help humans achieve all their desires. Education is an obligation every human must carry out; without education, humans have no purpose. So, through education, humans can have the highest level compared to other living creatures. Education is the hope of every human being who can bring about change for the better [3], [4]. Educational learning in junior high school is critical in preparing students to become reliable human beings (desirable person quality). Junior high school students have an essential role in the future of the nation because the future of the nation is in their hands. Therefore, science learning in junior high school can lead to the formation of students who are good, intelligent, knowledgeable, and have character [5], [9].

Natural Sciences is an education that can optimize students' potential. In science learning, there is a process of discovering, analyzing, and understanding all forms of events in the universe, starting from living creatures, inanimate objects, and the atoms that form objects on the face of the earth [10], [11]. Science education is knowledge gained through experimental activities or observation, where science learning will be easier to remember and understand if it is explained through what is observed. Through science learning, we can find out what is around us, so we do not just learn about a set of facts, concepts, or principles but rather the process of investigating and discovering something new [12], [13]. Science learning in class is directly related to the school curriculum. However, science learning must follow the new curriculum, namely the independent curriculum (*Merdeka Melajar*). The independent curriculum focuses on freedom and creative thinking. The advantage of implementing the Independent Curriculum is that teachers can be creative and innovative in learning. Apart from that, there are class projects that must be done by students so that students are challenged to learn [14], [17].

Innovative learning is designed to be different from general learning (conventional). This learning is centered on student learning outcomes. The creative learning model is very suitable for the current learning process. There are various learning models, including the Problem-Based Learning (PBL) model [18]. The PBL model is a student-centered learning strategy that requires students to be skilled and sensitive in solving problems in the surrounding environment. This learning model is very effective and can support differentiated learning [19], [20].

One aspect that influences learning success is the teacher's ability to manage learning and determine the model used. The learning model used by teachers in classroom learning aims to ensure that all students' potential can develop according to the learning objectives to be achieved. Teachers must be able to choose appropriate learning models relevant to the goals to be achieved and the

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topics being studied. The teacher only becomes a facilitator in the learning process carried out by students [21], [24]. The use of inappropriate learning models makes students quickly bored, and their activeness in participating in learning decreases, thus affecting student learning outcomes. The choice of learning model that teachers will use in teaching should be made carefully because a learning model is a pattern or Design used as a guide in carrying out the process of learning activities in the classroom. Not only that but by using the lecture method, students are presented with concepts directly by the teacher, so they cannot find what they are learning [25], [27].

Based on the results of an interview with the teacher from SMP Negeri 11 Gorontalo with the science teacher in class VII, the science learning process, especially regarding Temperature and Expansion topics in class VII, had not implemented learning using the PBL model. Then, in the science topics, especially in the Temperature and Expansion topics, the application of learning with the help of textbooks looks less attractive; namely, the books are still very limited. Students tend to be passive in the learning process, have low interest in learning, and lack attention and interest in the topics provided. The solution to the problem above is using the PBL model, which seeks to increase students' knowledge and understanding to influence student learning outcomes on temperature and expansion topics because there are still students who do not understand these topics. In the learning process, students can improve their critical thinking skills in solving problems to be actively involved.

Learning that makes students active is very supportive of improving their ability to think and communicate in a structured manner. Based on the discussion above, the difference is evident that PBL needs to be applied in a learning process because PBL can activate students in learning activities and improve students' way of thinking so that students' scientific literacy during learning. Based on the background description, the researcher is interested in researching the influence of the PBL Model on Temperature and Expansion topics on student learning outcomes.

Research Methods

The research method used is the experimental method. The Design used in this research is a group Pre-test and Post-test Design on the flow chart of research in Figure 1. The treatment results can be known accurately with the research design, and the effect can be seen. The sample for this research has an experimental class and two replication classes. This research was carried out at SMP Negeri 11 Gorontalo, Gorontalo City. This research was carried out over one year in the 2023/2024 -2024/2025 academic year.

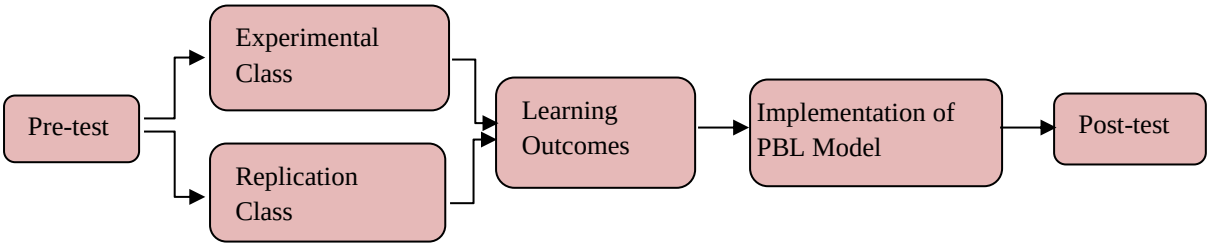

Figure 1. The flow chart of the research

The instruments used in this research consisted of two: the instrument used to see student learning outcomes, namely the learning results test, and the instrument used to measure learning implementation, namely the learning implementation observation sheet. The learning outcomes test instruments used are the Pre-test and Post-test. The pre-test is used before implementing the PBL model or before delivering topics on temperature and expansion to determine to what extent students have mastered the topics to be taught. On the other hand, the post-test is carried out at the end of the learning process after being given treatment by applying the PBL model to temperature and expansion topics to determine the extent of students' understanding of the topics studied. Giving learning outcomes tests is carried out to assess student learning outcomes.

The reliability test uses the Cronbach Alpha formula with Microsoft Excel. After the alpha coefficient value for the test instrument's reliability is obtained, the learning outcomes are obtained. Next, feasibility is assessed using the criteria contained in Table 1 [28]. Based on Table 1, the test instrument can be categorized as reliable if the Cronbach alpha value is > 0.60.

Table 1. Reliability Level based on Cronbach Alpha [29].

Cronbach Alpha	Reliability level
$0.00 \leq r < 0.20$	Less reliable
$0.20 \leq r < 0.40$	Somewhat reliable
$0.40 \leq r < 0.60$	Quite reliable
$0.60 \leq r < 0.80$	Reliable (good)
$0.80 \leq r < 1.00$	Very reliable

To determine the improvement obtained, this research used analysis of the course average normalized gain, single student normalized gain, and n-gain per indicator. After calculating the categorization of the N-gain value obtained, it can be determined based on the criteria in Table 2 [30]. Based on Table 2, n-gain measures the effectiveness of the treatment used to determine the increase in student learning outcomes. The n-gain has criteria, namely: low if n-gain ≤0.30, medium if 0.30 < n-gain ≤ 0.70, and high if n-gain > 0.70 [30].

Table 2. N-gain Value Categories [30].

N-Gain value	Criteria
$g > 0.70$	High
$0.30 < g < 0.70$	Medium
$g < 0.30$	Low

Results and Discussion

Learning outcomes

The data on student learning outcomes analyzed in this research consisted of three classes: experimental class, replication 1, and replication 2, using the PBL model on temperature and expansion in Table 3.

Table 3. Results of Average Student Learning Outcomes

Class	Pre-test	Post-test
Experiment	37.93	79.82
Replication 1	38.39	77.78
Replication 2	45.45	72.78

Table 3 shows a difference between the average Pre-test and Post-test scores for each experimental class, replication 1 and replication 2. The average learning outcomes in the post-test, both experimental and replication classes, exceed the average learning outcomes in the Pre-test. Then, after being given a pre-test for the three classes, both in the experimental class, replication 1 and replication 2, they were given treatment or treatment in the form of learning using the PBL model on temperature and expansion topics, where this treatment or treatment lasted for four meetings for each -Each class corresponds to a teaching module, after being given treatment or treatment in these three classes. Next, a post-test was given to the three experimental courses. Student learning outcomes are obtained through written tests in the form of essays that validators have validated.

Learning Outcomes in the Cognitive Domain

Data on learning outcomes in the cognitive domain of students is obtained from the results of tests carried out by students, which have been arranged based on question indicators and mental level. The average achievement of each student's cognitive domain from cognitive levels C2 to C6 in the experimental, replication 1, and replication 2 classes is shown in Figure 2.

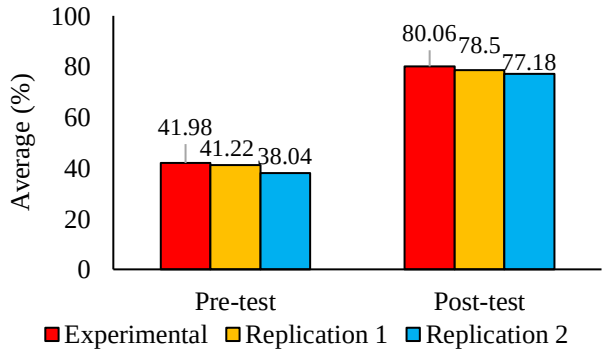

Figure 2. Student Learning Outcomes in the Cognitive Domain

Based on Figure 2 in the experimental class, replication 1 and replication 2, the average calculation results for each achievement of cognitive levels C2 to C6 have increased from pre-test to post-test. In the experimental class, the average pre-test achievement was 41.98, and the post-test was 80.06. In replication class 1, the average pre-test was 41.22, and the post-test was 78.50. In replication class 2, the average pre-test was 38.04, and the post-test was 77.18.

Calculating the average student cognitive learning outcomes proves that learning using the PBL model influences student learning outcomes regarding temperature and expansion topics. This is the opinion of previous researchers that learning using the PBL model affects students' cognitive abilities because they are encouraged to be actively involved in solving a problem presented [31]. Based on the research that has been carried out, the data used in the study is a test of student learning outcomes using an instrument in the form of a written test in the form of an essay with a total of 10 questions. For the learning outcomes test, research result data is in the form of a pre-test and post-test given in the experimental class, replication 1 and replication 2.

Reliability Test

Reliability is the extent to which a measurement's results can be trusted [32]. The reliability test uses the Cronbach Alpha formula with Microsoft Excel. After the alpha coefficient value for the test instrument's reliability is obtained, the learning outcomes are obtained. The reliability test results of the learning outcomes test instrument that researchers have carried out are shown in Table 4.

Table 4. Average Reliability Test Results of Learning Outcome Test Instruments

Class	Cronbach Alpha		Information
	Pre-test	Post-test	
Experimental	0.855	0.797	Reliable
Replication 1	0.851	0.813	Reliable
Replication 2	0.815	0.602	Reliable

Table 4 shows the average reliability results of learning outcome tests. In calculating the 10 questions, the Cronbach Alpha from each pre- and Post-test class showed a Cronbach Alpha value > 0.60. the test instrument can be categorized as reliable if the Cronbach alpha value is > 0.60 [29]. In conclusion, this question is included in the reliable category. Calculate the reliability test results of the learning outcomes test instrument for each question item in the experimental class, replication 1 and replication 2.

Test N-gain

The n-gain analysis test determines the improvement that occurs before and after learning. This study used pre-test and post-test instruments, and the results were analyzed based on student scores. The following n-gain analysis of test results using the course average normalized gain per class can be seen in Table 5.

Table 5. N-gain Test Results

Class	N-gain	Criteria
Experimental	0.68	Medium
Replication 1	0.63	Medium
Replication 2	0.47	Medium

Based on the results of the n-gain test calculations in Table 5, it shows that the experimental class obtained an n-

gain value of 0.68, for replication class 1, it received an n-gain value of 0.63, and for replication 2, it obtained an n-gain value of 0.47. From the results of these calculations, the n-gain category in the experimental class and replication class falls into the medium criteria. Previous researchers make this statement regarding the average standard score in the three classes. The post-test score is higher than the pre-test score because the material studied is related to events in the surrounding environment, making it easier for students to understand the learning material [33]. During the ongoing learning process, treatment was given using the PBL model, and the average student learning outcomes were in the medium category. In this case, it shows that after being given treatment, there was an increase in understanding for each student who initially did not use the PBL model in learning. The experimental class had a higher average Post-test score than the replication 1 and replication 2 classes because the experimental class students' enthusiasm for learning was outstanding as long as the author taught using the PBL model.

N-gain per-indicator

Analysis of n-gain per indicator was also carried out to determine the increase in students' understanding of concepts for each indicator question in the topics on temperature and expansion. The results of the n-gain analysis per indicator can be seen in Figure 3.

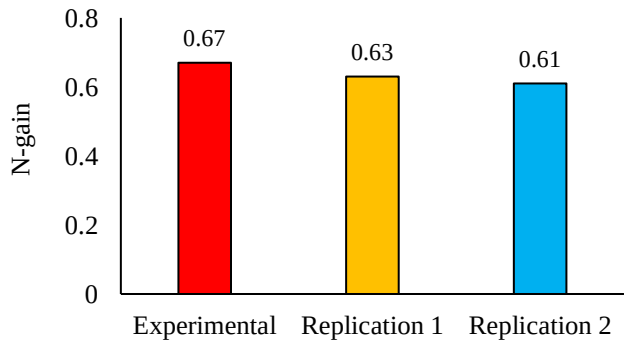

Figure 3. Graph of n-gain per-indicator

Figure 3 shows that the average calculation result of the N-gain test for the experimental class is 0.67, which is included in the medium criteria. In replication class 1, it was 0.63, which was also in the medium criteria, and replication class 2 was 0.61, which was also in the medium criteria. The n-gain analysis per indicator was carried out to determine the increase in students' conceptual understanding of each indicator question in the topics on temperature and expansion. Based on Figure 3, the n-gain analysis shows increased knowledge per indicator. Students gain new understanding or strengthen previous understanding. The PBL model is based on temperature and expansion topics, which affect student learning outcomes.

Normality Test

This research uses the Kolmogrof-Smirnov normality test formula using Microsoft Excel. The results obtained from statistical tests can be seen in Table 6.

Table 6. Data Normality Test Results

Class	Fi	K	Status
Experimental	0.968	0.235	Normally distributed
Replication 1	1.927	0.275	Normally distributed
Replication 2	1.691	0.287	Normally distributed

Based on Table 6, the results of data normality testing in Table 6, it is known that Fi ≥ K for the real level α = 0.05. In the experimental class, Fi 0.968 is more excellent than K 0.235. In replication class 1, Fi of 1.927 is more amazing than K of 0.275, and in replication class 2, Fi of 1.691 is more excellent than K of 0.287. So, it can be concluded that the research data for the experimental class, replication 1 and replication 2, are typically distributed. This is in line with previous researchers that the normality test using Kolmogorov-Smirnov can compare a series of data in a sample against a normal distribution of a series of values with the same mean and standard deviation [34]. In short, this test is carried out to determine the normality of the distribution of some data.

Hypothesis Testing

Hypothesis testing was conducted to determine whether the PBL model influenced student learning outcomes. Based on the research data, associative statistical hypothesis testing was carried out using the t-test statistic. The hypothesis aims to determine whether the PBL model influences temperature and expansion topics in the experimental and replication classes. Hypothesis testing in the experimental class, replication 1 and replication 2, can be seen in Table 7.

Table 7. Hypothesis Testing Results

Class	t-count	t-table	Status
Experimental	7.513	1.697	Ha accepted
Replication 1	4.679	1.720	Ha accepted
Replication 2	2.080	1.729	Ha accepted

Based on Table 7, the results of hypothesis test calculations in Table 7, the t count for the experimental class was 7.513, for replication class 1, 4.679, and replication class 2, 2.080. Each class had different tables, depending on the number of students. In the experiment, it was 1.697; in replication class 1, it was 1.720; in replication class 2, it was 1.729. So, it can be concluded based on hypothesis testing in the experimental class, replication 1 and replication 2, namely that the calculated t is more prominent or greater than the t table for the α = 0.05 level, then Ha is accepted, and Ho is rejected. This can be seen from the good post-test results from the three classes, where there is an increase in the average value of student learning outcomes from the pre-test scores. The results show that the average value of student learning outcomes is greater than or equal to the criterion value for achieving learning objectives of 70. In conclusion, the PBL model influences student learning outcomes.

This shows that the PBL model influences temperature and expansion topics in class VII and student learning outcomes. This is because using the PBL model can be an effort to improve science learning outcomes because the beginning of learning begins by presenting a problem, identifying the problem, continuing with

discussions, and designing a solution that will be achieved at the end of learning by collecting various sources of knowledge obtained from the internet, books, even through observation [35].

Observation of Learning Implementation

Based on the data from the calculation of student learning outcomes above, there is an increase in student learning outcomes after treatment using the PBL model. This is supported by the implementation of learning by observers or teachers who support science subjects in class VII. The following are the results of observations of the implementation of learning using the PBL model in each class, both experimental class, replication 1, and replication 2, which can be seen in graphical form in Figure 4.

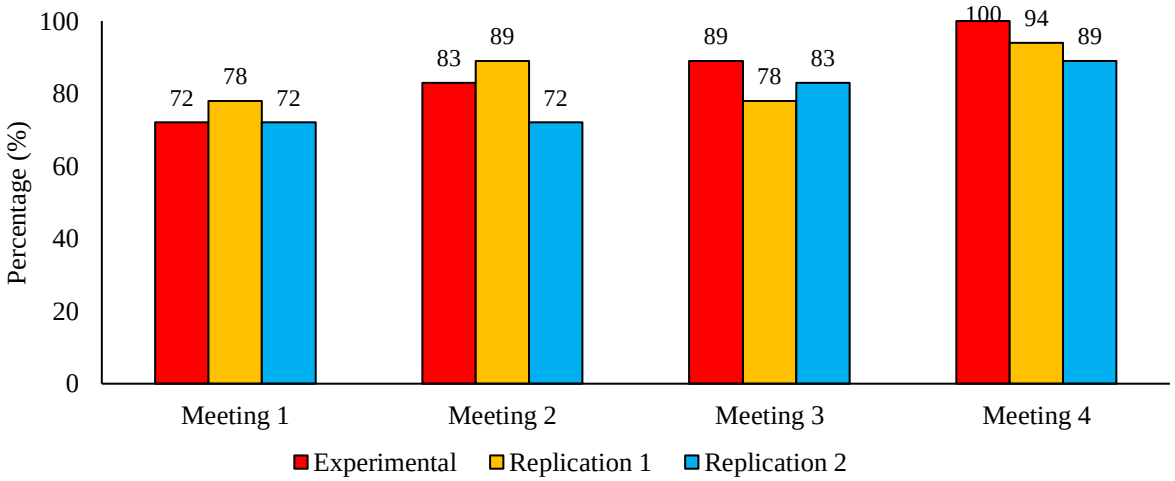

Figure 4. Percentage of Learning Implementation

Based on Figure 4, the results of the percentage of observations on the implementation of the PBL model show that the implementation of learning at meetings 2 to 4 is better than meeting 1. This can be seen from the large percentages at meeting 2 and meeting 4, which are higher than at meeting 1. The percentage results show that implementing the PBL model is in the very good category in the learning process.

Learning activities using the PBL model consist of several stages, including orienting students to problems, organizing students to learn, guiding them for investigations, developing and presenting results, and analyzing and evaluating problem-solving. Other learning activities, such as introductory and closing activities, support it. The results of the percentage of learning implementation are included in the very good category. This is shown by the increase at each meeting in each class, both experimental class, replication 1 and replication 2.

The PBL model can also be used to train students' high-level thinking skills and character, improve their critical thinking skills, and increase their in-depth understanding and capacity to apply the concepts they have learned. Operationally, PBL steps include orienting students to the problem, organizing students to learn, guiding students to conduct investigations individually and in groups, developing and presenting problem-solving procedures, and analyzing and evaluating the problem-solving process. Thus, the PBL model can be used to overcome student learning difficulties [36].

Conclusion

Based on the results of research that has been carried out using experimental research methods and experimental classes, replication 1 and replication 2 show that the PBL model on temperature and expansion topics can influence student learning outcomes. This is demonstrated by the results of the hypothesis test where for the experimental class, t-count 7.513 is more significant than t-table 1.697, for replication class 1, t-count 4.679 is more significant than t-table 1.720, and for replication class 2, t-count 2.080 is more significant than t-table 1.729. It can be concluded that the hypothesis testing in each class is t-count greater than t-table; this can be interpreted as the PBL model influences student learning outcomes.

Author's Contributions

Halisa Assagaf: Conceptualization, writing-original draft preparation, methodology; Mursalin: Methodology; Tirtawaty Abdjul: Curation, writing-original draft preparation; Nova Elysia Ntobuo: Writing-review and editing; Trisnawaty Junus Buhungo: Formal analysis, methodology; Citron S. Payu: Validation.

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