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Application of the PBL Model on Temperature and Heat Concepts to Student Learning Outcomes

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Abstract: This research aims to analyze the application of the Problem-Based Learning (PBL) learning model on temperature and heat concepts on student learning outcomes. This research is experimental research, with the research design used being a one-group pretest-posttest design. The sampling technique used in this research was the total sampling technique. The population in this study was all class VII of MTs Al-Khairaat Kwandang for the 2023/2024 academic year. The sample in this study consisted of 3 classes, namely Class VII B as the experimental class, Class VII A as replication 1, and Class VII C as replication 2, where the experimental and replication classes were determined randomly by drawing lots. Research data was collected using test techniques, then the data was analyzed using descriptive statistics and inferential statistics, which include normality tests, hypothesis tests, and n-gain analysis. The results obtained for all sample classes, the average for class VII students is greater than the Criteria for Achieving Learning, which is shown by the average value of the experimental class of 85.49, replication 1 of 84.18, and replication 2 of 82.92. Based on the results of the course average normalized gain obtained by the experimental class was 0.78, replication 1 was 0.76, and replication 2 was 0.75, which means that all sample classes are in the high category. Thus, the PBL learning model has a significant effect on student learning outcomes in concepts of temperature and heat.

Keywords: Heat; PBL model; Student learning outcomes; Temperature

Introduction

Education is a planned effort to create a pleasant teaching and learning process, with the aim that students can actively develop their religious and spiritual potential, good morals, intelligence, and skills. According to Yulasri (2018), education is an educator's effort to improve human knowledge and skills. Education is very important to ensure the country's life keeps pace with advances in science and technology. The results of research conducted by Pristiwanti et al. (2022), show that education is very important for the progress of a country and that high-quality education is demonstrated by students' proficiency in completing assignments and subjects that are in line with their educational goals.

All parties involved in the educational process, namely students, teachers, and learning materials must work together in an ideal environment so that learning can take place. The primary objective of education is for teachers to assist students in acquiring knowledge and achieving their learning goals. In science education, the aim is for students to apply and enhance their knowledge in practical, real-world situations. Students are also advised to participate actively because science learning includes four fundamental elements: perspective, which includes learning about nature, living things, and a series of events that produce new

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challenges that require resolution; procedures, which include the use of approaches. scientific to solve problems; final results, which include knowledge in the form of facts, principles, ideas, and laws; practical use of scientific techniques and concepts in everyday life (Schulz et al., 2023; Nurcahyati et al., 2020). The learning process must prioritize student involvement to eliminate passivity because involved learning will attract students' interest and allow them to focus on the material provided (Fathurrohman, 2015).

Based on the results of observations in Madrasah Tsanawiyah school Gorontalo in MTs Al-khairaat Kwandang, it is known that students have difficulty understanding scientific subjects, and teachers continue to use traditional teaching techniques during the learning process. They also feel bored because teaching methods are still teacher-centered. Learning like this makes the understanding obtained by students less than optimal, thus having an impact on student learning outcomes. One of the causes of less-than-optimal learning outcomes is that many concepts still need to be explained, and problems need to be solved. This is different from the objective of science learning; students are less motivated to look for answers when solving problems. Students must explore their knowledge and curiosity about events and phenomena that occur through experiments.

To create a learning process and learning experience for students, teachers must be able to choose a problem learning approach, which is considered the most efficient teaching method to improve students' skills in generating, expressing, exploring, and communicating ideas. Teachers need to develop students' problem-solving skills. Implementing the appropriate learning model can help students grasp lessons more effectively and reach the desired educational goals (Castro, 2023; Devi, 2024; Abdjul et al., 2022). The problem-based learning (PBL) model is an instructional approach that can enhance students' active participation in the learning process (Safitri et al., 2023; Abidin, 2019; Anggraeni et al., 2023).

The PBL model begins the learning process by using problems as a starting point for acquiring new knowledge (Meng et al., 2023; Yusuf & Yusuf, 2019; Suradika et al., 2023). It is focused on various problems that require authentic investigation, namely investigations that require students to seek real solutions to existing problems (Kaeedi et al., 2023; Murdani et al., 2022; Ichda et al., 2023; Kawuwung & Mamahit, 2023). According to Gulo (2022), the PBL model is based on real life because students are faced with problems that exist in everyday life. Fauzan et al. (2017), concluded that science learning combined with the PBL model can effectively improve student learning outcomes. This is in line with research conducted by Kumala & Widiawati (2022), which indicates that the PBL model is more effectively used to improve students' thinking abilities and learning outcomes.

The PBL model often uses problems as learning material that must be solved because in learning using the PBL model, students are emphasized to be active but still with the teacher's guidance in discovering concepts. Students are given the freedom to think more creatively and actively. Based on the background description, the PBL model was chosen in this research because this learning model encourages students to be active in acquiring knowledge and is expected to create a sense of enthusiasm and enjoyment in learning so that learning can be active and increase understanding of science concepts which can encourage students to improve their learning outcomes.

Method

This research uses an experimental method. The design is a one-group Pretest-Posttest Design. This design was chosen because there was an initial test before treatment and a final test after treatment. In the experimental and replication classes, treatment was given by applying the PBL model on the flowchart of research in Figure 1. This research was carried out for two months in the odd semester of the 2023/2024 academic year at MTs Al-Khairaat Kwandang, North Gorontalo Regency, Gorontalo Province. The population in this study was all class VII students at MTs Al-Kahiraat Kwandang, consisting of three classes: class VII-A, class VII-B, and class VII-C. The sampling technique in this study used a total sampling technique, so class VII-B was obtained as the experimental class, VII-A as replication 1, and VII-C as replication 2.

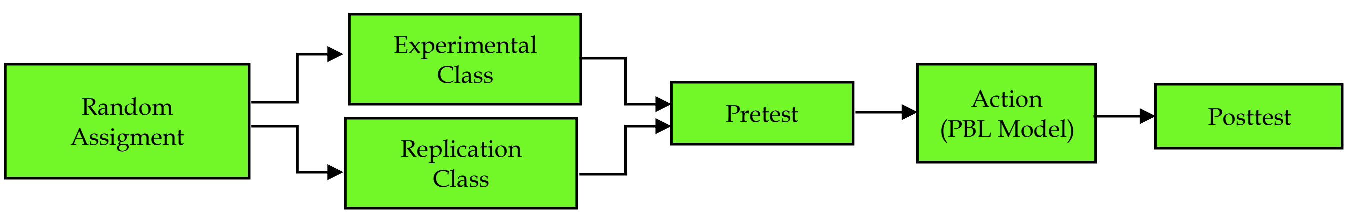

Figure 1. The flowchart of the research

The data in this research are student learning outcomes. Data was collected using pretest and posttest techniques. The instrument used in this research is an essay test instrument to measure student learning outcomes. Student learning outcomes data were analyzed using the data normality test, hypothesis test, and n-gain test.

Result and Discussion

Result

Research entitled the application of the PBL Model on Temperature and Heat concepts on student learning outcomes was carried out at MTs Al-Khairaat Kwandang. Data on student learning outcomes was obtained after students were given treatment using the PBL model. The normality, hypothesis, and n-gain tests were used to measure student learning outcomes.

Table 1. Results of student learning outcomes

Class	Average	
	Pretest	Posttest
Experimental	36.04	85.49
Replication 1	34.95	84.18
Replication 2	32.56	82.92

Table 2. Results of Data Normality Test

Class	F_i	K	Status
Experimental	0.477	0.259	Normally distributed
Replication 1	0.477	0.259	Normally distributed
Replication 2	0.475	0.269	Normally distributed

Tabel 3. Results of Hypothesis Testing

Class	T_{count}	T_{table}	Status
Experimental	6.646	2.060	H_a Received
Replication 1	5.870	2.060	H_a Received
Replication 2	5.053	2.069	H_a Received

Table 4. Results of N-Gain Test

Class	N-gain	Criteria
Experimental	0.78	High
Replica 1	0.76	High
Replica 2	0.75	High

Based on Table 1, the average pretest score for the experimental class was 36.04, replication 1 was 34.95, and replication 2 was 32.56. The posttest score for the experimental class was 85.49, replication 1 was 84.18, and replication 2 was 82.92. This shows that the average student learning outcomes increased. For Table 2 shows the results of the data normalization test: $Fi \geq K$ for the real level a = 0.05. Thus, it can be concluded that the research data for the experimental class, replication 1 and replication 2, are normally distributed.

Table 3 shows that $T_{count} \geq T_{table}$ with a level of α = 0.05 for the experimental class, replication 1, and replication 2. Therefore, H_0 is rejected, and H_a is accepted. It can be concluded that the application of PBL model on temperature and heat concepts influences student learning outcomes in the experimental class, replication 1, and replication 2. Meanwhile, based on Table 4, the n-gain value for the experimental class, replication 1, and replication 2 are included in the high category. It can be concluded that student learning outcomes in temperature and heat concepts using the PBL model have increased.

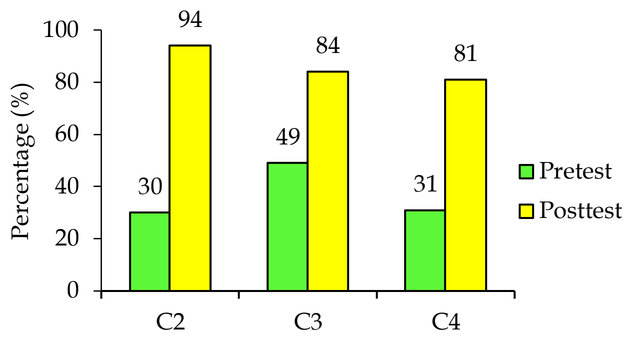

Figure 2. Percentage of Cognitive Achievements of the Experimental Class

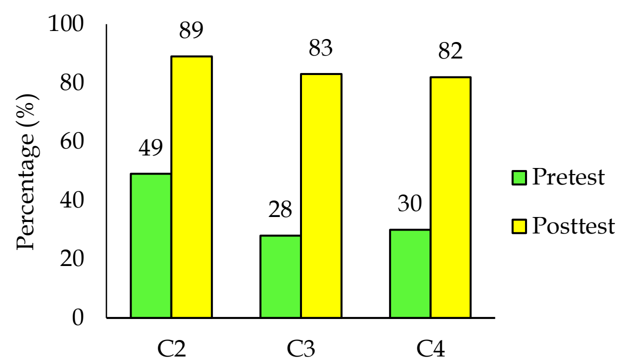

Figure 3. Percentage of Cognitive Achievements of the Replication 1

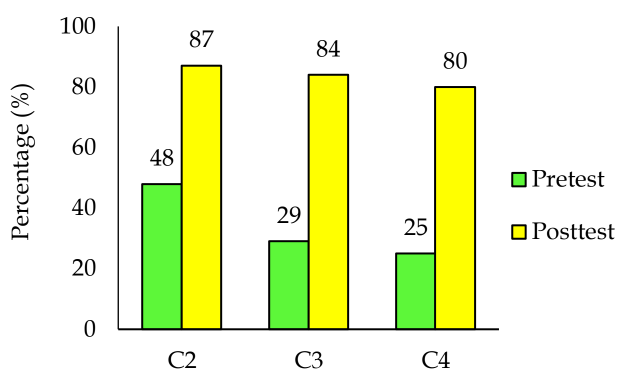

Figure 4. Percentage of Cognitive Achievements of the Replication 2

Students' cognitive abilities can be assessed based on C2 (Understanding), C3 (Applying) and C4 (Analyzing). Then, the average presentation of students' cognitive domain achievements will be calculated, and the following results are obtained in Figure 2. Based on Figure 2 shows that the cognitive criteria C2 to C4, obtained from the pretest percentage, show that C3 has a higher percentage than C2 and C4. The posttest value shows that C2 has a higher percentage than C3 and C4. For Figure 3, it can be seen that the cognitive criteria C2 to C4 obtained from the pretest percentage show that C2 has a higher percentage compared to C3 and C4, and the posttest value shows that C2 has a higher percentage compared to C3 and C4. Meanwhile, Figure 4 shows that the cognitive criteria C2 to C4, obtained from the pretest percentage, show that C2 has a higher percentage than C2 and C4. The posttest value shows that C2 has a higher percentage than C3 and C4.

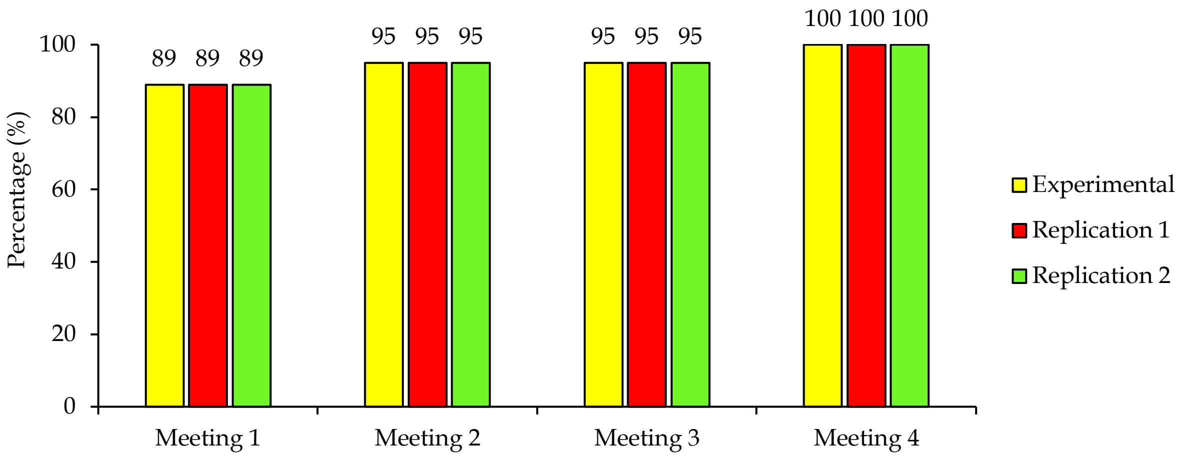

Figure 5. Percentage of Learning Implementation

This statement is supported by observations of the teaching practices of class VII science educators at MTs Al-Khairaat Kwandang. The findings from the learning implementation sheet are illustrated in Figure 5. According to Figure 5, the initial meeting faced challenges due to the uncontrolled classroom environment and the adjustment period. However, the outcomes significantly improved by the second, third, and fourth meetings as the researcher consistently addressed and corrected the issues encountered in each session.

Figure 6 displays the single-student normalized gain in the experimental class, revealing that more students in the high category than those in the medium category.

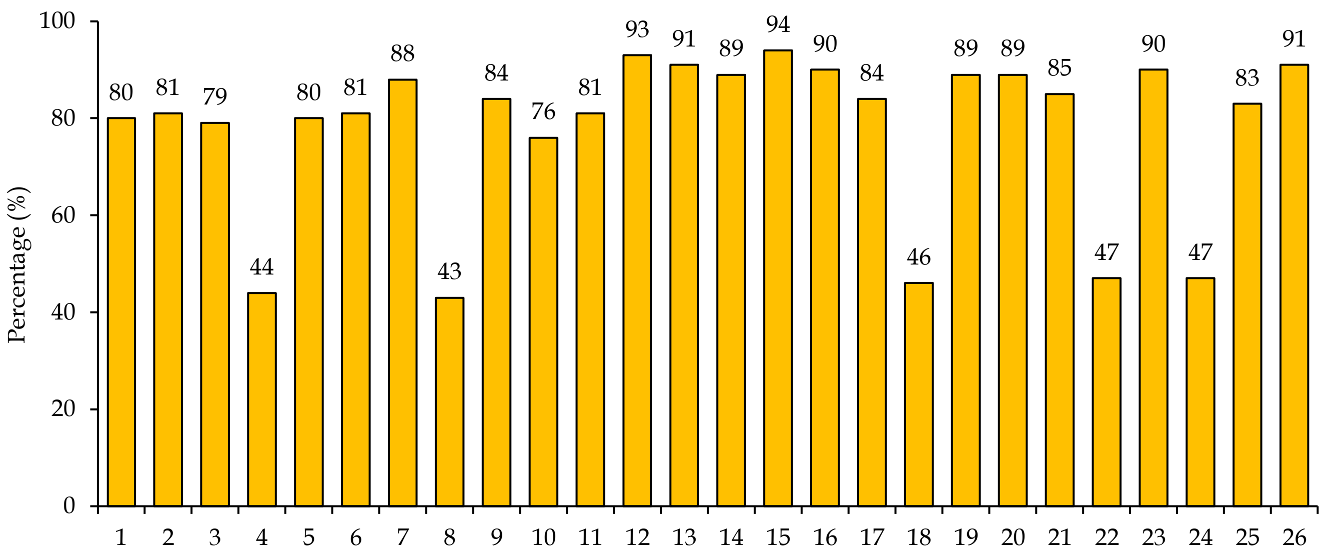

Figure 6. Single Student Normalized Gain in Experimental Class

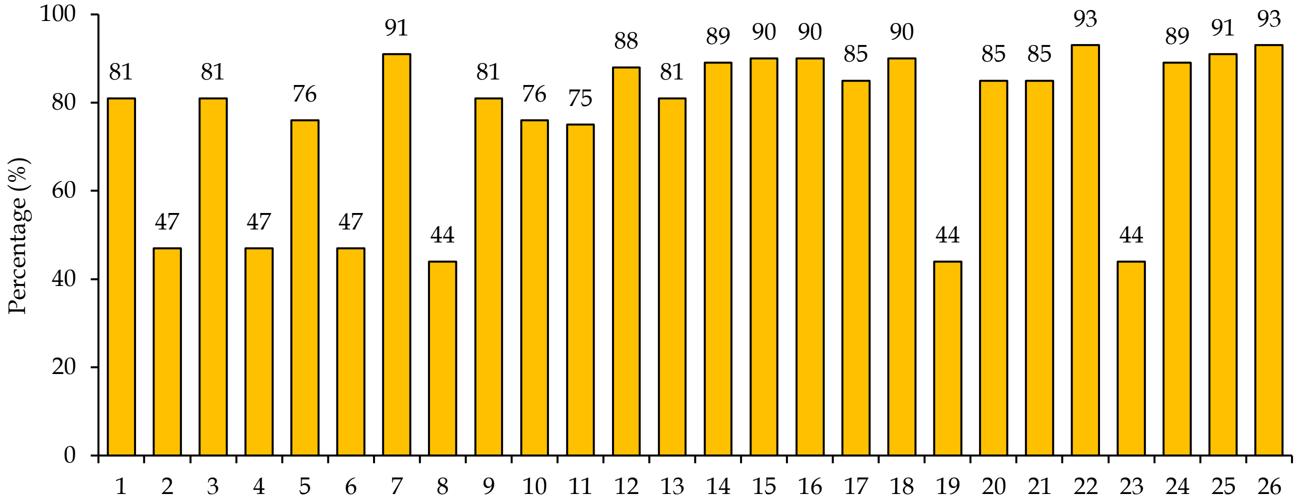

Figure 7. Single Student Normalized Gain in Replication 1

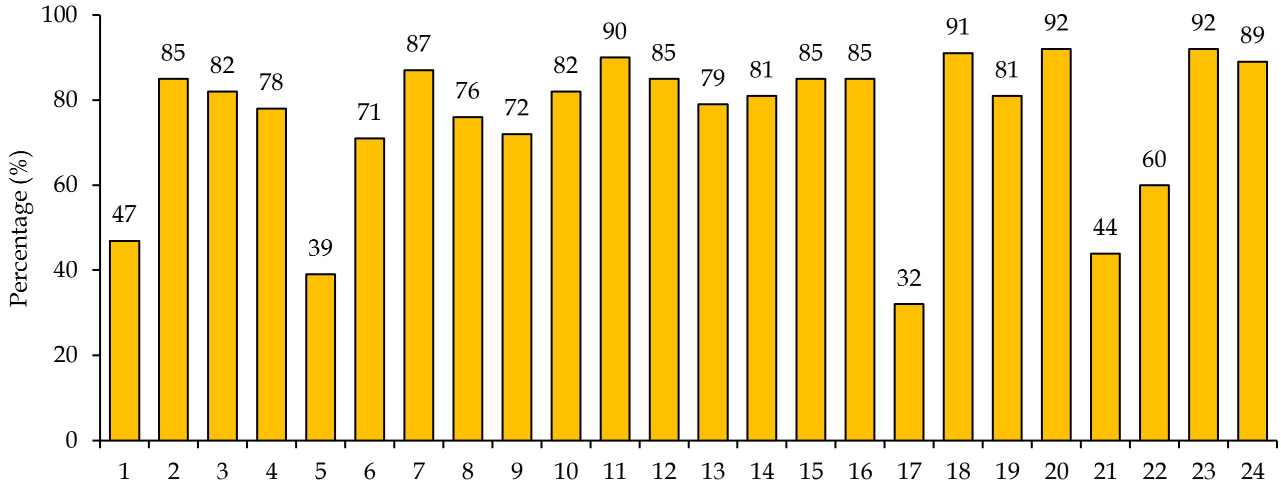

Figure 8. Single Student Normalized Gain in Replication 2

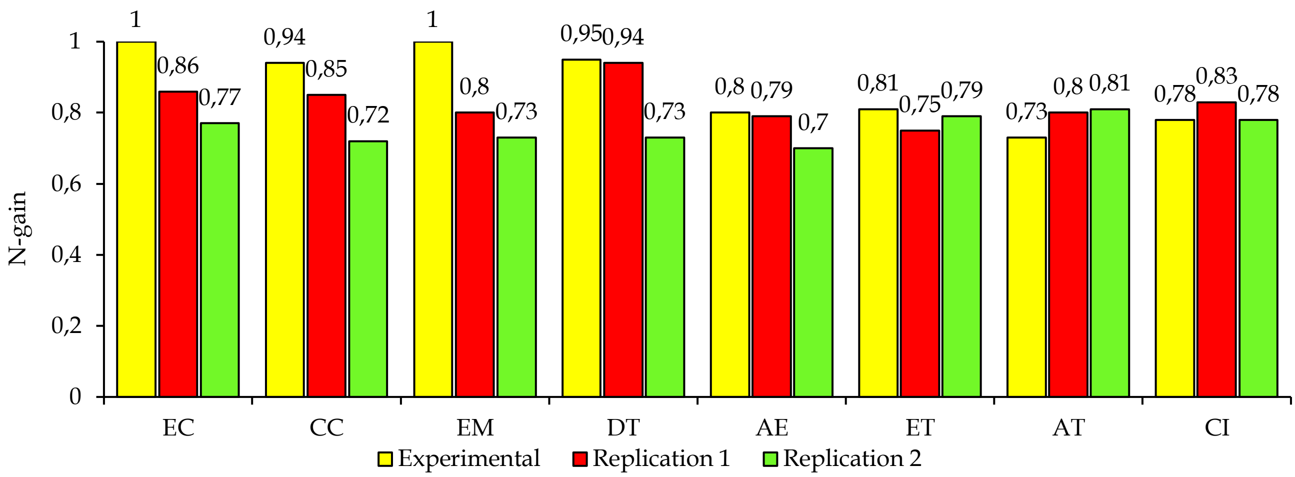

Figure 9. N-gain Analysis per Indicator

Based on Figure 6, each student in the experimental class shows an increase in understanding. This shows that the PBL model improves the learning outcomes of each student in the experimental class. Furthermore, the single student normalized gain for replication class 1 in Figure 7 also obtained more in the high category than the medium category. Based on Figure 7, each student in replication 1 shows an increase in understanding. After being given treatment, each student's learning outcomes increase. The PBL model improves each student's learning outcomes in replication 1. Then, as seen from the single student normalized gain in replication 2 in Figure 8, replication 2 also obtained higher categories than the current. Meanwhile, Figure 8 shows each student in the replication class shows an increase in understanding, and there are no students in the low category for all sample classes. This shows that the application of PBL model influences each student's learning outcomes.

The n-gain analysis per indicator aims to determine whether students' conceptual understanding of each indicator in the temperature and heat concept has increased. The n-gain analysis uses several indicators, including: explaining the concept of temperature in everyday life (EC); calculating temperature conversions on a thermometer scale (CC); explaining the meaning of heat in everyday life (EM); differentiating between temperature and heat (DT); analyzing the effect of heat on temperature changes (AE); explain heat transfer by convection, conduction, and radiation (ET); apply heat transfer in everyday life (AT); and classify insulators and conductors (CI). The results of the n-gain analysis per indicator can be seen in Figure 8. Meanwhile, Figure 9 shows an increase in understanding per indicator. Students have gained new understanding or strengthened previous understanding, meaning that the PBL model influences the learning outcomes of class VII students on temperature and heat concepts.

Discussion

The research was carried out using the PBL model on temperature and heat concepts in class VII, which was carried out at MTs Al-khairaat Kwandang. This research took class VII as the subject population. Then, the sample consisted of 3 classes: class VII-B as the Experiment class, class VII-A as the Replication 1 class, and class VII-C as the replication class 2. The replication class in experimental research aims to obtain strong and accurate research results that were not obtained by chance (Fatmawati & Shofiyah, 2022). According to Sudjana (1998), replication is repeating an experiment to produce better estimates and see the consistency of the results. This research aims to know how to apply the PBL model influences student learning outcomes. The PBL model aims to enable students to acquire and form knowledge.

The PBL model used in this research consists of five phases: orienting students to the problem. During this phase, there is an improvement because the researcher introduces concepts using familiar, everyday language that students can easily understand. The researcher organizes students into small groups and assists them in identifying tasks related to the problem. During individual and group investigations, the researcher guides students through experiments and helps them answer the questions. There is further improvement in developing and presenting results and analyzing and evaluating the problem-solving process as the researcher provides evaluations in clear and comprehensible language. This approach aligns with previous research conducted by Adjilahu et al. (2021) that using the PBL model can improve learning outcomes, where students learn through problems they often encounter daily. This is supported by research of Desni et al. (2019) that in PBL activities, the teacher presents a problem that can challenge students' thinking abilities to be able to solve it, so with this stage, students tend to feel challenged to solve the problem given by the teacher.

Based on the percentage of cognitive achievements in the experimental class, replication 1 and replication 2 regarding student learning outcomes obtained from the average posttest scores show that C2 has a higher percentage than C3 and C4. This is because students participate (actively) in the learning process by asking questions when they don't know each other and the teacher. Of the four questions in criterion C2, students are more dominant in answering questions 1 and 5 because questions 1 and 5 are relatively easy. Namely, understanding temperature and heat in everyday life and distinguishing between temperature and heat so that students understand more when explaining the concept of temperature in everyday life and distinguishing between temperature and heat. The score that tends to be low is C4 (Analyzing), which is found in questions number 6, 7, and 10. This is because students need to improve at analyzing the questions so the answers to these questions could be more optimal. The calculated results revealed that the data indicated significant improvements: the posttest percentage for the experimental class was 85.49%, compared to the pretest percentage of 36.04%. Similarly, replication class 1 had a posttest percentage of 84.18%, up from 34.95% in the pretest, and replication class 2 showed a posttest percentage of 82.92%, compared to 32.56% in the pretest. These results demonstrate enhanced learning outcomes in temperature and heat concepts after implementing the PBL model. This aligns with research by Supartin et al. (2022), which states that the PBL model is alternative and creative learning that can improve student learning outcomes. This is supported by research by Gulo (2022), that in the learning process using the PBL model, students become more active and feel interested in learning, generating interest, attention, and participation and encouraging students to solve problems, which can improve student learning outcomes.

The PBL model enables students to learn actively and develop their knowledge to improve student learning outcomes in temperature and heat concepts. This learning can solve problems related to everyday life so that students can link their initial knowledge with the lessons they learn in class. This aligns with research by Nuzula & Sudibyo (2022), which found that the PBL model can encourage students to critically explore contextual questions related to scientific concepts to solve problems. The results of the analysis of learning implementation support this. At the first meeting, the researcher was still hampered by the uncontrolled classroom conditions and was still in the adjustment stage. Meanwhile, the results were very good at the second, third, and fourth meetings because the researcher always corrected the deficiencies at each meeting during the learning process. It was carried out well at the second, third, and fourth meetings with a 95 - 100% percentage.

Data analysis in this study carried out several tests, namely the normality test, hypothesis test, and n-gain test for each class, including experimental class, replication 1, and replication 2. To test the normality of data for the experimental class, replication 1 and 2 used statistical goodness-of-fit tests. Using the Kolmogorov-Smirnov test statistics as described in Chapter III and conducted with Microsoft Excel (as shown in the attachment), it is evident that the normality test for the experimental class, replication 1, and replication 2 indicates a normal distribution. Subsequently, statistical testing using the t-test in Table 3 shows that T_{count} is greater than or equal to T_{table} at a significance level of $\propto = 0.05$ for the experimental class, replication 1 and replication 2. Therefore, it can be concluded that H_o is rejected and H_a is accepted. Hypothesis testing concludes that the PBL model positively impacts student learning outcomes in temperature and heat concepts. According to the n-gain table, the experimental class and replications 1 and 2 fall into the high category. This indicates an improvement in student learning outcomes using the PBL model. This finding aligns with Gulo (2022), who reported that the PBL model enhances junior high school science learning outcomes. Additionally, Sutrisna & Sasmita (2022) found that students using the PBL model achieve higher average scores, confirming that apply the PBL learning model influences student learning outcomes.

The advantage of the PBL model proposed by Rerung et al. (2017) is that it can increase learning activities and help students understand relevant problems in everyday life. Lestari (2018) states that PBL has several advantages, including its ability to increase focus on relevant knowledge, stimulate thinking, build group work, motivate students, and help students understand the essence of learning as a way of thinking, not just understanding.

Conclusion

Based on the research results, application of the PBL model significantly influences student learning outcomes in temperature and heat concepts at MTs Al-Khairaat Kwandang in both the experimental and replication classes. This is evidenced by the hypothesis testing criteria, where Tcount is greater than or equal to Ttable at a significance level of $\propto = 0.05$ for the experimental class, replication 1, and replication 2, leading to the rejection of H0 and the acceptance of Ha. Additionally, the normalized gain for all sample classes, both experimental and replication, falls in the high category, with values of 0.78 for the experimental class, 0.76 for replication 1, and 0.75 for replication 2. Application of the PBL model effectively enhances student learning outcomes in temperature and heat concepts at MTs Al-Khairaat Kwandang.

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Author Contributions

Andini Pratiwi M. Mahmud: Conceptualization, methodology; Muhammad Yusuf: Writing—original draft preparation; Tirtawaty Abdjul: Validation; Masrid Pikoli: Methodology; Nova Elysia Ntobuo: Curation; Dewi Diana Paramata: Writing—review and editing, formal analysis.

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Conflicts of Interest

The authors declare no conflict of interest.

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