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Analisis Kemampuan Hasil Belajar Siswa SMP pada Konsep Kalor dan Perubahannya

(Analysis of Junior High School Students' Learning Outcomes on the Concept of Heat and Its Changes)

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ABSTRACT. Students' learning outcomes in the topic of heat and its changes are often limited by difficulties in understanding and analyzing thermal concepts. This study aims to explore students' learning outcomes based on four cognitive indicators: remembering (C1), understanding (C2), applying (C3), and analyzing (C4), as well as to identify individual student performance through two rounds of testing. This research used a descriptive, quantitative approach with 30 seventh-grade students, from whom six were selected as subjects for deeper analysis. Data were obtained through written tests administered twice and analyzed descriptively. The results showed that students achieved excellent performance on the remembering indicator (95%) and good-to-excellent performance on the understanding (75%) and applying (80%) indicators. However, performance in the analyzing indicator remained low (60%), indicating that students' higher-order cognitive skills are not yet adequately developed. Individual analysis further showed that most students fell into the fair category. The novelty of this study lies in the combined use of indicator-based and individual learning-outcome analyses with repeated measurements, which allow a clearer picture of students' cognitive strengths and weaknesses. Overall, these findings highlight the need for learning strategies that promote analytical thinking to improve student outcomes in the topic of heat and its changes.

INTRODUCTION

Science Education at the basic education level plays a strategic role in developing students' abilities to understand natural phenomena, reason, and make evidence-based decisions. The national curriculum emphasizes that science learning must develop students' scientific process skills, conceptual understanding, and problem-solving abilities as the foundation of scientific literacy [1]. In the context of 21st-century education, students are expected not only to master factual knowledge but also to possess critical thinking skills, creativity, communication and collaboration abilities, as well as technological literacy that are essential for responding to rapid developments in science and technology [2], [3]. Therefore, science learning needs to be designed meaningfully to cultivate strong conceptual understanding and higher-order cognitive skills.

One of the essential topics in physics learning at the junior high school level is the concept of heat and its changes. This topic forms the foundation for students' understanding of thermal phenomena, heat transfer, changes of state, and other everyday energy-related processes. However, previous studies indicate that the concept of heat is one of the topics that often leads to misconceptions, such as students' belief that heat and temperature are the same concept, difficulties distinguishing mechanisms of heat transfer, and challenges in applying equations such as $Q = m \cdot c \cdot \Delta T$ and latent heat correctly [4], [5]. These misconceptions hinder students' understanding of questions that require analytical thinking and proper conceptual application. This situation highlights the need for learning approaches and evaluation strategies that emphasize conceptual understanding rather than rote memorization of formulas.

The urgency of this issue is reinforced by preliminary interviews with the seventh-grade physics teacher at SMP Negeri 1 Kota Ternate. The interviews revealed that students' learning outcomes in heat were relatively low, as reflected in test scores that generally did not meet the school's minimum mastery criteria (KKM) of 70%. Furthermore, most students were only able to answer low-level cognitive questions, particularly those involving remembering (C1) and understanding (C2), but encountered significant difficulties in answering questions that required applying (C3) and analyzing (C4). These challenges became evident when students were asked to compare different heat transfer events, interpret graphs of temperature changes over time, or explain changes of

state based on energy input or release. Students also struggled to understand basic heat equations, particularly in determining changes in temperature, mass, specific heat, and latent heat. Classroom observations showed that learning was still dominated by lecture-based instruction, leading to passive student engagement and minimal experimentation or analytical discussion. Such limited learning experiences constrain the development of students' critical thinking skills and higher-order cognitive abilities.

Previous research has primarily focused on implementing specific learning models to improve students' learning outcomes and critical thinking skills. For example, Al-Fikry et al. reported that Problem-Based Learning significantly improved students' critical thinking skills in the topic of heat [6]. Hatina et al. also found that students' critical thinking abilities improved after being exposed to appropriate instructional strategies on heat and heat transfer [7]. Other studies reveal that misconceptions and students' difficulties in solving contextual questions contribute to low learning outcomes in heat-related topics [8]. Priyadi et al. emphasized that students' limited analytical skills stem from inadequate conceptual mastery and insufficient practice with analytical problem types [9]. Although these studies provide insights into the importance of developing higher-order thinking abilities, several research gaps remain unaddressed.

The gaps identified include the following. First, the majority of studies focus on implementing learning models, whereas only a limited number specifically analyze students' learning outcomes based on cognitive indicators (C1–C4) in the topic of heat. Second, very few studies have been conducted in the local context of SMP Negeri 1 Kota Ternate, particularly those employing two rounds of testing (temporal triangulation) to observe consistency and changes in students' performance. Third, individual analysis of each student's learning outcomes is rarely conducted, even though such analysis is vital for identifying the unique difficulties each learner faces. Fourth, no previous research has combined indicator-based analysis and individual analysis, resulting in an incomplete picture of students' learning abilities. Therefore, this study aims to fill these gaps by providing a more detailed and comprehensive analysis.

The novelty of this research lies in several aspects. This study does not merely assess general learning outcomes but adopts a two-dimensional analytical approach: analysis based on cognitive indicators (C1–C4) and analysis of individual student performance. This dual approach allows for a more detailed identification of each student's strengths and weaknesses in learning the concept of heat. Moreover, this study employs two separate tests administered at different times to observe trends of improvement, decline, or stability in students' performance. Conducting the study specifically at SMP Negeri 1 Kota Ternate also contributes to its novelty, as limited research has examined learning outcomes on the topic of heat in this particular school context.

Based on the aforementioned background, the research problem is formulated as follows: (1) How are the learning outcomes of junior high school students in the topic of heat and its changes based on the cognitive indicators of remembering (C1), understanding (C2), applying (C3), and analyzing (C4)?; (2) How are the individual learning outcomes of students based on the two tests administered?; and (3) What factors contribute to students' low performance on specific cognitive indicators?

This study aims to: (1) analyze students' learning outcomes based on the four cognitive indicators (C1–C4) in the topic of heat and its changes; (2) describe the individual learning performance of students through two rounds of testing; and (3) identify the factors contributing to students' difficulties in understanding and applying the concept of heat. Theoretically, the study is expected to contribute to the literature on students' cognitive abilities in learning fundamental physics concepts. Practically, the findings can serve as a reference for teachers in improving instructional strategies, designing indicator-aligned test questions, and enhancing the quality of assessment in the topic of heat and its changes. The scope of this study is limited to the topic of heat and its changes in seventh-grade classes, focusing on the four cognitive indicators of Bloom's revised taxonomy and conducting an in-depth analysis of six selected students as research subjects.

RESEARCH METHODS

This study employed a descriptive research approach supported by quantitative data, which aims to describe students' learning outcomes as they naturally occur in the actual learning environment [Sugiyono, 2017]. This approach was selected because the research focuses on mapping students' cognitive abilities based on the indicators of remembering (C1), understanding (C2), applying (C3), and analyzing (C4), without providing specific interventions.

The population of this study consisted of all seventh-grade students of SMP Negeri 1 Kota Ternate, totaling 210 students distributed across seven classes. The sampling technique used was purposive sampling, in which the

selection of the class was based on the physics teacher's considerations regarding time availability, class characteristics, and alignment with the research objectives. Based on these considerations, class VII-E consisting of 30 students was selected as the primary sample. However, since this study emphasizes in-depth qualitative analysis, six students were chosen as research subjects. The selection of the six subjects was based on variations in academic performance (high, medium, low) and teacher recommendations to obtain a more representative depiction of students' cognitive abilities.

Data were collected through three techniques: observation, interviews, and tests. Observation was conducted to examine the learning process, student participation, and classroom interactions related to the topic of heat. Interviews were conducted with the physics teacher and several students to obtain additional information regarding learning difficulties, conceptual understanding, and factors influencing students' learning outcomes. A written test was administered to measure students' cognitive abilities on the topic of heat and its changes. The test was conducted twice and consisted of items aligned with cognitive indicators C1–C4.

The test results were analyzed using descriptive analysis techniques to obtain the mean scores, percentage achievements, and learning outcome categories for each indicator. Additionally, an individual analysis was performed for each of the six students to identify their progress, patterns of errors, and consistency of responses across the two test administrations. The findings from the test, interview, and observation data were then integrated to produce a comprehensive description of students' learning outcomes.

$$Percentage\ (\%) = \frac{Total\ Score\ Obtained}{Maximum\ Possible\ Score} \times 100\% \quad (1)$$

The guidelines for determining the categories of students' learning achievement levels are presented in Table 1, which shows the percentage categories of learning achievement [14].

Table 1. Percentage Categories of Learning Achievement Ability

Percentage (%)	Category
86-100	Excellent
75-85	Good
60-74	Fair
55-59	Poor
0-54	Very Poor

RESULTS AND DISCUSSION

This study was conducted at SMP Negeri 1 Kota Ternate, involving 30 students of class VII E, with 6 students selected as subjects. The research data were obtained from written tests administered during two separate sessions (triangulation) at different times. This was done to examine the students' learning achievement. The data from this study were then analyzed descriptively as follows:

Data Analysis of Students' Learning Achievement Ability per Indicator in General

Indicator: Remembering (C1)

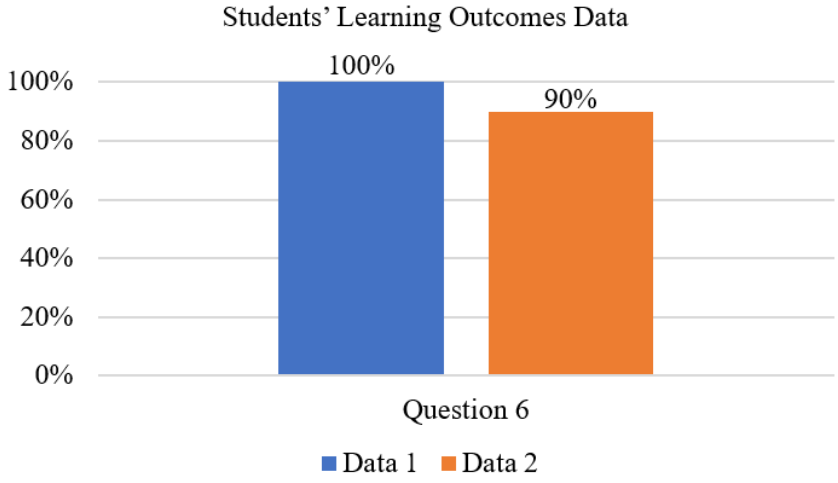

Figure 1. Graph of Students' Learning Outcomes on the C1 Indicator

Based on the students' learning outcomes data for the remembering indicator (C1) as shown in Figure 1, Question 6 indicates that in the first treatment, the percentage of mastery reached 100%, which falls into the excellent category. In the second treatment, the percentage decreased to 90%, categorized as good. The average score of both treatments was 95%, which is classified as excellent. This shows that the students' remembering ability remained at an excellent level, although there was a slight decrease in the second treatment. This decline may have been caused by students' concentration during the second test or a slight difference in the level of difficulty of the item. Nevertheless, the results from both treatments indicate that the students demonstrated a very good understanding of the material in the remembering (C1) indicator.

Indicator: Understanding (C2)

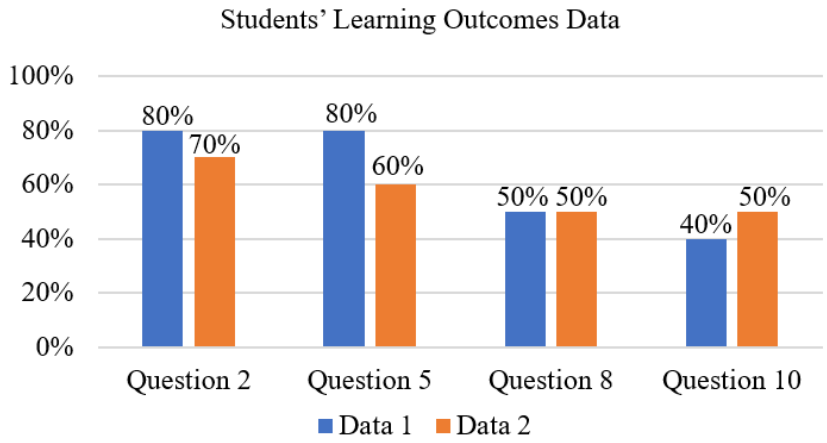

Figure 2. Graph of Students' Learning Outcomes on the C2 Indicator

The students' learning outcomes data for the understanding indicator (C2), as presented in Figure 2 and consisting of Questions 2, 5, 8, and 10, show that the average score in the first treatment was 63%, which falls into the fair category. Meanwhile, the average score in the second treatment was 58%, categorized as poor. This decline indicates that students' understanding of the material has not yet reached the expected level. The decrease may be influenced by factors such as limited conceptual comprehension, higher item complexity, or students' difficulty in relating concepts to real-life contexts. Therefore, additional reinforcement or alternative instructional strategies may be required to improve students' performance on the understanding (C2) indicator.

Indicator: Applying (C3)

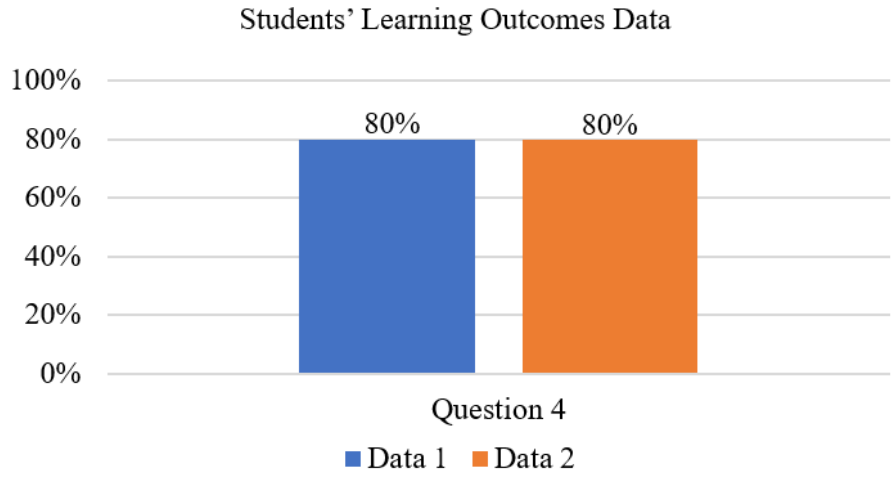

Figure 3. Graph of Students' Learning Outcomes on the C3 Indicator

As shown in Figure 3, which is based on Question 4, the average score for the applying indicator (C3) in the first treatment was 80%, classified as good. The second treatment also yielded the same score of 80%, which falls into the good category as well. These results indicate that students demonstrated consistent ability in applying the learned concepts during both test sessions. This also suggests that students were able to transfer their knowledge into the context of the task provided. However, this performance still has room for improvement to reach the excellent category through enhanced problem-solving activities and more varied practice opportunities.

Indicator: Analyzing (C4)

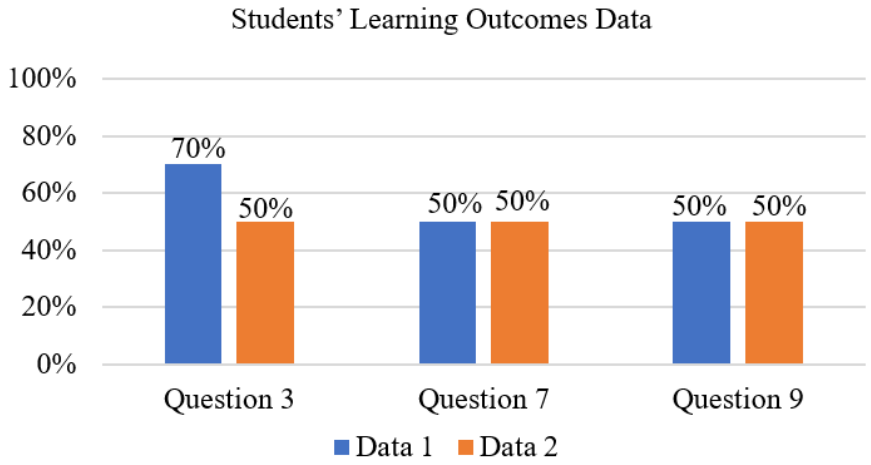

Figure 4. Graph of Students' Learning Outcomes on the C4 Indicator

Based on the students' learning outcomes for the analyzing indicator (C4) presented in Figure 4, the data were obtained from three test items, namely Question 3, Question 7, and Question 9. In the first treatment, the average achievement score reached 57%, which is categorized as poor. Meanwhile, in the second treatment, the average score was 50%, which still falls into the very poor category.

These results indicate that students' analytical abilities in understanding physics concepts have not yet developed optimally in both treatment stages. In addition, the decrease in the average percentage during the second treatment suggests that the intervention provided did not lead to a significant improvement in students' analytical skills. Therefore, a more effective instructional strategy is required to help students enhance their analytical competence.

Analysis of Students' Learning Outcomes Data

The learning outcome data collected from the six students who participated as research subjects are presented in Table 2 below.

Table 2. Analysis of Each Student's Learning Outcomes.

No	Name	Data 1	Data 2	Average	Category
1	AL	65	75	70	Good
2	NM	62,5	57,5	60	Fair
3	RZ	67,5	65	66,25	Fair
4	GL	72,5	63,8	68	Fair
5	PI	65	40	52,5	Poor
6	NL	67,5	62,5	65	Fair

Based on the results of the study conducted at SMP Negeri 1 Kota Ternate in the 2023–2024 academic year regarding students' learning outcomes on the topic of heat and its changes, it was found that performance on the remembering indicator (C1) was categorized as high. This is reflected in the increase in the percentage of correct responses from 60% to 70% between Test 1 and Test 2. This result indicates that students were able to recall and recognize the basic concepts they had learned.

For the understanding indicator (C2), an improvement was also observed, although it was not consistent across all assessed items. Some questions showed a decrease in performance, such as Question 5 (understanding the concept of conductors and insulators) and Question 8 (interpreting temperature change data). This suggests that students' conceptual understanding varied across subtopics.

The applying indicator (C3) was categorized as good, with an average score of 80%, and no decline or improvement was observed between both treatments. This result indicates that most students were able to apply the concept of phase change in real-life situations or new contexts. The applying level of cognitive ability is higher than understanding, as it involves the use of principles, laws, theories, and procedures in concrete situations [15].

Next, for the analyzing indicator (C4), a decline of 7% in the average score was observed. Analytical skills, which involve the ability to break down information, identify relationships between components, and evaluate the logical structure of a concept or procedure, were not yet well-developed based on the students' responses to

Questions 3, 7, and 9. Higher-level thinking at the analysis level requires a stronger emphasis on procedural knowledge in more complex contexts [16], [17]. Students' low analytical performance may be influenced by difficulties in interpreting problems, limited conceptual understanding, lack of practice in solving problems related to heat and temperature, and challenges in performing mathematical operations [18].

The analysis of individual learning outcomes showed that only one student achieved the Good category, while most students were in the Fair category and one student was classified as Poor. Overall, students' learning outcomes were in the Fair category. Although improvements were observed in some indicators, the increase was not substantial, indicating that higher-order thinking skills remain limited among students.

Errors in answering the questions may be attributed to several factors, including factual errors, conceptual errors, principle errors, and operational errors [19]. Additionally, learning activities that still rely heavily on lecture-based instruction result in limited student engagement in analytical tasks, thereby inhibiting the development of critical thinking skills. Therefore, it is necessary to implement more active learning strategies and conduct reflective activities at the end of learning sessions to support improvement in subsequent lessons.

Overall, the findings confirm that the students' performance remains concentrated at the lower cognitive levels (C1–C2), while higher-order cognitive skills (C3–C4) have not been optimally developed. This aligns with previous studies highlighting that limited analytical and applicative experiences in learning heat contribute to low student achievement [6], [7]. Therefore, There is a need for instructional strategies that emphasize learning activities which challenge students to reason, analyze, and apply concepts in various contexts through experiments, discussions, and problem-solving based tasks.

CONCLUSION

Based on the analysis of students' learning abilities on the topic of heat, it was found that the achievement levels for each cognitive indicator varied across categories. For the remembering indicator (C1), the students obtained an average score of 95%, categorized as very good. For the understanding indicator (C2), the average score was 75%, categorized as good. Next, for the applying indicator (C3), the average score reached 80%, categorized as very good. Meanwhile, for the analyzing indicator (C4), the average score was only 60%, which falls into the sufficient category. In addition, the analysis of individual student abilities indicated that most students were in the sufficient category.

Overall, the results of this study show that students are able to master lower- to mid-level cognitive aspects well, particularly in remembering, understanding, and applying the concepts of heat and its changes. However, their analytical ability has not yet developed optimally. This condition indicates the need for the implementation of learning strategies that focus more on improving higher-order thinking skills, especially in analyzing scientific information within the context of heat and its changes.

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