Improving conceptual understanding on temperature and heat through modeling instruction

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Abstract. Although conceptual understanding is one of the goals of learning physics and influencing other thinking skills, many students have difficulty in understanding physics concepts. This study aims to determine the increase of students’ conceptual understanding through Modeling Instruction in Temperature and Heat. The subjects of this study were 63 students of SMAN 5 Jambi in class XI-science. The research design uses one group pretest-posttest design that is analyzed quantitatively. Data obtained from the pretest and posttest values which are then presented in the form of percentages and statistics. Quantitative data were analyzed by determining descriptive statistics, paired sample t tests, then continued the N-gain test and effect size. The qualitative data analysis is done by reducing data, presenting data, and drawing conclusions. The results showed that there was an increase of 0.397 (medium) in the posttest value. The influence of modeling instruction on increasing students' concept mastery is seen from the d-effect size of 4.814 (high). The results of this study suggest that teachers should teach with Modeling Instruction on the topic of Temperature and Heat. On the other hand, based on the results of the interview, students still have difficulty in understanding fundamental concepts and understanding concepts in various representations.

1. Introduction

The achievement of a good understanding of the concept by students is one of the goals of physics learning that needs to be achieved in learning [1]. A broad and deep understanding of concepts must be achieved in learning. Many researchers have revealed the level students’ conceptual understanding on several topics. Students are expected to be able to understand concepts in depth and then use them to solve problems [2–4]. In contrast to the findings by researchers, students actually have difficulty in understanding the concepts of physics. One of the causes of these difficulties is due to abstract physics topics. Students have difficulty imagining the concepts they are learning. Abstract physics concepts will be more difficult for students to understand. Not only that, abstract physics concepts are also more difficult to teach. Teachers also prefer to deliver physics directly through conventional learning because it is easier and faster. This causes students to memorize formulas more often without understanding the concepts. In addition, student knowledge tends to be incoherent so it is difficult to understand the concept of physics as a whole [3,5].

One of the concepts of physics that is abstract and has a wide scope is temperature and heat. Students have a low conceptual understanding on the topic of temperature and heat [6]. Some difficulties, for example, in understanding the concepts of thermodynamics [7], azas Black [8], distinguishing between
temperature and heat [9], and so on. To overcome these problems, meaningful learning is needed [10]. One meaningful learning model that can be used in physics learning is Modeling Instruction.

Modeling Instruction is one of the learning models that can be applied in science learning. Modeling Instruction emphasizes the construction of conceptual models that centralizes the learning and understanding of science [11]. If viewed from the pedagogical function, Modeling Instruction is useful to build a complete understanding of students about nature through models specifically [12,13]. Research on Modeling Instruction has been done a lot before. From several studies conducted, Modeling Instruction has been proven to be able to increase students conceptual understanding [14,15], increase student learning efforts [16], make concepts easier to understand [17], effectively applied in physics learning [18], provide opportunities for students to develop physics concept models and invite students to practice more [19], and improve students' problem solving abilities [20,21].

During this time, research in the field of education that implements Modeling Instruction is still largely focused on the topic of Mechanics [22,23]. Although several studies have been carried out on other topics, they are not as broad as the topic of Mechanics. Modeling instruction is still rarely used on the topic of Temperature and Heat, especially in Indonesia. Modeling instruction is suitable to be applied to improve concept understanding on the topic of Temperature and Heat because it emphasizes the coherence between concepts [17]. Consideration of the effectiveness of time and the achievement of learning materials with Modeling Instruction can be maximized [15]. Therefore this article is focused on discussing the effectiveness of Modeling Instruction in improving students' understanding of concepts on the topic of Temperature and Heat.

2. Methods
This research is a mixed method research. The design used in this study is embedded experimental design. The type of experiment used is one group pretest-posttest design. The data obtained are qualitative and quantitative data. Qualitative data is used as supporting quantitative data. The study was conducted at SMAN 5 Jambi. The population in this study were all students of class XI-Science, namely 239 students (7 classes). The sample in this study was 63 students (2 classes).

This study aims to determine the effectiveness of Modeling Instruction in improving students' understanding of the Temperature and Heat concepts. To achieve this goal 22 reasoned multiple choice questions were used. The questions used have met the eligibility requirements, which are valid and reliable. The choice of students' answers in answering these questions is a source of quantitative data while the reason students are a source of qualitative data. Interviews were then conducted with 11 students to support deeper findings.

Quantitative data analysis is performed by determining descriptive statistics such as averages, medians, standard deviations, and skewness. Based on the results of the normality test showed that the data of the pretest and posttest groups were normally distributed so that to test the effectiveness of the Modeling Instruction was carried out with a different test namely paired sample t-test. To see how much increased understanding of students' concepts from pretest to posttest, the N-gain score was calculated. To determine the strength of the difference between pretest and posttest scores is determined by calculating the d-effect size. The qualitative data analysis is done by reducing data, presenting data, and drawing conclusions.

3. Results and Discussion
3.1. Learning process
Modeling instruction consists of the process of modeling and acquiring coordinated modeling skills. The stages of this process are the development model and the deployment model [24]. The first stage that carried out in learning activities is the development model. This stage begins with demonstrations and class discussions aimed at establishing a general understanding of the question. In this stage, students are grouped, then collaborate in planning and conducting experiments. Students present conclusions in oral and written form regarding the formulation of the model for the phenomenon in
question and the evaluation of the model by comparison of data. The teacher introduces technical and representation tools to sharpen the model, facilitate modeling activities, and improve the quality of discourse. The teacher guides the investigation and discussion with various questions and comments.

Examples of the modeling cycle of model development (Lab paradigm) are with pre-lab discussions, lab investigations, and post-lab discussions. Pre-lab discussion is the student observes and the teacher guides the student to investigate to determine the physical phenomenon and determine the mathematical model of the phenomenon. The investigation lab is students collecting data and displaying the results on the board and preparing presentations. Post-Lab Discussion: Students present the results of laboratory investigations to the whole class and the teacher leads the discussion after all lab groups are presented.

The second stage is the deployment model. In this second stage, students apply the models they find to new situations to deepen and perfect their understanding. Students work on a worksheet with a group of friends, then present the results in front of the class.

Examples of the modeling cycle of a deployment model are worksheets, quizzes, Lab practices and unit tests. In the worksheet, students complete worksheets that contain the application of the models they find to new situations with the group. The use of worksheets aims to guide students so that they can learn actively [25]. Then prepare a presentation and present it in class. After that the teacher continues to ask students to find out the extent of students' knowledge and understanding, and correct if there are misconceptions. Quizzes are conducted by giving questions to each student. Students do not only answer questions with the final result, but must provide reasons appropriately. However, the ability to provide arguments will indicate a good understanding of physics concepts [26]. Lab Practicum is a teacher asking students to complete a Lab practicum and students work in groups until reaching an agreement on the solution, then testing the solution. Unit tests are students taking unit tests where students are asked to incorporate previously developed models into their problem solving.

Students must be involved in discussions and arguments to produce revisions to their explanations. Modeling Instruction focuses on helping students build appropriate models to explain phenomena. When students correctly identify the physical system, draw a diagram, and apply the model to the situation they are learning, then over time the students' misconceptions will disappear. In Modeling Instruction, students are more active in constructing their knowledge, unlike conventional learning which tends to be 'teacher-centered' [27]. Therefore, in learning science, especially physics, Modeling Instruction is more recommended to be implemented in class compared to conventional learning.

3.2. Improved Students' Conceptual Understanding of Temperature and Heat

Students' conceptual Understanding on the topic of Temperature and Heat is first seen based on descriptive statistical data. The data is as shown in Table 1.

| Table 1. Descriptive Statistics Data |
|-------------------------------------|
| Pretest                             |
| Mean                                | 53.19 |
| Median                              | 50.00 |
| Mode                                | 50.00 |
| Standard Deviation                  | 4.71  |
| Skewness                            | 0.187 |
| Post Test                           |
| Mean                                | 74.14 |
| Median                              | 68.75 |
| Mode                                | 68.75 |
| Standard Deviation                  | 4.91  |
| Skewness                            | 0.113 |

Based on Table 1, it can be seen that students' understanding of concepts has increased, namely 53.19 in the pretest to 74.14 in the post test. This shows that the understanding of students' concepts for the better. To see the significance of the difference, the Paired T-Sample Test was performed. The test is carried out because the data is normally distributed based on the results of the normality test. Based on the test results obtained $t = 68.142$ and Sig. (2-tailed) = 0.000 so that it can be concluded that there is a significant difference between the pretest and post test scores.

To see how much increased understanding of students' concepts on the topic of Temperature and Heat, the N-Gain value was determined. Based on calculations obtained N-Gain = 0.397. This shows
that increased understanding of students' concepts in the medium category [28]. The magnitude of the effect of Modeling Instruction learning in increasing understanding of the concept can be seen from the d-effect size score. The calculation results show that the d-effect size is 4.814. This shows that Modeling Instruction has a great influence on improving students' understanding of concepts. The results of this study contribute to the effectiveness of Modeling Instruction on increasing students' understanding of concepts, especially on the topic of Temperature and Heat. These results are supported by the research of Yaumi, et al [14] who showed that Modeling Instruction improves understanding of the concept of the Kinetic Gas Theory.

Improved understanding of students' concepts after learning with Modeling Instruction because students learn through scientific approaches. The scientific approach has been proven to be able to construct concepts in students better. On the other hand, in learning this Modeling Instruction students also learn collaboratively in planning and conducting experiments. This is useful for building the ability of students to coordinate and communicate. Modeling Instruction has a big impact on improving students' ability to communicate and coordinate because it involves learning in groups [29]. Modeling Instruction not only improves communication skills but also improves students' argumentation skills. This certainly has an impact on students' understanding of concepts that are getting stronger because students with good argumentation skills have a good understanding of concepts too [30].

Although the students' understanding of the concepts has increased, but still found some difficulties in students based on the results of the interview. Students still have difficulty in explaining fundamental concepts in various representations. This often happens, even a senior teacher also has difficulty in teaching fundamental concepts to students [31]. In this case, further research needs to be done on how Modeling Instruction is integrated with Multi Representation learning so that students have a more comprehensive understanding of concepts.

4. Conclusion
Modeling Instruction can improve students' understanding of concepts on the topic of Temperature and Heat. This is indicated by an increase in student scores and based on the results of paired t-sample tests. Improved student scores in the medium category based on N-gain values. Modeling Instruction has a strong influence on increasing the score of students' understanding of concepts based on the value of the d-effect size. On the other hand, the interview results still show that students still have difficulty in understanding the fundamental concepts and represent its in different representations.

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