Guided inquiry model with virtual labs to improve students’ understanding on heat concept

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Abstract: Inquiry-based learning is one of the pedagogical approaches to motivate students to solve problems. Laboratory activities are important for inquiry-based learning, but traditional laboratory activities have a disadvantage because they need high costs associated with the procurement of equipment, space, and maintenance staff. The virtual lab is an alternative to solve the problem. The purpose of this study was to test the effectiveness of inquiry models that aligned with the virtual laboratory in improving students’ understanding of the heat problem. This study included quasi-experimental with pretest and posttest control group design. The subjects were divided into two groups, the experimental group and the control group. Research data were analyzed by N-gain test. The results showed that the achievement of conceptual understanding of the experimental group was better than the control group. It can be concluded that the guided inquiry model with virtual laboratories is effective in improving students' understanding of the concept of heat. In general, the increase in the experimental group is higher than the control group, in both the cognitive aspect and sub-concept of heat.

1. Introduction
Learning is an activity where teachers and students interact with each other. Learning activities should be student-centered, so they will be able to construct knowledge, find a concept and make a conclusion through the teacher's direction. In fact, the subject of physics still has not emphasized the systematic way of finding out about nature, but by the process of transforming the teacher's knowledge directly to the students which called teacher-centered. This makes students understand partially what has been described and is unable to construct their knowledge.

Piaget states that knowledge could not simply be transferred, but must be constructed or at least to be interpreted by the students through experience [1]. In addition, the application of learning models and learning media that are still less precise causes students difficult to understand the existing concepts. This impact was on the low ability of students in understanding the concepts of physics, especially on the concept of heat. It is important for students to be involved in the process of understanding and mastering concepts.

One of the learning models that can help students in constructing their knowledge is guided inquiry model. Guided inquiry is a discovery-based model, where students act like scientists experimenting, collecting and analyzing data, formulating and evaluating hypotheses, and so on. Inquiry-based learning is a pedagogical approach in which students are motivated to ask their own questions when dealing with problems. Lederman, et al. [2] suggests that through this learning model, students perform scientific activities, such as skilled in observing, measuring, classifying, drawing conclusions, and communicating findings, so it can be concluded that inquiry learning model can improve student learning outcomes. In
addition, according to Jack [3], guided inquiry learning can assist students in developing individual responsibility and ability to understand concepts and solve problems. Student learning activities using guided inquiry model still require teacher direction, so the students are able to construct their knowledge through the inquiry stages well. In its application, guided inquiry model requires auxiliary media that can make students understand and construct their knowledge. One of the appropriate media is the use of virtual labs. A virtual lab utilizes computer technology as a tool to run it. The use of virtual labs is based on the concept of physics, especially on the concept of heat which has many abstract concepts and is difficult to visualize. In addition to the hardness concept characteristics that are difficult to visualize, Hermansyah, et al. [4] argued that the use of virtual labs also can overcome the problems of the lack of physics laboratory equipment, expensive equipment, or long experimental time.

The virtual laboratory is one of the important components of the learning system. Virtual labs are also a platform for delivering messages or information, generating motivation, student attention and producing memorable learning [5, 6, 7]. Computers can be used to support the implementation of physics labs so that computers can be used in the learning process [8]. A number of forms of interaction can be generated through computer media such as the presentation of practices and exercises, tutorials, games, simulations, inventions, and problem-solving [9]. The use of computer technology in its various forms in physics learning has also proven to increase curiosity and openness to new ideas [10]. In addition, Jimoyiannis [11] argues that virtual labs containing simulations can be used as an alternative learning media because they can help students construct conceptual understandings and overcome weaknesses in theoretical physics.

Several relevant studies show that the inquiry models proved to improve student learning [12, 13, 14]. In addition, Junaidi et al. [15] stated that the use of the virtual laboratory with a learning model can improve the understanding of the student in wave concept. Kusdiastuti, et al. [16] suggest that virtual labs which integrated with the learning model can improve the understanding of students' physics concepts. Hermansyah, et al. [17] also stated that the use of virtual laboratories in guided inquiry learning positively influences the understanding of student concepts. Because of that, the authors are interested in examining the effectiveness of guided inquiry model with virtual labs in improving student's understanding of heat concept.

2. Experimental Methods

This quasi-experimental research aims to examine the effectiveness of guided inquiry models with virtual labs on the understanding of students' concepts of heat. In this study, the independent variable is guided inquiry models with virtual labs and the dependent variable is the student's conceptual understanding. The study was conducted at one of the high schools in Mataram City in the academic year 2017/2018. The sampling technique uses cluster random sampling. The research respondents were 58 students divided into two groups, the experimental group and the control group.

This research used pre-test and post-test control group design. The experimental group did the learning by using guided inquiry model with the help of virtual labs, while the control group did the conventional learning. The data of conceptual understanding collected using the instrument of concept mastering in the form of 6 essay questions. Understanding of the concept in question is the concepts on the matter of heat. Substances to be studied are temperature, expansion, heat, change of substance, black principle, and heat transfer. The instrument of understanding of concepts follows the cognitive domain of Bloom's taxonomy revisions Andersoon which are: C1 (memorizing), C2 (comprehending), C3 (applying), C4 (analyzing), C5 (evaluating), and C6 (creating), so in this study will be discussed three data understanding of student concepts that are generally to the material of heat, based on each material concept, and based on the level of cognitive aspects.

Conceptual understanding data obtained before and after treatment. The data were analyzed using the N-gain score test to find out how much improvement the understanding of the concept of learners after being treated. The data obtained were interpreted with high category (N-gain > 70.0), medium (70.0 > N-gain ≥ 30.0), and low (N-gain <30.0) [18].
3. Result and Discussion

The improvement of conceptual understanding in this study was observed from the increase of score obtained by students between pretest and posttest of caloric material. The level of understanding of the concept of students is then analyzed according to matter characteristics and types of indicators of understanding of physics concepts on heat matter. Based on the research data, it was found that the experimental group experienced a higher increase with the gain score of N-gain 63.5 compared with the control group that got the score of N-gain 30.5. Nevertheless, the scores for both groups are still in the medium category.

Figure 1. Comparison Average Score of Student Concept Understanding

The improvement of conceptual understanding in the experimental group was higher than the control group. For more details, the average comparison of conceptual understanding was shown in Figure 1. This increase occurs because of the combination of guided inquiry model with virtual labs. This model had been able to construct students' knowledge. Scientific activities which conducted by using virtual labs on this research help students understand the concept of the heat through its visualization of abstract concepts.

The results showed that the guided inquiry model with virtual labs improves student's understanding of heat concept. According to Kusdiastuti, et al. [16], the inquiry models with virtual labs improved students' understanding of physics concepts. Hayati, et al. [19] and Nisrina, et al. [20] also shows that the use of guided inquiry model with interactive multimedia influenced the student's understanding of physics concepts. Gunawan et al. [21] reveal that virtual labs are an alternative to the limited equipment of physics experiments and help visualize abstract concepts. The development of technology information became a great opportunity for building and using the computer during the learning process. As a new innovation of the 21st century, computer simulation became an important function in laboratory experiments as a virtual form.

This study also reviewed the level of student's understanding in each of heat concept as shown in Figure 2. Student's understanding in the experimental group obtained the highest score on the concept of expansion and the lowest on the concept of heat transfer. The control group experienced the highest increase in the concept of temperature and lowest on the concept of heat transfer. Students' understanding in the experimental group is higher than the control group in almost all concepts except in temperature concept. This is because the students' ability to apply equations is still lacking in this concept. This is due to the lack of training, such as working on problems which similar to the test. In addition, the students' ability to convert temperature units still needs to be improved. Most students are not able to solve the problem with this concept.
Figure 2. Comparison of Student Improvement Each Concept

Based on Figure 3, the highest cognitive aspect improvement of both groups occurs on the understanding aspect and the lowest on creating aspect. Students' understanding in experimental group on each cognitive aspect is generally higher than the control group, except in creating aspect. This is because students do not understand the concept of phase change, which make students not be able to make a graph of the relationship between temperature and the amount of heat. Chu [22] stated that without proper treatment, the media can negatively impact students' learning outcomes. In his research, Chu [22] also found the learning outcomes of the control group were significantly better than the experimental group. Different results found by Imran, et al. [23] which states that the use of simulation positively affects the ability of students in solving the problem on phase change concept.

Figure 3. Comparison Improvement of Students’ Concept on Each Cognitive Aspect

Generally, the level of students' understanding in the experimental group is higher than the control group on the cognitive aspect and sub-concept of heat. Guided inquiry learning with virtual labs gives students the opportunity to construct their knowledge. Learning with virtual labs in this study was conducted in groups. According to Gunawan et al [24], the virtual laboratory used in cooperative learning was proved to help students become more creative. Nurhadisah et al. [25] stated that learning and work together in groups help students understand the concept better because each student has a responsibility in their groups. In addition, Gunawan et al. [26] reveal that virtual laboratory has a positive effect on student problem-solving ability. Students should be familiar with the virtual lab features, so they can learn regularly. This will make it easier to achieve goals. Students also become very motivated in solving various problems according to the concepts which have been learned.
4. Conclusion
Implementation of guided inquiry model with virtual labs in physics learning can improve students’ understanding on heat concept. The increase of students’ understanding in the experimental group is higher than the control group. Generally, the level of students’ understanding in the experimental group is higher than the control group on cognitive aspect and sub-concept of heat.

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