Implementation of levels of inquiry to improve sound wave concept mastery in junior high school

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Abstract. The low mastery of physics concept was caused by a lack of experimental abilities in the learning process. Levels of Inquiry (LoI) is an appropriate step for develop experimental abilities because it has a systematic, structured stages, and it can flexibly applied to the various dominancy of students and teachers role according to conditions. This study was conducted to observe students sound wave concept mastery improvements after the implementation of LoI in learning. The study used one group pretest-posttest design, which involved 152 students in one of public junior high school in Bandung. Instrument used in this study was descriptive concept mastery test. Data were analyzed using t-test and normalized gain to determine the improvement of student’s mastery concept. The results showed that students sound wave concept mastery improvement was improved by Levels of Inquiry in overall (\( <g> = 0.38 \)). The results also included detailed analysis of student’s concept mastery development by general, each cognitive aspect and each sub matters of lesson. Based on the results, Levels of Inquiry (LoI) implementations can improve the student’s concept mastery on sound wave.

1. Introduction

Science learning essentially consists of processes and products [1]. The process of learning science is seen as important as an opportunity to provide meaningful experiences for students to have ways to build knowledge, skills, abilities or other competencies that are considered important [2-3]. Experiment activities in the learning process of science, especially physics cannot be separated because it can train students in ways of thinking and how to work [4].

The ability to experiment can be said to be a combination of knowledge and skills to build an important process in a scientific investigation [5]. Through experiential learning, students will have the ability to investigate and uncover basic concepts that can be developed to solve problems [6]. In order for students to solve problems in studying science especially physics, it is very important for students to master the basic concepts of physics in depth [7]. So, there is a connection between the ability to experiment with the mastery of concepts that are possessed by students.

Previous studies have been conducted to determine the profile of the ability to experiment and mastery of student concepts. One of them is the result of research of Imansyah et al. which states that the ability to experiment which is owned by students in one junior high school in the city of Bandung is still relatively low in terms of making predictions, knowing variables, designing experimental activities, processing data, and concluding experimental results [8]. In addition, the results of other studies suggest that mastering the concept of junior high school students on the topic of vibration, waves and sound is still in the low category, namely 35% of students can understand wave motion and 12.5% of students can apply the concept to determine wave length and propagation [9].
The results of preliminary study with the method of observation and interviews conducted in one of the state secondary school in the city of Bandung shows that the learning process of science has not been optimally trained the ability to experiment. Based on the results of interviews with one science teacher at a state school in the city of Bandung, for class VIII expressed that during one semester held only two experiments. The experiments conducted are still verification and the practice manual used in the experiment is still a recipe book. This is evident from the characteristics of the practice manual where students only fill in the worksheets that have been listed the list of tools and materials, experimental procedures, as well as data tables required. The explanation indicates that the science learning process that has not provided sufficient experimental experience, so that the impact on the low mastery of student concepts.

In connection with the problems and results of the preliminary study above, an appropriate solution is needed to support students in gaining the ability to experiment and mastering good concepts. Levels of Inquiry (LoI) learning model developed by Wenning offers answers to problems in training the ability to experiment and build mastery of concepts [10]. The stages in the Level of Inquiry (LoI) include discovery learning, interactive demonstration, inquiry lesson, inquiry lab, real-world application, and hypothetical inquiry [10].

There is a close relationship between Levels of Inquiry (LoI) with the effort to train the ability to experiment and mastery of concepts. Discovery Learning stage honing students' ability to observe an event and predict what will happen. In the Interactive Demonstration stage, students have the opportunity to identify variables related to a phenomenon, then hypothesize if the value of a variable is varied. Inquiry Lessons make students hone skills in terms of identifying independent, bound and control variables, and designing experiments to solve a problem. The Inquiry Laboratory trains students to take the necessary data, analyze the data and conclude the experimental results [6].

Some of the results of previous studies stated that through the application of the Levels of Inquiry (LoI) model can improve the ability to experiment and mastery of concepts. Research conducted by Nurinsani and Danika identified the development of the ability to experiment at each meeting and increased mastery of the concept of static and energy fluid in junior high school students [11-12]. Other research results also show that science learning with inquiry learning laboratory can improve the mastery of students' science concepts and process skills [13].

This study aims to see the impact of the application of Levels of Inquiry (LoI) on increasing mastery of concepts. The study will produce an output in the form of an overview of the increase in mastery of sound wave concept using the statistical test of students on through the application of Levels of Inquiry (LoI). The working hypothesis is the learning by using Levels of Inquiry (LoI) can improve the mastery of student concepts on sound waves.

2. Methods

The research design used was pre-experimental design. The type of pre-experimental design used in this study is one group pretest-posttest design because no difference in treatment was compared in the purposes of this study [14]. So, the subjects of the study were only one experimental group given treatment and no control class [14]. Participants in this study were students of class VIII academic year 2017/2018 in one of the State Junior High School in Bandung with the number of 152 people using cluster random sampling technique. The use of this technique is based on research intent to represent a population that has been divided into several groups and can be generalized [15].

The research procedure starts from giving pre-test to know the mastery of initial concept of student before Levels of Inquiry (LoI) applied in learning. After the pre-test done the treatment provided with the Levels of Inquiry (LoI) learning strategy during the three meetings and provide the Student Worksheet (LKS) that the student must fill in the learning activities. Post-test is given to know the mastery of student concept after applying Levels of Inquiry (LoI) for three meetings. The result from pre-test and post-test will be used to measure the gain of every student.

These data will be analyzed by statistics t-test. And then calculating n-gain to compare which treatment has more effect on the improvement of student achievement. After that it can be determined whether learning by using Levels of Inquiry (LoI) can improve the students concept mastery on sound waves.
3. Result and Discussion
These parts will present the result of the research. It will be presented within three section consist of 1) statistical hypothesis test, 2) N-gain result, and 3) discussion.

3.1. Statistical hypothesis test
Mastery of the concept of students is assessed using a written test in the form of a description that contains three sub-materials, each consisting of 6 points items, so the total of the test question of mastering the concept tested is as much as 18 points items. Mastery of the concepts examined include the concept of vibration and waves, sounds, and hearing in humans and animals. The cognitive aspects measured in concept mastery are limited to the ability to understand (C2), apply (C3), and analyze (C4). Before being analyzed using the t-test it must be ensured that the data is normally distributed. Kolmogorov-Smirnov test has been used to determine whether the data is normally distributed or not using the sample size (N) 152 and significant value (α) 0.05. The normality test will be presented in table 1.

| Table 1. Normality test between the pre-test and post-test |
|-------------------|-------------------|
|                   | Pre-test          | Post-test         |
| Mean              | 44.97             | 65.65             |
| SD                | 6.88              | 9.97              |
| \( |A_e - A|_{\text{max}} \) | 0.0376            | 0.1160            |
| Critical Value    | 0.1322            | 0.1322            |
| Result            | Normal            | Normal            |

From this result it is concluded that t-test will be performed to determine whether the learning by using Levels of Inquiry (LoI) can improve the students concept mastery on sound waves. The result presented in table 2 using degree of freedom (df) 150 and significant value (α) 0.05. It is shown that t-value is lower than t-critical which means learning with Levels of Inquiry (LoI) is considered capable of significantly increasing the mastery of the concept of sound waves.

| Table 2. Statistical hypothesis test result |
|-------------------|-------------------|
|                   | t-value          | t-critical       |
|                   | -24.14           | 1.65             |

3.2. N-gain result
The calculation result of n-gain will be presented in table 3 as it is shown below. Further analysis is presented in the results of normalized gain calculation (n-gain) in each cognitive aspect in the mastery of the concept and each sub matter as follows.

| Table 3. N-gain calculation result. |
|-------------------------------------|
| % < S_i > Pre-test | % < S_f > Post-test | N-gain <g> |
| 44.97                | 65.65                | 0.38       |
Table 4. N-gain calculation result of each cognitive aspect.

| Cognitive Aspects   | % < S_i > Pre-test | % < S_f > Post-test | N-gain < g > |
|---------------------|--------------------|---------------------|-------------|
| Understand (C2)     | 46.73              | 64.32               | 0.33        |
| Apply (C3)          | 51.25              | 74.74               | 0.48        |
| Analyze (C4)        | 36.93              | 57.91               | 0.33        |

Table 5. N-gain calculation result of each sub matter

| Sub matter           | % < S_i > Pre-test | % < S_f > Post-test | N-gain < g > |
|----------------------|--------------------|---------------------|-------------|
| Vibration and Waves  | 43.88              | 73.44               | 0.53        |
| Sound                | 42.45              | 66.96               | 0.43        |
| Hearing in Humans and Animals | 48.59 | 56.56 | 0.16 |

Judging from the value of n-gain can be seen between the pre-test and post-test. By overall, it can be interpreted that there is an increased mastery of the concept on sound waves in learning by using Levels of Inquiry (LoI).

3.3. Discussion

In this study, sound waves were taught during three meetings with each having a 2x40 minute time allocation. Learning activities started from observing and predicting phenomena at the discovery learning stage, followed by recognizing the variables and making hypotheses from the demonstrations displayed at the interactive demonstration stage. Then the students operationalize the variables and create experimental procedures that will be done at the inquiry lesson stage to prove the hypothesis that has been made. Learning ends with activities to retrieve data, process data, analyze data and make conclusions from experimental results at the stage of laboratory inquiry. At the first meeting, the sub-material taught was the concept of vibration and waves with the experiments being carried out to determine the velocity of waves in water. At the second meeting, the sub subject taught is the concept of sound with the experiment conducted is to determine the speed of the sound in the air. Then at the third meeting, the sub subject taught is the concept of hearing in humans and animals with experiments conducted is to determine the intensity of muffled sound.

According to the n-gain calculation of each class in each cognitive aspect it is found that the highest conception mastery is applied to the applied aspect (C3) with a gain value of <g> 0.48 (medium). The second and third highest improvement values are aspects of understanding (C2) and aspects of analyzing (C4) with <g> 0.33 (moderate). In the cognitive aspects of understanding (C2), students are asked to explain the phenomena that occur and interpret them into the mathematical relationship of the phenomena contained in the question. In the applying aspect (C3), students are asked to apply the equations that have been learned during the previous three meetings. In the aspect of analyzing (C4), students are required to be able to determine the relationships between parts of a material or the relationship between these parts. Anderson and Krathwohl stated that educatively, analyzing (C4) is an extension of the understanding aspect (C2) [16]. This result correlate with some researches that suggest Levels of Inquiry (LoI) give positive influence to student's achievement [11-12].

There is a link between improving conceptual mastery with the development of experimental abilities. As students practice their experimental skills, they also tap into their mastery of conceptual skills. For example, when students are asked to make predictions, students are required to master the cognitive aspects of C2 or to understand the strong. So, there is an increase in mastery of student concepts because students are also trained how to understand the concept of making predictions. For students who are not accustomed to inquiry, the impact on teachers’ dominance in learning is still high. Learning by example and guiding questions become teachers’ dominance in learning.
4. Conclusion
Having known that the pre-test and post-test scores are normally distributed, it is done by left tail to find out whether there is a significant improvement in student concepts mastery through Level of Inquiry learning. Obtained t-value -24.14 and with significance level 0.05 and degree of freedom 152 obtained the value of t-critical is of 1.65 so t-value < t-critical. By analyzing n-gain values from pre-test and post-test scores it is concluded that the highest increase in concept mastery is found in the cognitive aspect of applying (C3). From these results it can be concluded that Levels of Inquiry implementations in learning can improve the students' concept mastery of sound waves. Application of Levels of Inquiry with a longer time allocation will give better results in improvement of student’s concepts mastery.

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