Students’ conceptual understanding consistency of heat and temperature

Indah Slamet Budiarti1, Suparmi2, Sarwanto3, Harjana4

Graduate Student’s Sebelas Maret University1, Lecturers of Sebelas Maret University2,3,4 Jl. Ir. SUtami 36A Kentingan Jebres Surakarta 57126, INDONESIA

E-mail: indah_budiarti@student.uns.ac.id, indah_budiarti@yahoo.com

Abstract. The aims of the research were to explore and to describe the consistency of students’ understanding of heat and temperature concept. The sample that was taken using purposive random sampling technique consisted of 99 high school students from 3 senior high schools in Jayapura city. The descriptive qualitative method was employed in this study. The data were collected using tests and interviews regarding the subject matters of Heat and Temperature. Based on the results of data analysis, it was concluded that 3.03% of the students was the consistency of right answer, 79.80% of the students was consistency but wrong answer and 17.17% of the students was inconsistency.

1. Introduction

The consistency of students’ response in comprehending concepts in Physics demands deeper understanding on some of students to see the equality of physics problems presented in various ways [1]. A deeper understanding of physics concept makes a student consistent about what he or she perceives to be true. An indirect effect of such a consistency is examined using representative consistency in that what he or she perceives to be true or may be contrary to science. However, this is not the case if equivalence is considered from different representation perspectives since such an equivalence requires considering various representations of Physics concepts [2]. Students’ consistency will reflect that there are a higher level of understanding in perceiving Physics concepts represented in various problems.

Heat and temperature concept is prevalent throughout the science curriculum at all levels of elementary, secondary, and graduate education [3]. Students have difficulty in the concept of heat transfer using conduction, in a seat belt is made of metal and non-metal [4]. Students have a misconception of heat and temperature. The temperature of an object related to its size [5]. The concept developed by students comes from the interpretation of ideas raised from everyday experience [6]. To understand the concepts of physics, students must be skilled in expressing these concepts in various ways or forms (multiple representations). Representation skills are a must-have capability to interpret and apply the various concepts in solving problems appropriately [7]. Multiple representations are representations of concepts in various way such as verbal, graph, diagram, etc.

A student’s ability to succeed at learning is determined, among others, by his or her thinking skills. This is the key point in solving problems during the learning process. By applying thinking skills students can train and develop their cognitive intelligence as well as relate various facts or information.
to previously acquired knowledge to make a prediction on result or outcome which is then formulated. Teaching-learning activities should involve explicit thinking ability, thereby facilitating categorizing thinking ability based on the available framework [8].

Based on the theoretical and case studies the researchers have conducted studies to investigate the students’ conceptual understanding consistency of Heat and Temperature. The research question proposed in this study was How Consistent is the Students’ conceptual understanding consistency of Heat and Temperature?

2. Research Method
The research methodology employed in this study was descriptive in nature to identify students’ understanding consistency of Heat and Temperature. The samples were taken using purposive random sampling consisting of students of three Senior High Schools in Jayapura City. The testing instruments were adapted from HTCE (Heat and Temperature Concept Evaluation) [9]. The data were collected using multiple-choice test items with reasoning as well as interviews. Twenty multiple-choice test items consisting of two items regarding temperature, eight items regarding heat and the other ten regarding heat transfer were administered. The interviews were conducted to collect data on the rationale provided by the students.

3. Result and Discussion
The percentage of the students’ understanding consistency based on their answers can be seen in Table 1 below.

| Consistency Level | SMAN 1 Jayapura | SMA Katada | SMA Pembangunan V Yappis | Average |
|-------------------|-----------------|------------|--------------------------|---------|
| Correctly consistent | 4.08            | 3.33       | 0                        | 3.03    |
| Consistently with the wrong answer | 75.51            | 80         | 90                       | 79.80   |
| Inconsistent      | 20.41           | 16.67      | 10                       | 17.17   |

Based on Table 1 above, it can be seen that the percentage of SMA Pembangunan V Yapis students who consistently gave right answers was 0 %. This suggested that students do not understand the concept of Heat and Temperature. In other words, the students had difficulties understanding equivalent problems presented in various ways of representation. A deeper understanding is achieved when a student is consistent about what he or she perceived to be true. A representation of a problem out of the various forms of representation demands a scientific perception on the part of the students. However, inconsistency in scientific perception resulting from a taken perspective based merely on a single representation rendered the students having a tendency toward consistently giving wrong answers. Based on consistency theory, a learner is brought to a higher level of understanding when exposed to various Physics concepts presented in different problems.

About the data on the percentage of Consistency Level obtained from the students of the three senior high schools taken as samples in this study, the students’ conceptual understanding consistency of Heat and Temperature is elaborated as follows:

**Temperature concept**, featured in the test items could have been answered correctly by the students. “The questions asked the students in the items number 5 and 6 refer to two cups, A and B, of the same material, each containing 150 grams of water. The glasses are in the room temperature of 25 °C. In the beginning, the temperature of the water in glass A was 60 °C and in the cup, B was 75 °C.” Which glass reaches the final temperature earlier? Cup A or cup B? The answer yielded in the written
test was confirmed by the interview result with a student as follows: “The student states that the temperature reached by an object depends on its size.” Such a concept in the student’s mind might stem from the student’s false understanding of “the heat of an object positively correlates with its mass”. It, however, should have been “the heat released from an object positively correlates with its mass.” Such students might not have discussed the matter deeply, resulting in the false understanding being internalized. Thus the expression of “the heat of an object positively correlates with its mass is consequently wrongly perceived as “any big object always has a higher temperature than smaller ones. When faced with the problem of multivariable, people generally reduces complexity by either ignoring some variable or variables merge into a relationship of one variable [10]. If time is taken into account, the student tended to think that the temperature would remain the same for a long period, which means that the temperature remains the same at any given time. This can be seen in the student’s choice on the graph showing the relationship between temperature and time (Figure 1) below.

**Figure 1.** A student’s choice on the relationship between Temperature and Time

**Heat Concept** featured in the items numbers 3 and 4 in the conceptual understanding consistency of Heat revealed that once concept regarding Heat is correctly perceived. Heat is energy released from an object with a higher temperature to another with a lower one. The one releasing heat will have a lower temperature whereas the one receiving it will end up with a higher one. In this case, learners showed a good understanding. A caveat should be noted here that this is true as long as phase transition does not take place. The data showed how Black’s Principle is at work as measured by a calorimeter. This particular learning activity taught a valuable lesson to most of the students that they internalized a correct perception. However, about a phase transition, the students were distracted by the problems presented, as evident in a student’s choice in Figure2.
Heat Transfer Concept. Based on the data, the students in Level 1 response quality group (Consistently right answer) did give a concrete explanation on the microscopic mechanism about conduction process taking place in metals. They did respond by stating that conduction mainly takes place in solid objects. However, the majority of the students could not yield a satisfying reason why that is the case. This can be seen in Figure 3 below.

Based on the answers of the students, it appears that the students had not understood the problems it faces. At issue, did not mention the type of metal ruler. This proves that the students only knew that only iron is a metal. Supposedly students understand the concept of the rate of heat and energy so that students choose a selection that heat energy travels from hand to metal faster than wood.

4. Conclusion
Based on the result and discussion, it can be concluded that students’ conceptual understanding consistency of Heat and Temperature was low. In addition to that, another factor at work was the tendency toward learning Physics by means of memorizing without fully comprehending the subject matter concepts. Furthermore, the day-to-day Physics learning activities in the country still offer...
students how to solve problems without a fully detailed understanding them. As such, the low mastery of Physics subject matters renders our students only partly understanding Physics concepts.

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