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Student's understanding consistency of thermal conductivity concept

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ABSTRACT: Preliminary observation in three universities revealed that its focus remains on the level of knowledge, understanding, and application. The aims of the research were to explore and to describe the consistency of students' understanding of thermal conductivity concept, whereas the testing instruments were adapted from HTCE (Heat and Temperature Concept Evaluation). The study was carried out in three higher learning institutions: IKIP PGRI Madiun, UIN Sunan Kalijaga Yogyakarta, and Lampung University with a sample of 145 students. Descriptive research design was employed, while the purposive random sampling technique was used to obtain the sample. Data were obtained using multi-representation tests and in-depth interviews. Based on the data analysis, it was found that 87.59% students were inconsistent to answer test of multi-representation concept.

1 INTRODUCTION

Learning Physics is an endeavor to comprehend Physics concepts and to discover how to gather fact information and induce the principles underlying such facts as well as the attitude of the Physicists toward their discoveries. It is through studying Physics that students can discover the meaningfulness of the concepts under study and as such can apply those concepts in their daily lives. Rosser (1984) stated that a concept was an abstraction representing a class of objects, events, activities or relationships sharing the same attributes. It may be the case that the concepts the students have evolved from daily encountered phenomena. However, such intuitive comprehension is completely different from scientific concepts. It is, therefore, important to analyze how students' concepts differ from scientific explanation (Alwan, 2011).

The concepts of Temperature and Heat is offered in as early as Elementary School years through High School to Higher Learning Institution. Sozbilir (2003) the concepts of Temperature and Heat which were still abstract or vague upon learning resulted in the various interpretation or perception on the part of students. Thomas et al. (1995) found that students had difficulties accepting or internalizing such concept as "the final temperature of two different objects will be the same upon being exposed to the same temperature in a particular environment." This result consistent with the research findings observed by Baser (2006), in that the students had difficulties solving the problem of heat transfer using conduction taking place in a seat belt, partly made of metal and non-metal. The comprehension of concepts by students can observe from their correct answer consistency. Ainsworth (2006) stated that "the consistency of the students' responses in comprehending Physics concepts demands a deeper understanding on the part of the students themselves to perceive equality of Physics problems presented in various or multiple ways." A more in-depth understanding will make a student consistently adhere to what he or she perceives, understands and believes. An implication of such consistency is attested inconsistency of representation in that what they perceive may not be scientifically true. It takes an understanding of the equivalence of the multiple representations and scientific consistency which demand scientific comprehension to perceive it consistently (Nieminen, Savinainen, & Viiri, 2010). Students' consistency will take them to a higher level of understanding in perceiving different Physics concepts represented in various problems.

A student's ability to succeed in learning is determined, among others, by his or her thinking skills he or she possesses. The most important is the ability to solve problems encountered during learning processes. By putting his or her thinking skills into practice, a student can train and develop his or her cognitive intelligence he or she possesses, as well as relate various facts or information to the knowledge previously gained to formulate a prediction of the outcome. Thinking ability is not restricted to defining. Thinking is considered an intellectual process or higher-order cognitive process (Wilson, 2000). Thinking ability is thus a skill and strength to be internalized in learning subject matters to enhance performance and lessen learners' weaknesses (Heong, 2011). Teaching-learning activities should involve specific thinking ability, thereby facilitating categorizing thinking ability based on the open framework (Kong et al., 2012).

Senk et al. (1997) stated that higher-order of thinking showed the characteristics of solving unusual problems and the solutions were a result of logical thinking. The characteristics of mental activities of higher-order of thinking processes often involve complex thoughts, non-algorithmic in nature, as well as independence in thinking processes and being able to provide various applicable solutions (Resnick, 1987) upon encountering unusual situations filled with problems, faced with options requiring him or her to make a decision (King, Godson & Rohani, 1998).These high order thinking skills in this study refer to the three top domains of Bloom's Taxonomy. Zoller (1993) stated that the three highest cognitive domains of Bloom's Taxonomy, i.e. analyzing, evaluating and creating, which demands higher-order thinking skills.

Based on the theoretical and case studies the researchers conducted the study to explore and describe the consistency of students' understanding of thermal conductivity concept. The research question proposed in this study was how consistent the Students' conceptual understanding consistency of conductivity is?

2 RESEARCH METHODS

The method of study was descriptive in nature to scrutinize and describe the consistency relationship between the students' comprehension of the concept of conduction and their higher-order thinking skills. The sample was taken using purposive random sampling from three higher learning institutions, namely IKIP PGRI Madiun, with twenty-five students participating; UIN Sunan Kalijaga Yogyakarta, with fifty-two students; and Universitas Lampung, with sixty-eight students. The test of consistency of representation concept can also use as a tool for identifying the cause of misconceptions (Cari, et.al, 2016). The data were collected using multiple-choice test items with reasoning as well as interviews. Four multiple-choice items were those regarding heat transfer using conduction. The interviews were conducted to investigate the students' underlying comprehension in yielding the answers, thereby revealing their understanding of the concept line with their higher-order thinking skills.

3 RESULTS AND DISCUSSION

The percentage of the students' understanding of thermal conductivity concept based on their answers can see in Table 1 below. Based on Table 1, the average of consistently correct answers yielded by the students was 1.38%, this indicates that their comprehension of the concept of heat transfer using conduction was low, meaning that they had difficulties to see equivalence in problems presented in multiple or various ways. The students should have had a better understanding if they had been consistent toward what they perceive to be true. The multiple representations of problems demand a scientific comprehension on the part of the students. However, as a result of inconsistent comprehension resulting from different perspectives employed in perceiving the problems, consistently incorrect answers occurred. Based on consistency theory, students will be brought to a higher level of comprehension in perceiving various Physics concepts presented in multiple representations.

About the data on the percentage of consistency level obtained from the students in the three higher-learning institutions taken as a sample in this study, in the following is described the students' consistency of concept comprehension regarding the subject matter of heat transfer using conduction.

Table 1. The percentage of the consistency of the students' comprehension of concept.

	Percentage (%)			
Consistency level	UIN sunan kalijaga	Universitas lampung	IKIP PGRI madiun	Average
Correctly Consistent	1.92	1.48	0	1.38
Consistenly with the wrong answer	7.70	11.76	16	11.03
Inconsistent	90.38	86.76	84	87.59

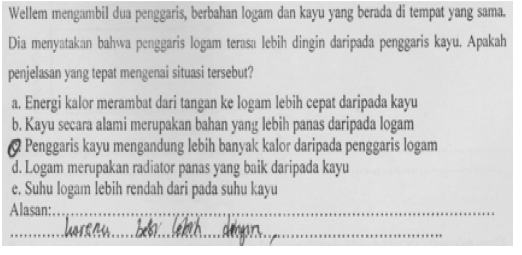
3.1 *The consistency of students' understanding of thermal conductivity concept*

Based on the data, the students who yielded low-quality responses clear gave an explanation on the microscopic mechanism about conduction taking place in metals. The majority of the students' responses about conduction mainly in solid objects was not supported by a satisfying argument since they could not state the correct reason. The student's answer is shown in Figure 1 below.

Based on Figure 2, it can see that the student was hesitant in deciding between the choice A and D before finally deciding on the latter. Considering the reason stated, it could identify that the student already had the correct concept regarding Temperature and Heat. However, this particular student's answer not in line with the problem presented. The problem presented in this particular item is the transfer of heat. As such, the correct answer yielded should have been A.

It can see from the Figure 4 above that the student did not comprehend the concept, the student's answer which does not reveal the relationships between Temperature, Heat and other units related to heat transfer using conduction.

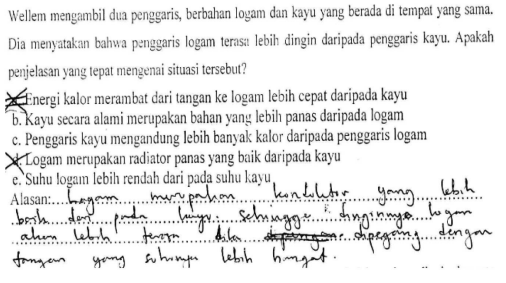
Based on Figure 5 above, it can see that the student was able to solve the problem well, as observed in the correct answer. The in-depth interview conducted revealed that the student could explain the relationship between the rate of heat transfer and


Wellem mengambil dua penggaris, berbahan logam dan kayu yang berada di tempat yang sama. Dia menyatakan bahwa penggaris logam terasa lebih dingin daripada penggaris kayu. Apakah penjelasan yang tepat mengenai situasi tersebut?

a. Energi kalor merambat dari tangan ke logam lebih cepat daripada kayu
b. Kayu secara alami merupakan bahan yang lebih panas daripada logam
c. Penggaris kayu mengandung lebih banyak kalor daripada penggaris logam
d. Logam merupakan radiator panas yang baik daripada kayu
e. Suhu logam lebih rendah dari pada suhu kayu

Alasan: karena ... lebih dingin

Figure 1. A student's incorrect answer to a problem presented verbally.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e. Suhu logam lebih rendah dari pada suhu kayu

Alasan: logam merupakan konduktor yang lebih baik dari pada kayu. Sehingga ... logam alam lebih ... baik ... dengan ... yang suhunya lebih hangat.

Figure 2. A hesitant student's answer to a problem presented verbally.

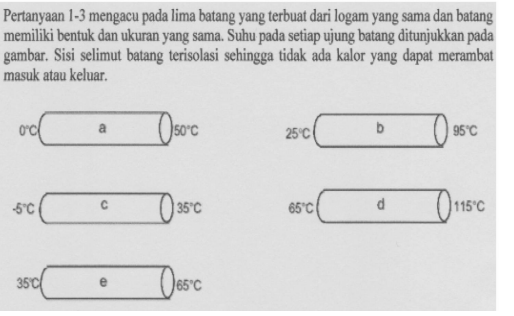

Figure 3. A problem on conduction presented visually.

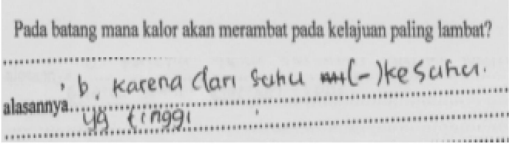

Figure 4. A student's incorrect answer to a problem presented visually.

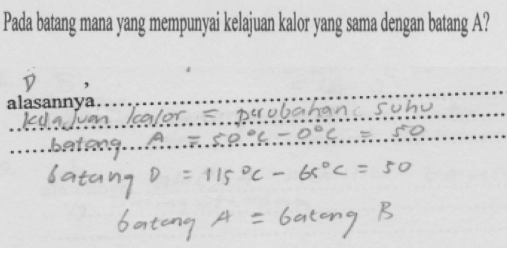

Figure 5. A student's correct answer to a problem presented visually.

change in temperature. As the rate of heat transfer using conduction is positively correlated to change in temperature, rod A has the same rate of heat transfer as rod D, since the temperature change in rods A and D are the same. The student's answer that "rate of heat transfer = temperature change" carries the meaning that the rate of heat transfer is positive correlate with temperature change.As such, it can say that the majority of the students was inconsistent in comprehending the concept of conduction as can be seen in their answers to both verbally and visually presented problems.

3.2 *Higher-order thinking skills*

The higher-order thinking skills in this study referred to the three top or highest domains of Bloom's Taxonomy. Zoller (1993) asserted that the three top cognitive domains in Bloom's

Taxonomy—analyzing, evaluating and creating—demand higher-order thinking skills. Based on their written and oral explanation, it could state that the students' comprehension was mainly still in the analysis domain. In other words, the students were not yet able to express their comprehension in the evaluation and creation domains.

3.3 *The relationship between the concept understanding consistency and the higher-order of thinking skills*

Based on the students' answers yielded during the tests and in-depth interviews, it could say that the relationship between the concept comprehension consistency and higher-order of thinking was attested. Several students' answers regarding conduction which were consistently correct. Based on these consistently correct answers, the researchers were able to detect the presence of higher-order of thinking skills. However, the correct answers yielded by those particular students revealed that their understanding was still in the analysis domain.

4 CONCLUSIONS

Based on the data analysis, it can conclude that the answers yielded by 1.38% of the students were consistently correct, 11.03% were consistently incorrect, and 87.59% were inconsistent. This result revealed that the relationship between the concept comprehension consistency and their higher-order thinking skills regarding the subject matter of conduction attested in their answers yielded in the tests and in-depth interviews. Apart from that, another factor at play was the tendency among the students to learn Physics merely using memorizing without fully comprehending the concepts. Furthermore, still another factor contributing to this low consistency was the daily practice of Physics learning which mainly dealt with how to solve problems without a deeper understanding of the details. As a result, the low mastery of Physics concepts rendered the students' comprehension weak, as attested in the higher-order of thinking skills regarding the concept of conduction.

Further factors triggering this lack of consistency learning everyday physics emphasize on how to resolve the matter, without understanding the issues in detail, consequently weak mastery of physics that make less profound understanding experienced by students, especially high-level thinking skills regarding conduction concept.

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