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Identification of consistency and conceptual understanding of the Black principle

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ABSTRACT: The concept of physics can be understood not only in mathematical language but through a variety of representations. By understanding the concept, someone will be consistent in addressing the problems, even though they are presented in different representations. Consistent answers to the questions in physics will show the level of understanding of the concepts. The purpose of this research was to identify the consistent answers about the Black principle. This research used the descriptive qualitative approach. The instrument used in this research was nine multiple choice questions with reasons. The essential concept is the Black principle. Some questions were adopted from the Heat and Temperature Concept Evaluation (HTCE). The sample for this research was 145 students of the Physics Education Program of Sunan Kalijaga State Islamic University, Institute of Teachers' Training and Education of PGRI Madiun, and State University of Lampung. The results showed that 81.74% of students were inconsistent, 1.13% of students were consistent with the correct answers, and 17.03% of students were consistent with the wrong answers when responding to the test of multi-representation concepts.

1 INTRODUCTION

Physics is a science that studies the natural phenomena. The natural phenomena that occur should be studied more deeply in order to get the causal occurrence. It requires a mature understanding to have reasoning when solving the problems that arise from the occurrence of the natural phenomena. Understanding the concept gives students the ability to not only remember but also to re-explain the definition, special features, nature, essence, and content using their own words, without changing the meaning of the content of the information they receive. According to Wospakrik & Hendrajaya (1993), physics is a branch of science that aims to study and provide a quantitative understanding of the various symptoms or processes of nature and the nature of the substance and its application. Physics is not only realized in mathematical language. Someone's understanding of the concept can be judged from the language of communication, the language of physics, the language of math, the language of intuition, and the language of definitions/provisions. When someone does not understand one of these languages, there will be no understanding of the concept and there could even be misconceptions (Search, 2016). Natural phenomena and processes in the universe have certain consistent patterns that can be studied and assessed systematically. According to Meltzer (2004), physics can also be translated into four representations, as follows: verbal representation, diagram or images representation, mathematical representation or mathematical symbols, and graphic representation. Thus, solving physics problems can be conducted by representing the questions of physics in various forms: verbal, graphic, images or pictorial, and math in the form of formulas. A concept can be built through the problem-solving task, which also involves the use of the system of representation. The students' knowledge of the concept would be more significant if they were able to reveal the differences in the representation of the concepts being learned.

Various representations have the power that can be used to solve the problems appropriately. For instance, the problem is inadequate if it is being solved only by the verbal representation. But if it is solved by the good graphic representation, it would provide the most appropriate solution. It requires the proper consideration in using the representations for solving the problems. By viewing the level of scientific consistency of the students' answers, the students' understanding of the concepts could be measured. The scientific consistency is based on the number of correct answers for each concept, measured by different modes of representations. According to Nieminen et al. (2010), the consistency of the students will lead them to a better level of understanding in viewing various concepts of physics as outlined in various problems. In line with Ainsworth

(2006), the consistency of response of the students in understanding the concept of physics requires a deeper understanding by the students to view the equivalence of the problems of physics as outlined in various ways. The results of preliminary research show that there are problems with the temperature and heat concept at the middle school level, not only in the low national test scores, but also in the daily tests. Based on the interviews with the physics teacher, it is found that the lack of understanding of the concept is because the concepts of temperature and heat are close to being an everyday phenomenon. In another study on the concept of the Black principle, the students have difficulties in distinguishing between $Q_{deliver}$ and $Q_{receive}$ (Winarti et al., 2015). Many students were confused about the concepts of heat and temperature due to the same thing, the perception of temperature is only about hot and cold, and temperature can be transferred. The students memorized this concept and were not able to make a connection between their knowledge and the physics phenomena in everyday life (Winarti et al., 2016). It needs to examine the failing process of knowledge transfer in the class. Based on the interviews with the students, the data shows that, when teaching the subject of temperature and heat, the teacher only asks the students to memorize the subject and does not embed the concept of thinking in solving the problems. It can possibly happen to students majoring in physics education. According to Prince (2011), misconceptions and incomprehension in college greatly affect the performance of teaching. As the institution producing the physics teachers, it is important for the college to determine the readiness of the physics teacher candidates to jump into the field in order not to bring the misconceptions and incomprehension to the students. Difficulty in the understanding of the concepts of heat and temperature have been investigated by many educational researchers. Many students have not understood even misconceptions about the concept of temperature and heat (Wiser & Carey, 1988; Lee, 2007). Students come to class with an understanding that is not empty; the students come with a variety of knowledge from everyday life. According to Arnold & Billion (1994), students' understanding of the concept of temperature and heat comes from the experience that they get from everyday life. The concept of temperature and heat is directly related to the environment and daily life (Ericson, 1979).

Therefore, it is important to 1) identify the consistency of understanding from the answers of the students, and 2) analyze the understanding and the errors that occur in the students associated with the concept of the Black principle.

2 RESEARCH METHODS

This research used the descriptive qualitative approach. The research was based on the depiction of the phenomena or events captured by the researchers with the existing facts. Qualitative research is the method used to examine the condition of natural objects (Bao et al., 2002). The research was a preliminary study to see the profile of the students' reasoning. The instrument used in this research was nine multiple choice questions with reasons. The essential concept tested in this test was that of temperature and heat. Some questions were adopted from the questions of the Heat and Temperature Concept Evaluation (HTCE).

The research was conducted at three universities, which are: Sunan Kalijaga State Islamic University, Institute of Teachers' Training and Education of PGRI Madiun, and State University of Lampung. For the sample, there were 52 students of the Physics Education Study Program of Sunan Kalijaga State Islamic University, 25 students of the Institute of Teachers' Training and Education of PGRI Madiun, and 68 students of the State University of Lampung. The data analysis was conducted by:

- Finding the average of the correct and incorrect answers of each concept being tested.
- Determining the fraction of students who answered correctly or those who answered incorrectly out of the total students.
- Determining the distribution of the consistency of answers from the group of respondents to each concept to determine the tendency of consistency of the respondents.
- Determining the conception of the group of respondents to each concept to determine the tendency of not knowing the concepts and the misconceptions.

3 RESULTS AND DISCUSSION

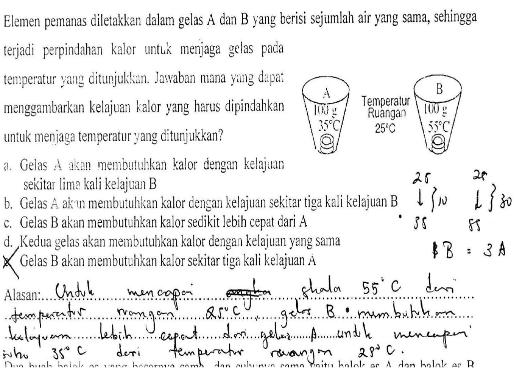
The results of the research showed that the level of consistency of the students' answers is as shown in Table 1.

It shows the values of the consistency of the students in answering the questions on the temperature and heat concept. It can be seen that the greatest value from the three universities is the inconsistency of the students' answers. The average of the inconsistency of the students' answers from the three universities is 81.74%. The average of the consistency with the correct answers is only 1.13%. When facing the same question, but in a different form of representation, the students become confused.

On the question of the Black principle, eighteen students correctly answered the multiple choice

Table 1. Percentage of the level of consistency.

Level of consistency	Percentage (%) Sunan Kalijaga State Islamic University (N = 52)	State University of Lampung (N = 68)	Institute of Teachers' Training and Education of PGRI Madiun (N = 25)	Average
Consistent with the correct answers	1.92	1.47	0	1.13
Consistent with the wrong answers	26.92	16.17	8	17.03
Inconsistent	71.15	82.24	92	81.74


Elemen pemanas diletakkan dalam gelas A dan B yang berisi sejumlah air yang sama, sehingga terjadi perpindahan kalor untuk menjaga gelas pada temperatur yang ditunjukkan. Jawaban mana yang dapat menggambarkan kelajuan kalor yang harus dipindahkan untuk menjaga temperatur yang ditunjukkan?

a. Gelas A akan membutuhkan kalor dengan kelajuan sekitar lima kali kelajuan B
b. Gelas A akan membutuhkan kalor dengan kelajuan sekitar tiga kali kelajuan B
c. Gelas B akan membutuhkan kalor sedikit lebih cepat dari A
d. Kedua gelas akan membutuhkan kalor dengan kelajuan yang sama
e. Gelas B akan membutuhkan kalor sekitar tiga kali kelajuan A

Alasan: Untuk mencapai suhu 55°C dari temperatur ruangan 25°C gelas B membutuhkan kelajuan lebih cepat dari gelas A untuk mencapai suhu 35°C dari temperatur ruangan 25°C.

Figure 1. Example of a student's answer on the subject of the Black principle.

question but gave the wrong reason. Figure 1 shows that the student only analogized it and took into account mathematically the calorific needs of each glass without using or relating to the concept of the Black principle and the rate of energy. It should be possible to use the equation to solve the problem. Glass B needs three times more heat than glass A because the heat is proportional to the rate of heat (Q ~ H), so glass B needs three times as much heat. The most common error seen from the answers of the students was that they only explained the difference in temperature and the thermal temperature alone, but they did not explain the rate of heat that occurs in glass A or glass B.

Based on the interviews, the students stated that the rate of heat concept was abstract and they could not find it in everyday life, so they answered incorrectly the questions related to the rate of heat. If the students really understood the concept, they should consistently answer the questions about representations of images and graphics correctly. A student's answer when working on the question about the representation of the graphic is shown in Figure 2.

In answering the question on the representation of the graphic in Figure 2(a), the student answered correctly because he was able to link the question with the concepts of physics. In solving the question, the student should determine the relationship between the changes in temperature (ΔT) and time (t). The students should also link the case with the concept of thermal equilibrium. In the case of glass A, it has a temperature of 35°C, and when filled with 100 grams of water it has a space temperature of 25°C. If it stays still at a certain time it will reach the thermal equilibrium. When reaching the thermal equilibrium, the graphic corresponding to the case is graph E. But for this case, actually glass A and glass B will experience the same thing; each will already reach the thermal equilibrium so the right choice is graph C, where the temperature will be inversely proportional to the time. The students who answered as in Figure 2(b) have not understood the concept because, based on the interviews, the students stated that the final temperature of glass A will be the same because they thought there

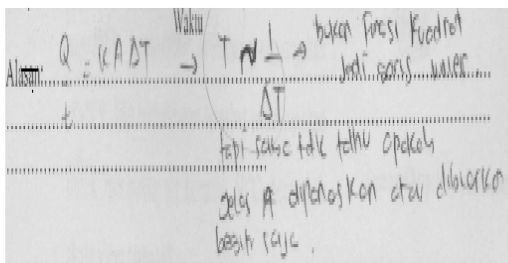


Figure 2(a). Result of writing the description of understanding the Black principle.

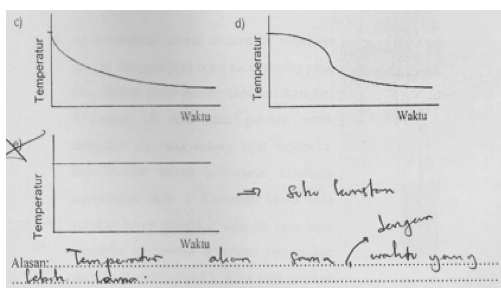


Figure 2(b). Wrong representation of the relationship of temperature and time.

was no change in the room temperature that affects the water temperature in glass A. The result of the answers of the interview on Figure B is as follows "the student stated that the temperature reached by an object depends on the time".

The results of the interviews show that the students sometimes used their intuition to answer the questions. This happens because the concepts presented in physics and in the questions are very close to daily happenings. Unfortunately, the analysis conducted by the students was less detailed in viewing the other factors that influence the case. The students only view one side, based on the visible variables, without thinking of the connection between the variables and the actual concepts. This is in accordance with the opinion delivered by Alwan (2010) in his research, who states that the students' concept develops based on their daily experiences, but sometimes their intuitive understanding is different from the scientific concepts. It is in line with Leura et al. (2005), who stated that the concepts embedded in the students' minds comes from the interpretation of ideas derived from their daily experiences (Leura et al., 2005).

4 CONCLUSIONS

Based on the research results and the data analysis, it shows that the level of consistency of the students' answers consists of the following: 1.13% are consistent with the correct answers, 17.03% are consistent with the wrong answers, and 81.80% are inconsistent. Based on the results of the interviews, the lack of understanding of the concept of the Black principle by the students was caused by the mixture between the correct understanding and the intuition encountered in their daily life. It is important to have an analysis to determine how the students' conceptions are different from the scientific explanation. The recommendations of this research are that, when getting to know the understanding or even the misconceptions of the university students or other students, we should keep doing the interviews to explore the reasons for the students' answers. It is very profitable to be able to investigate the problems that are caused by their incomprehension and to know what treatment is suitable to handle these problems, both in terms of learning and for the questions provided.

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