

Profile Analysis of Students' Concept Understanding on Heat and Temperature

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ABSTRACT

This research is aimed to know students' concept understanding profile on heat and temperature. This research is descriptive research using a qualitative approach. Subjects of this research are 10th-grade students in Surakarta in the academic year of 2016/ 2017. They represent high, medium, and low categorized school. Subject selection is based on the average score of physics at the latest four years. This research uses the question of extended response test through essay question. Before having given to the subjects, essay questions are validated by the experts. Based on the research result and the data analysis, students' concept understanding on heat and temperature as follows: (1) The average percentage of students' concept understanding at high categorized school is 60,66%, at medium categorized school is 51,47%, and at low categorized school is 48,83%, (2) Most students have misconception on basic concept of heat and temperature such as heat capacity, thermal conductivity, and expansion concept.

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1. INTRODUCTION

Education has important role to ensure the development and the life of a nation. In the effort to realize the aim of national education, it needs qualification profile of graduates' skill that has been explained in standard of graduates' competence. It is explained in section 35 of law number 20, the year of 2003 that standard of graduates' competence is a qualification of graduates' skill. The qualification consists of attitude, knowledge, and students' skill that must be reached at the basic and middle education institution.

The aim of education is to facilitate students to have concept understanding and can be expressed verbal, numeric, positive thinking plan, group life plan, and spiritual contemplation plan [1]. Students' conceptual understanding has become a focus on Physics Education Research (PER) for years. Many previous researches have reported students' learning difficulty [2].

The other researcher states the same case that the most educators agree that teaching and learning science must transform from science learning system as factual, count and memorize information to learning science that emphasizes to the conceptual understanding and skill of logical thinking process. However, this aim has not been achieved yet [3]. Literature review shows that the problem of conceptual understanding is widespread in students' scope. Conceptual understanding is defined as a skill to determine which relevant and accurate idea that is important for a problem. Besides, it is to understand the relation among microscopic attitude, macroscopic observation, and symbol and notation that are used to represent both [4-7].

Concept understanding and physics learning process are related to each other. Physics learning with concept understanding make physics not only remembering, but also applying concept. Concept is an idea of

a person or a group that is expressed into a definition to deliver knowledge products such as principle, law, and theory. Concept can be gained from facts, events, and experience, through generalizing and thinking abstractly [8]. Conceptual understanding needs knowledge and using scientific concept skill to develop scientific theory [9]. Therefore, teachers need to make sure the students' concept mastery [10].

Learning process with understanding will encourage students to connect new and former experience and students' concept. Learning science with understanding will make students to be able in giving explanation about a concept, making prediction, proposing question, doing test to the prediction and interpreting data. In another word, learning with understanding is learning by using science process skill [11].

In learning process, assessment has important role to know learning achievement. The assessment can figure out the true result. It also determines good and bad learning. To know students' understanding concept, it needs a proper assessment. Instruments used in assessment are various. One of them is extended response test through essay questions. Essay can help students to maximize all knowledge in writing form to answer the proposed questions. If it is compared with other forms (multiple choice, true-false, etc), this form is very flexible. The purpose of free essay test is to avoid the answer that only guesses.

Assessment instrument of essay can also assess students' skill in delivering their idea based on the concept they have learned. Essay test is a test that contains problems and demands test participants to construct their own answer [12]. Essay test has been popular especially in high education. Its use was started in 2300 BC in China and it was the only form used for centuries. Essay question, answers are not provided for students. Students should master much knowledge that enables them to develop facts and principles, to apply coherently and logically, and to apply ideas by writing the expression [13].

Assessing students' conceptual understanding has become a popular issue in physics education research [14]. The previous research has shown that scientists can use many representations fluently when they think and share ideas [15, 16]. It also states that the important purpose of physics education is guiding students to be capable in using some representation to solve problems and to have good conceptual understanding in physics.

Concept understanding in physics learning is very important, so that it needs a profile analysis of concept understanding that is assessed from essay instrument. One of concept in physics whose concept understanding still low is heat and temperature. There are many students who still face difficulty in understanding heat and thermodynamics [17-20]. One of the difficult concepts for students is differentiating between heat and temperature [18, 21, 22]. Based on the above elaboration, it needs profile analysis of understanding concept of heat and temperature on the 10th grade students in academic year of 2016/2017. Instrument to measure students' concept understanding is extended response test through essay question.

2. RESEARCH METHOD

This research is a descriptive research using a qualitative approach. The design of descriptive research uses a sample from experiment to document, to describe, and to explain whether there is phenomenon or not [23]. Qualitative research is used to count the percentage of concept understanding of each category school.

Subjects of this research were 10th-grade students in the academic year of 2016/2017 in high, medium, and low categorized school. The technique of selecting sample use purposive sampling technique. It is conducted by selecting students of high, medium and low categorized school. The selection of category school is based on the average of physics national examination at the latest four years. The total sample of this research is 96 students consists of 29 students from high categorized school, 36 students from medium categorized school and 31 students from low categorized school. Data were obtained through interview and essay questions that consist of 10 numbers. The questions were based on the indicators on the syllabus. The whole questions unearth the students' concept understanding on the material of heat and temperature.

Scoring technique was based on assessment rubric that was made from score 10, 8, 6, 4, 2, 1 and 0. The students' answers were corrected with the assessment rubric guidance with some keywords to easy the correction. The keywords on each question are not same because the keyword based on the concept and the indicator of questions. Through this rubric, subjectivity in scoring can be minimalized so that students' score will be same when it is corrected by other people. The assessment guidance of essay questions listed in Table 1.

Data is also collected by interviews with the students. Before interviewing, the interview sheets are prepared more structured. The interview is aimed to confirm students' answer to explore students' understanding of heat and temperature. Based on the scoring result of students' answer, it is then calculated on each number. After adding up the score, the average percentage of concept understanding on each number is counted and averaged. The average result shows the understanding percentage on high, medium and low categorized school.

Table 1. The assessment guidance of essay questions

| Score | Criteria of scoring |
|-------|--|
| 10 | True answer with explanation contain all parts of the scientifically accepted concept (more 2 keywords). |
| 8 | True answer with explanation contain all parts of the scientifically accepted concept (2 keywords). |
| 6 | True answer with explanation contain all parts of the scientifically accepted concept (1 keywords). |
| 4 | True answer with explanation contains a part of the scientifically accepted concept. |
| 2 | The true answer, but not given an explanation. |
| 1 | False answer, irrelevant or unclear response. |
| 0 | Blank or not answering. |

3. RESULTS AND ANALYSIS

Data from this research is students' answer in solving essay test about heat and temperature. Students' answers are analyzed based on the assessment rubric that has been compiled so that the average percentage of students' understanding of the concept is obtained. Average percentage understanding of heat and temperature concepts in 10th-grade students from high, medium and low categorized schools is presented in Table 2, Table 3 and Table 4.

Table 2. Data of concept understanding of heat and temperature at high categorized school.

| Number of questions | Number of students and achievement score | | | | | | | Total of students' score | Percentage of understanding (%) |
|--|--|----|----|---|---|---|---|--------------------------|---------------------------------|
| | 10 | 8 | 6 | 4 | 2 | 1 | 0 | | |
| 1 | 1 | 5 | 12 | 5 | 6 | 0 | 0 | 154 | 53.10 |
| 2 | 5 | 8 | 6 | 4 | 1 | 4 | 1 | 172 | 59.31 |
| 3 | 2 | 9 | 9 | 5 | 1 | 0 | 3 | 168 | 57.93 |
| 4 | 2 | 6 | 10 | 8 | 3 | 0 | 0 | 166 | 57.24 |
| 5 | 3 | 6 | 7 | 3 | 9 | 1 | 0 | 151 | 52.07 |
| 6 | 3 | 12 | 11 | 3 | 0 | 0 | 0 | 204 | 70.34 |
| 7 | 0 | 10 | 15 | 4 | 0 | 0 | 0 | 186 | 64.14 |
| 8 | 1 | 15 | 10 | 3 | 0 | 0 | 0 | 202 | 69.66 |
| 9 | 0 | 12 | 7 | 4 | 6 | 0 | 0 | 166 | 57.24 |
| 10 | 2 | 10 | 11 | 6 | 0 | 0 | 0 | 190 | 65.52 |
| The average of students' concept understanding (%) | | | | | | | | | 60.66 |

Table 3. Data of concept understanding of heat and temperature at medium categorized school.

| Number of questions | Number of students and achievement score | | | | | | | Total of students' score | Percentage of understanding (%) |
|--|--|---|----|----|----|---|---|--------------------------|---------------------------------|
| | 10 | 8 | 6 | 4 | 2 | 1 | 0 | | |
| 1 | 1 | 5 | 20 | 10 | 0 | 0 | 0 | 210 | 58.33 |
| 2 | 0 | 3 | 11 | 21 | 1 | 0 | 0 | 176 | 48.89 |
| 3 | 3 | 7 | 9 | 16 | 1 | 0 | 0 | 206 | 57.22 |
| 4 | 4 | 7 | 9 | 11 | 5 | 0 | 0 | 204 | 56.67 |
| 5 | 6 | 0 | 14 | 16 | 0 | 0 | 0 | 208 | 57.78 |
| 6 | 4 | 8 | 9 | 10 | 5 | 0 | 0 | 208 | 57.78 |
| 7 | 0 | 0 | 3 | 13 | 17 | 2 | 1 | 106 | 29.44 |
| 8 | 2 | 5 | 22 | 4 | 2 | 1 | 0 | 213 | 59.17 |
| 9 | 0 | 0 | 2 | 14 | 14 | 4 | 2 | 100 | 27.78 |
| 10 | 1 | 8 | 20 | 7 | 0 | 0 | 0 | 222 | 61.67 |
| The average of students' concept understanding (%) | | | | | | | | | 51.47 |

Table 4. Data of concept understanding of heat and temperature at low categorized school.

| Number of questions | Number of students and achievement score | | | | | | | Total of students' score | Percentage of understanding (%) |
|--|--|---|---|----|---|---|---|--------------------------|---------------------------------|
| | 10 | 8 | 6 | 4 | 2 | 1 | 0 | | |
| 1 | 1 | 4 | 9 | 9 | 7 | 0 | 0 | 146 | 48.67 |
| 2 | 2 | 4 | 8 | 8 | 4 | 4 | 0 | 144 | 48.00 |
| 3 | 1 | 7 | 9 | 6 | 3 | 2 | 2 | 152 | 50.67 |
| 4 | 1 | 4 | 9 | 11 | 4 | 1 | 0 | 149 | 49.67 |
| 5 | 2 | 6 | 8 | 4 | 9 | 1 | 0 | 151 | 50.33 |
| 6 | 1 | 5 | 9 | 10 | 4 | 1 | 0 | 153 | 51.00 |
| 7 | 0 | 5 | 8 | 10 | 6 | 1 | 0 | 141 | 47.00 |
| 8 | 0 | 7 | 8 | 9 | 4 | 2 | 0 | 150 | 50.00 |
| 9 | 0 | 4 | 6 | 10 | 9 | 1 | 0 | 127 | 42.33 |
| 10 | 1 | 7 | 7 | 7 | 8 | 0 | 0 | 152 | 50.67 |
| The average of students' concept understanding (%) | | | | | | | | | 48.83 |

Criteria of students' concept understanding is categorized into 4 categories, namely high, adequate, low and very low [24]. Category division is shown in Table 5.

Table 5. Category of concept understanding.

| Percentage of understanding | Understanding category |
|-----------------------------|------------------------|
| $75% < P \leq 100%$ | High |
| $50% < P \leq 75%$ | Adequate |
| $25% < P \leq 50%$ | Low |
| $0% < P \leq 25%$ | Very low |

Percentage of students' concept understanding on the material of heat and temperature heat using the formula below:

$$\text{percentage of understanding} = \frac{\text{score gained}}{\text{maximum score}} \times 100\%$$

At table 3, it contains a number of students, achievement score, and percentage of students' understanding at high categorized school. At table 1, the average of students' understanding concept at high categorized school is 60, 66%. According to Sugiyono, that percentage is an adequate category.

If it is viewed by its question item, category percentage of students' understanding at high categorized school belongs to an adequate category. Commonly, the understanding percentage is around 50% to 75%. If it is viewed quantitatively, the number of understanding percentage is quite various.

Data at table 3 is almost same as data at table 2. The average percentage is 51, 47% and belongs to an adequate category. Based on the understanding concept on each question item, there are three numbers that have a low percentage, namely number 2, 7, and 9. Percentage of number 7 and 9 does not reach 30%. Meanwhile, on other numbers, concept understanding has an adequate category.

Understanding percentage at low categorized school is almost same as at medium categorized school. Percentage of students' concept understanding on the material of heat and temperature is 48, 83% and it belongs to a low category. Most of the questions have 50% on its percentage (low). The low understanding concept is found at question number 1, 2, 4, 7, and 9 while other numbers belong to an adequate category.

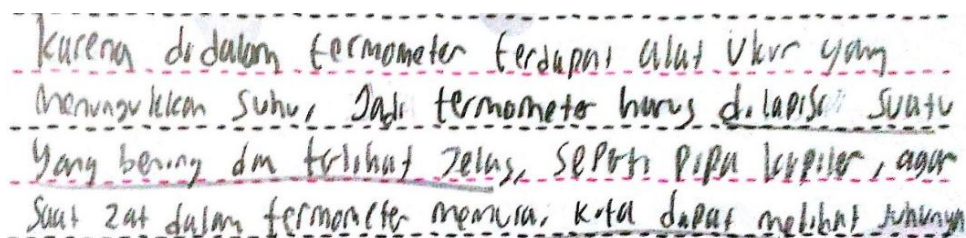
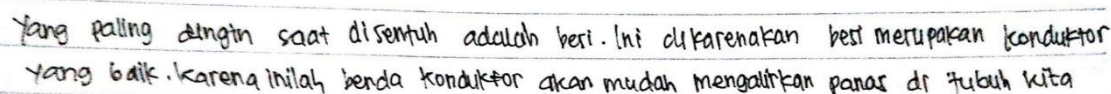


Figure 1. The example of students' answer that not understood the use of capillary pipe in making a thermometer.

Questions in the low category in three schools (high, medium and low categorized school) can be found at number 2, 7 and 9. The question at number 2 discusses the selection of capillary pipe in making a thermometer. In this question, students have not understood what capillary pipe is, the difference between capillary pipe and other pipes and its use in making a thermometer. The example of students' answer on number 2 can be seen in Figure 1.

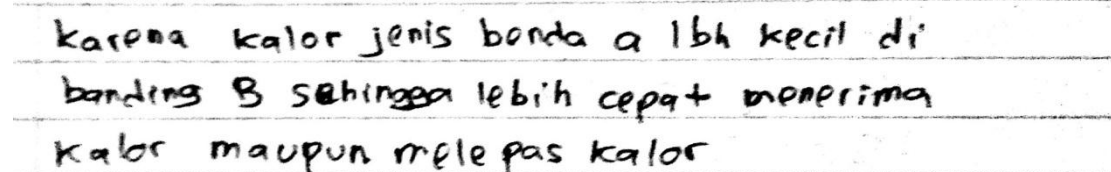
Besides number 2, number 7 has also low concept understanding. This question discusses the influence of thermal conductivity value on the heat transfer conductively. In this question, students are asked to select things (steel, wood, and glass) that have a cold sense if those previously have the same temperature. Commonly, students answer by differentiating things into 2 categories, namely conductor and isolator without seeing at the factor of thermal conductivity. Students still suppose that if isolator thing has zero value on its thermal conductivity. There are also students who answer by observing the value of specific heat. The example of students' answer on the low concept understanding of thermal conductivity can be seen in Figure 2.



Yang paling dingin saat disentuh adalah besi. Ini dikarenakan besi merupakan konduktor yang baik. Karena inilah benda konduktor akan mudah mengalirkan panas di tubuh kita.

Figure 2. The example of students' answer that not understood thermal conductivity concept.

In a study identified concepts of heat and temperature held by adolescents, adults, and scientists [19]. Many students believed that metals 'conduct,' 'absorb,' 'trap' or 'hold' cold better than other materials. Another number that has a low understanding concept is on number 9. This question contains the influence of heat capacity value towards an object. Students are ordered to explain why thing A is faster to be cold than thing B whereas both are heated with same source and time. In this question, many students have not been able to differentiate the concept of specific heat and heat capacity so that they are still wrong in understanding concept. Many students who still answer these questions based on the comparison of the value of its specific heat. The example of students' answer can be seen in Figure 3.



karena kalor jenis benda a lbh kecil di banding B sehingga lebih cepat menerima kalor maupun melepas kalor

Figure 3. The example of students' answer that not understood heat capacity concept.

The most of the students compare the concept of heat and temperature with the cold and hot phenomenon in which students have not understood yet the balance concept of thermal, specific heat and heat capacity [25]. Incorrect responses demonstrated a confusion between temperature, total heat transfer, and conductivity [26]. One of the two students who worked through conductivity still attributed the feeling of coldness to specific heat.

The low concept understanding can emerge misconception. Another researcher identified students' misconception on the material of heat and temperature. Misconception profile that happened states that heat is not energy, heat is same as temperature, heat can not be measured, the temperature can be transferred, the cold thing does not have heat, the temperature is certain character owned by material or thing and water can reach the temperature of 0°C [27].

According to examiner report of West African Senior School Certificate Examination (WASSCE) in WAEC (2007, 2008) states that the weakness of physics can be recognized from the lack of knowledge of basic principles, concept, law, and application to explain and to solve physics problems. This matter is because of bad understanding of physics concepts. That situation might emerge from some causes; one of them is students' misconception (a situation when the individual idea is different with the idea, view, and explanation of science) on physics concept [28, 29].

Study on students' understanding about physics concept shows that many students have misunderstanding concept. The concept is a basic knowledge of physics. Students' misunderstanding can widely interrupt meaningful learning and work on physics learning process [30- 33].

Concept understanding is a skill to remember and to explain again a definition, special character, essence, gist, and content with their own words. However, it must not change the real meaning of the information received. Understanding is a skill to explain something with own words [34].

In the learning process, students need to understand the concept well. It is related to the understanding of physical meaning of the received concept and its application in daily life [35]. There are 2 kinds of understanding based on its characters, namely conceptual understanding and algorithmic understanding. Both understandings can not be separated in learning science completely. Conceptual understanding is based on talks or diagram understanding. It needs students to involve basic concepts of science theory [4].

Concept understanding in physics learning process is very important because it relates to the students' skill to solve problems. Conceptual understanding helps students to solve problems, to develop

problem representation and to minimize solution searching by matching scheme or condition. It represents its character of problems and actions in procedural memory to deliver a satisfying result [36].

Based on the statement above, if people have better conceptual understanding, it makes them recognize the meaningful system and problem concept at a deeper level. Besides conceptual knowledge, procedural knowledge is also required to get maximum learning result.

To know students' concept understanding on the material of heat and temperature, it uses extended response test through essay question. The essay question is selected because of its advantages that can find out students' skill deeper. An essay test demands students to plan their own answers and to express it with their own words. Meanwhile, objective test question asks students to choose their alternative answers. In addition, the students study more seriously and thoroughly to prepare an examination in the form of essay test than an objective test [13]. Therefore, this test form is quite suitable to know students' concept understanding.

Despite having the advantage in recognizing students' concept understanding, essay question has weaknesses in the matter of assessment subjectivity. To reduce its subjectivity, it can be conducted by making scoring guidance in detail and clear. Therefore, the score will be relatively same. In essay scoring, the researcher uses graded assessment technique from score 10, 8, 6, 4, 2, 1, and 0.

The essay question is based on learning indicators in syllabus and lesson plan. The essay question is then validated to the expert lecturers. After essay question has been declared proper, it is then tested to the 10th-grade students at high, medium and low categorized school. Through essay question, a profile of students' concept understanding on the material of heat and temperature can be analyzed. Moreover, from this question, a profile of students' concept understanding that tends to students' score can be recognized.

4. CONCLUSION

Based on the research result and the data analysis, students' concept understanding on heat and temperature as follows: (1) The average percentage of students' concept understanding at high categorized school is 60,66%, at medium categorized school is 51,47%, and at low categorized school is 48,83%, (2) Most students have misconception on basic concept of heat and temperature such as heat capacity, thermal conductivity, and expansion concept. The result is expected to be a suggestion in physics learning process, especially on heat and temperature in order that student' concept understanding will increase. Moreover, the result is expected to be a reference for the same research in the future.

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