A profile of physics multiple representation ability of senior high school students on heat material

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Abstract. In physics learning, students need to be trained to develop multiple representations of ability. Physics multiple representation ability is a good and developing method to instil conceptual understanding, solving physics problems and difficulties caused by a large number of involved mental images. This research is pre-experiment research. The main objective of this research is to analyze the profile of senior high school students' physics multiple representation ability on heat material. The subjects of this research were senior high school students in Indonesia. The sample of this research was 93 students of class X senior high school, first year. Determination of the sample in this research using purposive sampling. The Physics Multiple Representation Test Instrument (PMRTI) to determine the profile of senior high school students' physics multiple representation ability on heat material. PMRTI consists of three indicators: verbal representation, mathematical representation, and visual representation. In the case of this research, the profile of senior high school students' physics multiple representation ability on heat material is generally still at a low level. The implication of this research can be used as empirical evidence that senior high school students' physics multiple representation ability on heat material still needs to be improved.

1. Introduction
Physics is the heart of the development of information and communication technology that has fundamentally changed human life. Based on global and historical views, physics provides more dynamic methods of helping humans solve the complex problems of life. It was found that many students studying physics were not interested and had no understanding after learning physics [1-3]. If viewed from the student's opinion, educators are required to present meaningful physics learning, and the younger generation is interested in learning it.

Student competence is formed when students are actively involved in their mental, physical, and social activities. Physics subjects indicate that learning must be student-centred based on scientific activities. Students need to appreciate the attitudes, knowledge, and skills they get from learning and
then adapt to their experiences through multiple representations. Students will learn more effectively and efficiently when they are active in processing information with multiple representations [3-7].

In physics learning, students need to be trained to develop multiple representation ability. Multiple representation ability is a good and developing method to instil conceptual understanding, solving physics problems and difficulties caused by a large number of involved mental images [7-8]. The form of multiple representation ability in physics is the ability to solve physics problems with various representational processes, namely mathematical, verbal (written or oral), and visuals (notation, pictures, and graphics) [9-11]. The main function of multiple representation ability in learning for students, namely: as a complement to cognitive processes, limiting interpretations between representations, and building understanding [12-13].

Reviewing the importance of multiple representation ability for high school students. So there is a need for research that focuses on looking at the profile of senior high school students' physics multiple representation abilities, especially in heat material. The results of this study are expected to be empirical evidence in the development of research in the field of physics education, especially multiple representation ability.

2. Method
2.1 General Background of Research
This research is pre-experiment research. The main objective of this research is to analyze the profile of senior high school students' physics multiple representation ability on heat material.

2.2 Sample of Research
The subjects of this research were senior high school students in Indonesia consisting of 93 students of class X senior high school, first year. Determination of the sample in this research using purposive sampling.

2.3 Procedure
This research procedure consisted of: (1) the researcher conducted a literature study related to multiple representation ability; (2) the researcher focuses on finding indicators and assessments of multiple representation ability in the field of physics; (3) researchers developed a draft Physics Multiple Representation Test Instrument (PMRTI) to determine the profile of senior high school students' physics multiple representation ability on heat material; (4) the researcher gave three experts to validate the Physics Multiple Representation Test Instrument (PMRTI); (5) The researcher revised based on input from the three validator experts; (6) The researcher measured 93 students using the Physics Multiple Representation Test Instrument (PMRTI) to determine the profile of senior high school students' physics multiple representation ability on heat material; (7) the researcher conducted an analysis and conclusions based on the results of the Physics Multiple Representation Test Instrument (PMRTI).

2.4 Instruments
In this research, using the Physics Multiple Representation Test Instrument (PMRTI) to determine the profile of senior high school students' physics multiple representation ability on heat material. PMRTI consists of three indicators: verbal representation, mathematical representation, and visual representation. This instrument has been declared valid and reliable by the three experts. Validation results of Physics Multiple Representation Test Instrument (PMRTI) in Table 1.

| Item Questions | Content Validity | R | Construct Validity |
|----------------|------------------|---|------------------|
|                | Assessment Score C |   | Assessment Score K |
| 1              | 3.00 4.00 4.00 3.67 V | Reliable | 3.00 3.00 3.00 3.00 V | Reliable |
| 2              | 3.00 4.00 3.00 3.33 V | Reliable | 3.00 3.00 3.00 3.00 V | Reliable |
| 3              | 3.00 4.00 3.00 3.33 V | Reliable | 3.00 4.00 3.00 3.33 V | Reliable |
Table 2. Completeness of indicators and students' multiple representations ability on heat material.

| Students Initial | Group 1 | Group 2 | Group 3 |
|------------------|---------|---------|---------|
|                  | Value   | Criteria | Value   | Criteria | Value   | Criteria |
|                  | IC      | IC      | IC      | IC      |
| A1               | 8.00    | Low     | 8.00    | Low     | 8.00    | Low     |
| A2               | 8.00    | Low     | 8.00    | Low     | 8.00    | Low     |
| A3               | 8.00    | Low     | 8.00    | Low     | 8.00    | Low     |
| A4               | 8.00    | Low     | 8.00    | Low     | 8.00    | Low     |
| A5               | 4.67    | Low     | 2.67    | Low     | 8.00    | Low     |
| A6               | 8.00    | Low     | 8.00    | Low     | 6.67    | Low     |
| A7               | 8.00    | Low     | 8.00    | Low     | 8.00    | Low     |
| A8               | 8.00    | Low     | 8.00    | Low     | 6.67    | Low     |
| A9               | 8.00    | Low     | 2.67    | Low     | 8.00    | Low     |
Based on Table 2, it has been shown that students' physics multiple representation ability on heat material is in the low category in all classes. As many as 93 students did not have a score above 8.00. All students also did not achieve completeness for the physics multiple representation ability indicators on heat material. PMRTI consists of three indicators: verbal representation, mathematical representation, and visual representation. All indicators are still in the low and incomplete category. It shows that the profile of senior high school students' physics multiple representation ability on heat material is still low.

It is possible for students who lack understanding of a concept will experience difficulties in working on multi-representation questions. Furthermore, students need concepts to interpret and connect each representation, which is a constituent element of multi-representation ability [14]. The solution for students who are still lacking is remedial learning effectively in learning to activate meaningful physics learning skills. In line with the results of research by Gunel et al. [15] found that multiple representation ability will create a learning atmosphere with an active role in all the potential of students, activate students' learning abilities, both minds-on and hands-on so that physics learning is more meaningful. Besides, students must gain an understanding of the concept and need learning activities that can present the concepts they have in their entirety with multi-mathematical, visual, and verbal representations (physics multiple representation ability) so that they succeed in achieving the desired competencies. Problem-solving skills cannot be separated from the contribution of multiple representation abilities [16-19]. The results showed that students who have good multiple representation abilities would also consistently have good problem-solving skills [20].

The results of this study indicate that students are still very weak in implementing the multiple representation ability of physics, especially in solving the physics problem of heat material. An alternative solution to the problem of the low physics multiple representation ability is to implement physics learning which by design has been proven valid, practical, and effective to improve students' physics multiple representation ability. Existing innovations that can still be developed are the results of research by Siswanto et al. [21-23] which found an Investigated Based Multi Representation model
with the following syntax: (1) Paying attention to the explanation; (2) Investigation activities; (3) Involving in multiple representations; (4) Doing problem-solving activities. The results of research by Ibrahim & Rebello [24] using approaches to nondirected tasks proved to be effective. The results of research by Huda et al. [25] with multi-representation learning tools have proven successful. Haratua & Sirait's [26] research results with representations based physics instruction proved to be effective and successful. Besides, there are also the results of research by Bimba et al. [27] using physics problem representation implementation. The problem of the lack of students' multi-representation ability to solve physics problems can be overcome by providing new and challenging experiences for students [28-29]. There have been many alternative solutions that can be used for teacher adaptation. Teachers still need to modify based on the characteristics of students in Indonesia, because differences in social, cultural, language and infrastructure backgrounds will affect the effectiveness of learning innovations that will be used to improve the physics multiple representation ability of senior high school students, especially in heat material.

4. Conclusion

In the case of this research, the profile of senior high school students' physics multiple representation ability on heat material is generally still at a low level. The implication of this research can be used as empirical evidence that senior high school students' physics multiple representation ability on heat material still needs to be improved. The limitations of this research are still using 93 senior high school students. Further research needs to be done to solve the problem of the low level of senior high school students' physics multiple representation ability on heat material.

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Adin conducted an experiment by heating water with a first mass of 2 kg, a second mass of 4 kg, and a third mass of 6 kg. It is known that the specific heat of water is 4.200 J/kg °C. Complete the questions below:

1. Analyze the experiments conducted by Adin, determining the value of the total heating capacity of water. Hint: determine the heating capacity of the water from each experiment.
2. Make a graph of the relationship between mass and heat capacity as a solution to the above problems. Hint: graph of the relationship of mass (kg) and heat capacity (J/°C)
3. Perform an analysis of Adin's experiments by answering the following questions:
   a. When the object's water mass is enlarged and its specific heat remains. How about the heating capacity value of water?
   b. When the object's water mass is reduced and its specific heat remains. How about the heating capacity value of water?

Tri conducted an experiment by heating ice with a first mass of 2 kg, a second mass of 4 kg, and a third mass of 6 kg. It is known that the specific heat of ice is 2.100 J/kg °C. Complete the questions below:

4. Analyze Tri's experiments by determining the total heating capacity value of the ice. Hint: Determine the heat capacity of the ice for each experiment.
5. Graph the relationship between ice mass and heat capacity as a solution to the problem above. Hint: Graph of the relationship between ice mass (kg) and heat capacity (J/°C)
6. Analyze Tri's experiments by answering the following questions:
   a. When the object's ice mass is enlarged and its specific heat remains. How about the value of the heating capacity of ice?
   b. When the object's ice mass is reduced and its specific heat remains. How about the value of the heating capacity of ice?

Marwati heated 0.1 kg of ice from -10 °C until all of it became water at 0°C. It is known that the melting heat of ice = 3.36 x 10^5 J/kg, the specific heat of ice = 2.100 J/kg °C. Complete the questions below:

7. Analyze the experiments conducted by Marwati, determining the amount of heat needed for the ice to reach a temperature of 50°C. Hint: determine the heat at each phase of the ice change process.
8. Make a graph of the effect of heat on changes in the form of ice as a solution to the above problems. Instructions: Graph of the relationship of heat (J) to changes in temperature (°C)
9. Perform analysis of the experiments conducted by Marwati, by answering the following questions:
   a. When the heat given to the ice gets bigger. What is the state of the temperature of the object when the object changes form?
   b. At 0°C the ice temperature does not change even though it continues to be heated. What happens to the ice when it continues to heat up at 0°C?

Hadi heated 0.1 kg of water from 50°C until all of it became steam at 100°C. It is known that the heat of water vapour = 22.6 x 10^5 J/kg, the specific heat of water = 4.200 J/kg °C. Complete the questions below:

10. Analyze Hadi's experiments by determining the amount of heat needed by water to a temperature of 50°C. Hint: determine the heat at each phase of the water change process.
11. Make a graph of the effect of heat on changes in water form as a solution to the problem above. Instructions: Graph of the relationship of heat (J) to changes in temperature (°C)
12. Analyze Hadi's experiments by answering the following questions:
a. When the heat given to the ice gets bigger. What is the state of the temperature of the object when the object changes form?
b. At 100°C the water temperature does not change even though it continues to be heated. What will happen to water when the water continues to heat up at 100°C?

Waluyo conducted an experiment by obtaining experimental data as below.

| Number | \(m_{\text{water}}\) (gr) | \(m_{\text{ice}}\) (kg) | \(T_{\text{water}}\) (°C) | \(T_{\text{ice}}\) (°C) | \(T_{C}\) (°C) | \(c_{\text{water}}\) (kal/gr °C) | \(c_{\text{ice}}\) (kal/gr °C) |
|--------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1      | 20              | 40              | 25              | 5               | 15              | 1               | 0.5             |
| 2      | 40              | 40              | 35              | 5               | 25              | 1               | 0.5             |
| 3      | 60              | 40              | 65              | 5               | 50              | 1               | 0.5             |

\(T_{C}\) = Temperature of mixture

If only the heat exchange occurs between water \((m_{\text{water}})\) and ice \((m_{\text{ice}})\). Complete the questions below:

13. Analyze Waluyo's experiments by determining:
   a. The heat provided by water
   b. The heat received by the ice
      Hint: determine the temperature of the mixture to determine the amount of heat provided by water and received by ice.

14. Make a graph as a solution to the problems above. Instructions: Graph of the heat relationship given by water to the heat received by ice.

15. Analyze Waluyo's experiments by answering the following questions:
   a. If water that has a higher temperature is mixed with ice at a lower temperature, then what is the final temperature of the water and ice mixture?
   b. How is the relationship between the heat provided by higher temperature water and the heat received by lower temperature ice?

A piece of iron with a mass of 100 grams and a temperature of 100°C is put into water with a mass of 100 grams and a temperature of 25°C. From the results of this experiment, the specific heat of iron is 450 J / kg °C. (Only water and iron are exchanged for heat and specific heat of water 4.200 J / kg °C). Complete the questions below:

16. Perform a thermal temperature analysis of the iron immersed in water. Hint: Determine the thermal temperature of the iron and water mixture.

17. Make a graph as a solution to the problem above. Hint: graph of the relationship between heat and temperature changes °C.

18. Analyze the experiment, answering the following questions:
   a. If iron which has a higher temperature is mixed with water at a lower temperature, then what is the final temperature of the mixture of iron and water?
   b. How is the relationship between the heat provided by a higher temperature iron and the heat received by lower temperature water?