

Development of multi-representation learning tools for the course of fundamental physics

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Abstract. This research is aimed at designing a learning tool based on multi-representation that can improve problem solving skills. It used the research and development approach. It was applied for the course of Fundamental Physics at Universitas PGRI Semarang for the 2014/2015 academic year. Results show gain analysis $\langle g \rangle$ value of 0.68, which means some medium improvements. The result of t-test is shows a calculated value of 27.35 and a table t of 2.020 for $df = 25$ and $\alpha = 0.05$. Results of pre-tests and post-tests increase from 23.45 to 76.15. Application of multi-representation learning tools significantly improves students' grades.

1. Introduction

Most of the materials in the course of Fundamental Physics are abstract that they require proper descriptions as to make them understandable. The old method of verbal explanation and mathematical expression present some problems for students to understand the materials better. According to Keller (1998), there are some reasons that make students fail to attain certain levels of problem solving skills. For one, they often worry that they may not be able to solve the problems. This is compounded by certain learning techniques that do not really help.

Students need to learn how to solve problems. It is the ways that students try and solve problems that this research refers to as problem solving skills. Problem solving skills allow students to determine the problem, choose the proper technique for certain situations, and think about the possible solutions. Problem solving skills is essential for both individuals and teams as this enable him/her or a team to deal with the problem he/she or they face and use the proper techniques necessary to finally solve problems they are dealing with as effectively as possible. Using multi-representation is deemed the key to success of understanding certain disciplines. There are two motivations to consider when it comes to multi-representation based learning; (1) how students use multi-representations to solve problems, and (2) what the best techniques to help students understand problem solving using multi-representation are.

The problem of this research is how does multi-representation learning model help students improve their Physics problems solving skills? The stages of this research as to make it more focused are; (1) confirming the validity of multi-representation based physics learning tools, and (2) ensuring the effectiveness of multi-representation based learning in instilling Physics problems solving skills.



Multi-representation in teaching and learning has the potential of creating a learning environment in which students actively make the most of their learning abilities, both minds-on and hands-on. This will make learning Physics a meaningful experience. Mayer (2003:125) states that multi-representation learning allows the formation of meaning in the works of the memory that enable students to simultaneously percept words and images. The various representation formats in learning certain concepts allow proper understanding of those concepts and the subsequent communicating process. In Physics, these means better understanding of how systems and processes work, and then communicating them to fellow students or teachers (Meltzer, 2005:463). Representation allows students to gain knowledge and solve problems. Hence, it can be inferred that high quality representation in solving problems is an adequate condition for an effective learning process to take place.

In the context of problem solving, Bodner and Domin (in Rosengrant, Van Heuleven & Etkina, 2006) differentiate internal representation to that of external representation. Internal representation is the way a person who tries to solve problems stores internal components in his/her mind (the mental model), whereas external representation relates to symbolizing or representing objects and/or processes. Therefore, representation is used to recall memory via description or imagination (Chittleborough and Treagust, 2006). Misunderstanding of concepts is caused by representation (visual-spatial) disorder that can be both internal and external in nature (Wu and Shah, 2004).

2. Research Method

This research is R and D in nature that employs the procedures of; (1) find and gather information on the needs for development, (2) plan the components to develop, determine goal, decide stages, and design measuring scale, (3) make an initial design as a model, (4) validate this conceptual model with the help of experts and practitioners, and conduct initial testing of the model/ stage I, (6) revise that initial model based on data analysis results, (7) conduct extended testing/stage II, (8) revise the model from stage II and refine it, should it is not satisfactory, and (9) write a report and disseminate it (Bord and Gall, 1989:784). Fig. 1 provides detail stages of this research.

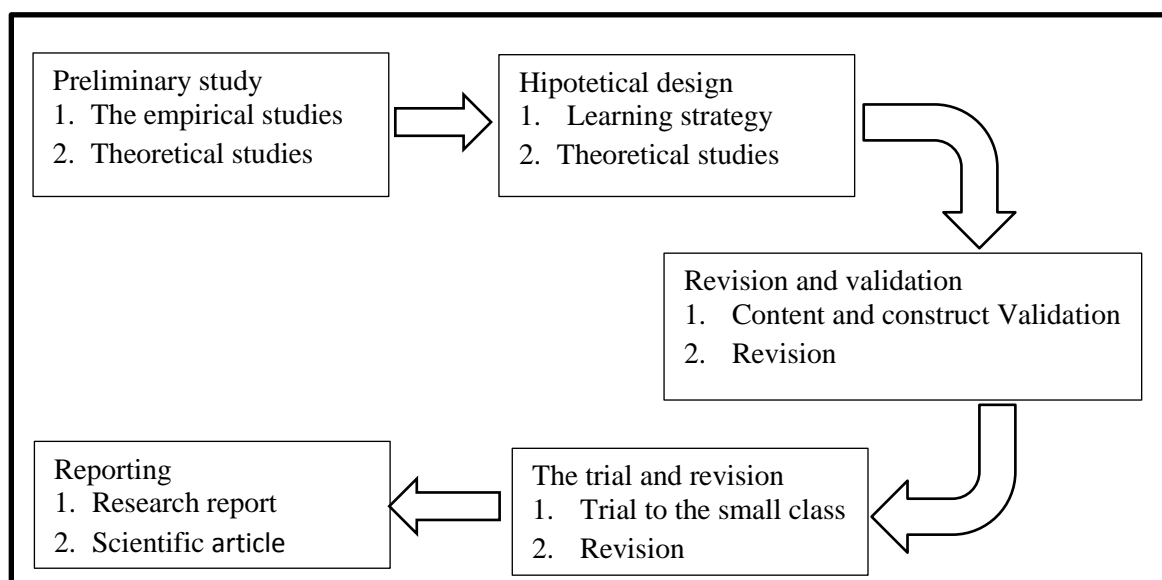


Figure 1. Stages of the research.

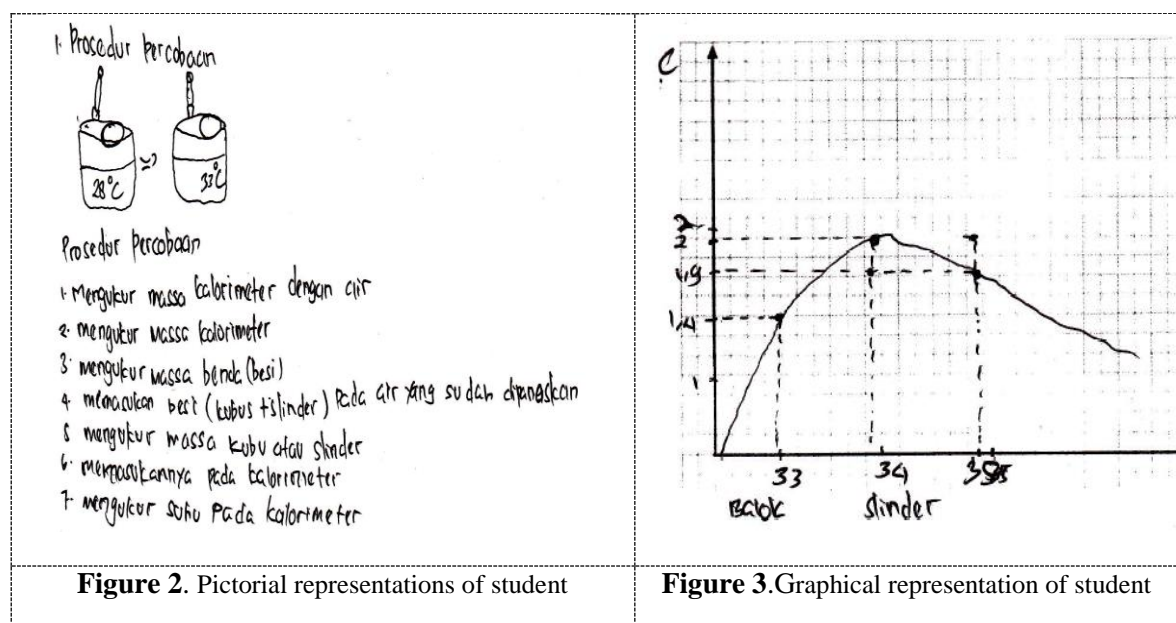
3. Analysis and discussion

This research started with preliminary empirical and theoretical studies. The empirical study relates to experiences of the learning process in the classroom, whereas the theoretical study concerns peering through earlier studies conducted by the other researchers. The specific material discussed in this research is specific heat. The next steps after empirical and theoretical studies are planning for hypothetical teaching strategies and arranging of tools. The teaching instruments include syllabus, course credit, student worksheet, material sheet on specific heat, and validation instrument.

The prepared instruments are then validated by a panel of experts. Once it is confirmed and given a go, the next step is teaching using the instrument. The students were Educational Physics students from class 2B at Universitas PGRI Semarang.

The introduction part consists of; (1) opening activity and check the presence, (2) providing examples of specific heat in daily life, and (3) check students' schemata on specific heat. The content part includes: (1) asking students to check two types of metal, (2) asking students to write the description of specific heat, (3) assigning students for group discussion, (4) preparing students for experiment, (5) observing students conducting experiments, (6) getting students to explain their result, (7) asking the student to decide the specific heat of the two metals and display them on a graph, (8) facilitating students in the discussion of the results. The closing part comprises of; 1) giving conclusion from the experimental results, and 2) evaluating the learning process.

In learning process, students try to make the representations in various forms. Among those who made the student is in the form of pictures and graphics. From the fig. 2 and fig. 3, students are taught to represent the process as well as the concepts of physics and students can represent picture and graphic form.



From the table 1 below, calculation of gain index shows an increase from prior to learning to after learning. The resulting $\langle g \rangle$ is 0.68. According to Hake, this belongs to the medium category. This is in line with the statement by Ainsworth (1999:131) who says that multi-representation is imperative to improve the ability of developing scientific concepts and methods. Results of difference analyses show counted t at 27.35 and table t at 2.020 for $df = 25$ and $\alpha = 0.05$. There is a significant improvement of

both pre and post test results from 23.45 to 76.15. Hence, it can be said that implementation of multi-representation learning tools significantly improves students' grades.

Table 1. Grades of class 2B students.

Item	Pretest score	Post-test score
Average	23.46	76.15
Total	610	1980
S.D	7.58	8.52

Multi-representation learning process has been conducted using the already developed instrument. This learning process involves introduction, content, and closing stages. There were two observers during the implementation of multi-representation learning in the classroom. Observer I stated that 50% of the techniques were covered during the introduction part, whereas Observer II said it was 100%. Both observers further agreed that the content stage covers 100% of the lesson objective. And they also agree again on the closing stage, by stating that it reached 100% of the target.

4. Conclusion

It can be inferred from comments from the observers that the multi-representation learning tools implemented for the teaching of specific heat in Physics class 2B of Universitas PGRI Semarang has been a success. It has been proven that this is a good method to help students improve their problem solving skills.

Acknowledgment

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5. References

- [1] Ainsworth, S 1999 The Function of Multiple-Representations *ESRC Centre for Research in Development, Instruction and Training* 1-16.
- [2] Chittleborough and Treagust 2006 *The modelling ability of non-major chemistry students and their understanding of the sub-microscopic level*
- [3] Duit R, Treagust D F, and Widodo A 2008 Teaching science for conceptual change in S Vosniadou (Ed) *International Handbook of Research on Conceptual Change* (New York: Routledge)
- [4] Gall M D and Borg W R 1989 Educational research: an introduction. Fifth edition. (New York: Longman) **784**
- [5] Keller K I 1998 Strategic Brand Management: Building, Measuring, and Managing Brand Equity (New Jersey: Prentice Hall)
- [6] Mayer R E 2003 The promise of multimedia learning: using the same instructional design methods across different media 125–139
- [7] Meltzer D E 2005 Relation between Students' Problem-Solving Performance and Representational Format *American Journal of Physics* **73** 5 **463**
- [8] Rosengrant D, Etkina E, and Heuvelen A 2007 *An Overview of Recent Research on Multiple Representations* (New Jersey: The State University of New Jersey)
- [9] Wu H K and Shah P 2004 Exploring visuospatial thinking in chemistry learning *Science Education* **88** 465–492