The problems of integrating multiple representation skills in physics learning

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Abstract. This is a preliminary research to find out what problems exist in physics learning related to students' ability in understanding the concept of physics with multiple representation learning approaches. Problem analysis is carried out in conjunction with physical content analysis and analysis of student characteristics based on data collected from interviews, observation and literature review. Of the 100 high school students in Padang who were interviewed and given a questionnaire, 80% of students did not understand the physical concepts of physics formulas that had been studied, mathematical formulas and equations in physics actually made them not understand the learning material and they hate physics subjects and assume that physics subjects are difficult subjects. Observation results indicate that 78% of teachers have used a multiple representation approach but it is not effective to improve understanding of the concept of physics. Literature review show that concept understanding will be more optimal if the approach in learning is presented in an interactive and interesting form as can be done if using ICT in learning. The results of this study then will be used as material in further research on the development of multiple representation modeling learning models to solve problem in physics learning.

1. Introduction

Many school students perceive that physics is a frightening lesson [1][2][3]. This perception is formed by various sources including parents, family, friends, and even teachers. Ornek, Robinson, & Haugan, [2] added that students felt difficulties with physics because they had to overcome differences in representations such as experiments, formulas and calculations, graphs, and conceptual explanations at the same time. In addition, they must transform between them. For example, students must be able to transfer from a graphical representation to a mathematical representation. This is a problem for students due to the lack of mathematical skills possessed by students [4].

Besides the reasons behind students' fear of physics as explained above, another reason that causes students to feel that physics is difficult and frightening is stated by Jackson [5] Redish [6] physics as a discipline requires students to use various methods of understanding and translating from one form to another in the form of words, table numbers, graphs, equations, and diagrams. Multi representation of mathematical equations is key in understanding physics [7][8] and understanding physics is hampered due to lack of mathematical skills. This problem is evidenced by Neves's et al [9] research results which shows that at the University of Lisbon's Faculty of Science and Technology there is often a high level of student failure in completing physics exams due to a lack of understanding of basic concepts of physics and mathematics, even students who have succeeded are aware that their understanding is
still limited. Entrance test results from the University of Lisbon's School of Science and Technology show that less than 30% of students who can take physics major and only 10% of them are believed to have good abilities in physics and are able to associate physical material on mathematical topics. The teaching implications made by the teacher in helping students understand the material of physics learning by using mathematical abilities is by preparing learning that can develop mathematical structural skills, namely the skill in placing mathematical knowledge appropriately to deal with situations in physics. To develop structural skills can be done by mathematical modeling or problem solving or problem solving approaches [10]. Mathematical-physics relationship analysis shows that mathematics is very important in solving physical problems, although the "language" of mathematics in physics is not as meaningful as that used in mathematics lessons [11]. Rohman, Erwin, & Effendi [12] and Pinsky & Galili [13] found a relationship that mathematics and physics support each other, good students in mathematics will be easier to understand physics.

The importance of mathematical understanding in forming multiple representation abilities in understanding physics lessons needs to be studied in Preliminary Research to get an ideal instructional design in developing multiple representation modeling learning models to solve problems in physics learning.

2. Literature Review

2.1. Previous research

Neves et al [9] research examines the learning of science and mathematics with explorative and interactive modeling aims to be able to produce science and mathematics learning activities in computational modeling so that it is adopted by secondary schools or colleges. Neves and his colleagues sought to develop learning activities with computational modeling in science and mathematics learning with explorative and interactive character. These activities are designed to emphasize cognitive conflict in understanding physics concepts, manipulating multiple representations of mathematical modeling and influencing analytic and numerical approaches applied to solve problems in physics and mathematics.

Other research relevant to multiple representation-based learning activities is carried out by Sarabando et al [14]. In his research he compared the effectiveness of learning from three treatments, 1) learning only with experimental activities, 2) learning to use experimental activities and computer simulations using Modellus software, and 3) learning only with computer simulations. The result is that grade 7 students in physics and chemistry learning have the ability to understand physics concepts that are high in learning using computer simulations, whether it is used alone, or combined with experimental activities. From the findings of this study it can be understood that the achievement of students' understanding also depends on the ability of teachers to use computer simulations in teaching the concept of physics.

Relevant to the multi-representation aspect in understanding the concept of learning also presented by Kurnaz and Arslan [15] which examines the effectiveness of multi representation in learning the understanding of physical concepts about energy. From the results of his research he suggested using several representations such as tables, data-meaning tables, conceptual change texts, concept maps and analogies to enhance students' conceptual understanding of the concept of energy.

2.2. Multiple representation

Multiple representations of mathematical equations in physics are developed to provide scaffolding to students' learning processes in concrete physical situations from forms of abstract representations of a mathematical equation used in physics. Associated with multiple mathematical equation representations Hinrichs [16] describes how the system scheme can function as a conceptual link between pictorial representation, graphs and free diagrams, to help students better understand the application of Newton's third law.
The concept of multiple representations of mathematical equations in physics should be done with interesting objects [17] the use of interesting objects and various types of interactions between objects has an important role in understanding the problems of students in solving problems [18]. Interesting objects and various types of interactions between objects will support the construction of deeper understanding when students are able to integrate information from various representations of the equation.

The use of multiple representations in the learning process is often associated with modeling approaches to understanding physics equations [19], which emphasize the development of good conceptual understanding through diagrammatic and graphical representations before turning to algebraic understanding of solving the problem of the equation itself. Equation representation modeling is seen as more effective as a medium and approach to learning in understanding students related to the physical meaning of the equation. Wong, et al [17] provides an appropriate visualization of modeling to represent problems based on several topics in physics. The classification of representation visualization for each physics material can be presented in Table 1.

| Physics Content     | Visual Representations            |
|---------------------|-----------------------------------|
| Kinematic           | Motion diagrams                   |
| Force and Dynamic   | Free-body diagrams                |
| Energy              | Energy bar charts                 |
| Fluid               | Field line/vector diagrams        |
| Electrical circuit  | Electrical circuit diagrams       |
| Optic geometric     | Ray diagrams                      |
| Wave                | Wavefront diagrams                |
| Quantum physics     | Energy level diagrams             |

3. Research Methodology

3.1. Research design
The design used in this study is a case study [20][21] this design is used to analyze descriptively about a broad problem related to the difficult assumptions of physics subjects because it uses several different forms of representation such as experiments, formulas, calculations, graphs, conceptual explanations of equations by high school students throughout Padang City.

3.2. Sample
The sample in this study consisted of 100 student respondents and 50 physics subject teachers from 53 high schools in Padang City who were randomly selected.

3.3. Data collection instruments
Instruments used to collect data in this study are: interview sheets and questionnaire sheets used to see the problems that arise in the difficulties of students and teachers in physics learning related to multiple representations of mathematical equations in physics subjects.

4. Research Result

4.1. Students understanding about physics concepts
Students' perception of the difficulty of understanding physics was taken using a questionnaire with basic competency classifications which were given sample questions, and students chose the level of difficulty of the problem and revealed the reasons for their choices. The results of students' perceptions of the difficulty of physics can be seen in table 2.
Table 2. Percentage of students' perceptions of difficulties in physics subjects

| No | Basic competencies                                                                                                                                                                                                                                                                                                                                 | Average | Percentage |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| 3.1 | Understand and apply the nature of the science of Physics, through multiple representations of equations and mathematical concepts to facilitate the understanding of Physics.                                                                                                                                                                                                                     | 3.9    | 78%        |
| 3.2 | Applying the principles of measuring physical quantities, accuracy, accuracy, important numbers, and scientific notation and representing them in tables and graphs.                                                                                                                                                                                                                                                   | 3.98   | 80%        |
| 3.3 | Apply the principle of calculating vector quantities.                                                                                                                                                                                                                                                                                                                                                       | 3.95   | 79%        |
| 3.4 | Analyzing physical quantities in straight motion with constant velocity (fixed) and straight motion with constant acceleration (fixed) and their physical meaning (students are able to represent physical equations into graphs, images, tables, and data).                                                                                                                                                                      | 3.96   | 79%        |
| 3.5 | Analyzing parabolic motion using vectors, following physical meaning and its application in daily life. (students are able to represent physical equations into graphs, images, tables and data).                                                                                                                                                                                      | 3.98   | 80%        |
| 3.6 | Analyzing physical quantities in circular motion with a constant rate (fixed) and its application in daily life.                                                                                                                                                                                                                                                                                             | 4.09   | 82%        |
|     | Total average                                                                                                                                                                                                                                                                                                                                                                                             | 3.98   | 80%        |

Based on data at Table 2, overall the percentage of students' perceptions of the difficulty of physics is 80%, this value is very large for an achievement and becomes a serious problem for students' ability in physics. Based on the results of interviews with students, the main difficulty encountered was the lack of students' understanding of the physical meaning of mathematical equations in physics so that students were not able to represent these equations in the form of graphs, images, data tabulations, and use them to draw conclusions on the experimental activities that students did.

4.2. Observation result

After observing the learning methods conducted by the physics teacher in his class at several schools, it was observed that the teacher had actually used a learning approach with various forms of representation in an effort to understand students. As seen on Picture 1 and Picture 2, From 50 physics teachers observed, 78% of them used various representations such as mathematical equations, graphs, tables, and images. It's just that its use is still rigid, does not make the physics subject matter more interesting and fun so it is still considered less effective to improve understanding of physics concepts. While 22% of other teachers did not use multi representation in teaching, but used lecture techniques and dictated in delivering physics learning material.
4.3. Problem solving analysis

Mathematical modeling through multiple representation approaches to mathematical equations can help students solve problems and understand the physical meaning of the equation itself [3]. With multiple representation modeling can support in constructing a deeper understanding when students integrate information from various representations to achieve insight, because multiple representation modeling is a representation of each system or process by displaying learning in the form of diagrams, tables, equations, text, graphics, animation, sound and video [18] on problems that students find difficult to understand the physical meaning of a mathematical equation. Wong, et al [17] asserted that the application of multiple representations in the learning process plays an important role in student learning by facilitating knowledge acquisition and guiding problem solving so that it leads to the realization of meaningful learning.

Modeling in multiple representations that display diagrams, tables, equations, text, graphics, animation, sound and video in learning no longer has significant obstacles for today's teachers with all the developments of the technology used in learning [22]. The use of IT development in physics learning can be in the form of virtual laboratory-based simulations [23, 24] that can realize learning objectives in physics laboratories and help overcome the difficulties faced by teachers due to time constraints, costs, and labor. Learning objectives certainly lead to understanding the physical meaning of mathematical equations through multiple representation modeling based on the use of IT in physics learning. Sarabando, Cravino, and Soares [14] emphasize the intended learning objectives are learning goals that provide different experiences to students, to help students develop basic abilities, help students understand the concepts of physics, and understand the direct role of the observation method, and develop skills collaborative learning.

Virtual simulations through computers in physics learning have been widely proven in several studies and the results are able to overcome problems related to the difficulty of understanding physics concepts [25]. Almost all physical processes, phenomena and experiments can be reproduced clearly through multimedia means [26]. This means that almost all materials in physics learning can be simulated or modeled. Examples of material that have been simulated in the study include heavy material and mass [14], projectile motion material [27], oscillation motion material [28], kinematics material [29], Newton's legal material [30], and many other materials.

Simulation learning or modeling learning to represent equations in physics can use a variety of applications or software. Some applications or software have been identified in research as media that can help simulate or model physical phenomena into the screen. Examples of software that can be used in physics learning include Easy Java Simulation [28][31][32][33], Phet [28], Open Source...
Physics (OSP) [28], Physlet [28], Modellus [24][28][33], Interactive Physics (IP) [33], Spreadsheet [34], Interactive Simulations [28], Dynamic Modeling System [35], Stella [36].

Based on the description above, there is no learning model that directly packs in the learning syntax to combine in the representation of a problem caused by students' difficulties in understanding equations and modeling them by utilizing software that has been developed in learning technology to facilitate students in understanding the problem. From this calculation it is important to make an instructional design summarized in multiple learning models representing problem modeling so that students are able to understand the problems that arise from mathematical equations that exist in physics learning.

5. Conclusion
This is a preliminary research to find out what problems exist in physics learning related to students' ability in understanding the concept of physics with multiple representation learning approaches.

a. 80% of 100 high school students in Padang who were interviewed and given a questionnaire, did not understand the physical concepts of physics formulas that had been studied, mathematical formulas and equations in physics actually made them not understand the learning material and they hate physics subjects and assume that physics subjects are difficult subjects.

b. Observation results indicate that 78% of teachers have used a multiple representation approach but it is not effective to improve understanding of the concept of physics. Literature review show that concept understanding will be more optimal if the approach in learning is presented in an interactive and interesting form as can be done if using ICT in learning.

The results of this study then will be used as material in further research on the development of multiple representation modeling learning models to solve problem in physics learning.

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