Developing a computer simulation to minimize misconceptions in motion concept

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Abstract. In this paper, we report the effort to minimize the students’ misconception in motion concept by developing a computer simulation. This research and development are applied with Borg and Gall methods. In developing a computer simulation, Forced Concept Inventory (FCI) with Certainty Responses Index (CRI) scale is used to detect misconceptions of the students. The steps to develop a computer simulation are: (1) detecting misconception (pre-test), (2) designing and making a computer simulation, (3) validating simulation by an expert, (4) giving a chance to students on giving their opinion to a computer simulation, (5) trying the simulation in physics learning; the last step is (6) committing students’ conception test (post-test). Based on the FCI test, it was found that good conception of the students was 40%; less conception of the students was 20%; misconception of the students was 40%. According to our identification, the misconceptions were found in some motion concept i.e. linear motion, free fall, and parabolic motion. Then, a computer simulation was developing by designing it using Borland Delphi 7.0. After that, it was evaluated by material and media experts. The students gave their opinion about the computer simulation. Finally, a computer simulation was used in physics learning on the students of SMAN 2 Palu. It is found that students’ misconception is decreased about 25% after the computer simulation is applied.

Keywords: physics, misconception, computer, and simulation

1. Introduction

Misconception is a conclusion, which is incorrect, because it is based on a faulty thinking or facts that are also incorrect [1]. Misconception can occur in any field in physics. Common misconceptions are occurring in mechanics and electromagnetism [2]. Misconception can make the students’ conception of physics decreases. Some recent studies show that most of the topics of physics: mechanics, electricity, magnetism, thermodynamics, waves, and optics are the common misconceptions. It is because the physics concept was abstract [2]. It can take the effect of opportunities for students to experience a misconception. Moreover, model of applied learning conducted by teachers is still dominated by conventional physics.

Most of physics teachers applied conventional methods such as direct instruction or cooperative approach in the learning process [3]. The teachers are not used to experiment in the laboratory. It is because the science instruments are not available in the laboratory or the teachers cannot create it [4, 5]. Therefore, this situation makes the students are difficult to understand physics concepts and it can make the students are not keen on this course. According to Koleak et.al. (2014), simulation can be used for overcoming misconceptions because by using it the students can find the concept themselves [6].

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In the Revolution Industry 4.0. Era, the use of digital learning such as a computer simulation in learning physics is one of the important things. Thus, to overcome the misconceptions, the researches use a computer simulation that has not been done in Palu. The use of a computer simulation not only increases students’ conception but also reduces students’ misconceptions.

In this study, we found that the problem of students’ misconceptions in Palu was higher than a computer simulation applied to overcome the misconceptions. This study aims to design and develop a computer simulation of physics to minimize physics misconceptions. This approach is done by identifying misconceptions using Force Concept Inventory (FCI) [7], designing physics simulation, and developing it by employing research and development design.

2. Methods
This research and development were done by employing Borg and Gall methods [8]. In the first step, the students’ conception about mechanics concept was identified using the Forced Concept Inventory (FCI) test with the Certainty Responses Index scale (CRI) [7]. This test contained 10 multiple choice questions and the students give their certainty related answer. As a result, it was identified that there were three categories of students’ conception; they are students know the concept well, students are lack of knowledge, and students have misconception. Based on students’ conception, a computer simulation is designed and made by using Borland Delphi 7.0. In developing the simulation, material and media are evaluated by experts to know its quality, efficiency, and effectiveness. The final simulation then applied in physics learning at the classroom; furthermore, physics students in SMAN 2 Palu give their responses to a computer simulation by filled the questionnaires. Every statement in the questionnaires has a choice and the score for each choice is as follows: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (not agree at all). The FCI test was given to know students’ conception after the computer implementation.

3. Results and Discussion
By applying the Force Concept Inventory with the CRI scale, students’ conception was detected. It was found the categories of students’ conception, they were 40% of misconception, 20% of less conception, and 40% of well-understood the concept. Based on the result, a computer simulation was designed for each question in the test.

![Figure 1. Motion problem in the FCI test](image)

Based on one of the diagnostic tests as illustrated in Figure 1, we found that 70% of students answered that the speed of the red ball when took the BC path was not constant (initial velocity of red ball is zero). Similarly, when a red ball left the table (point C), the majority of students assumed that the ball speed was constant and the trajectory was formed straightly. On the other hand, students also assumed that the blue ball did not coincide with the red ball that reached the floor.

To improve students’ conception, a computer simulation was designed for the motion concept by employing a Borland Delphi program. Figure 2 shows a computer simulation which developed for the case to describe Figure 1.
After this simulation was designed, experts validated material and media by filling out the assessment questionnaire provided. The result of the validation in Table 1 shows that all aspects related to the simulation namely content, presentation, and contextual are in a very good category. Based on this result, the expert of material states that this teaching material is worthy of being tested in the field.

**Table 1. Result of feasibility validation by expert of material**

| Aspect                  | Score | Category   |
|-------------------------|-------|------------|
| Content of Feasibility  | 3.64  | Very good  |
| Feasibility of Presentation | 3.40  | Very good  |
| Contextual Assessment   | 3.63  | Very good  |
| Average                 | 3.56  | Very good  |

The result of media assessment by expert was carried out by the physics lecturer at Tadulako University as reported in Table 2. The aspects assessed from this media included material presentation, language, display of quality, display of design, and implementation. From the result, the media expert states that this teaching material is worthy to be tested in the field.

**Table 2. Results of feasibility validation by expert of media**

| Aspect              | Score | Category   |
|---------------------|-------|------------|
| Display of Quality  | 3.40  | Very good  |
| Display of Design   | 3.80  | Very good  |
| Implementation      | 4.00  | Very good  |
| Average             | 3.73  | Very good  |

To know students’ opinion to this computer simulation, physics learning by using a computer simulation was done. Then, students’ opinion was collected by using a questionnaire. It was conducted on 20 students of SMAN 2 Palu by filling out a questionnaire that had 10 positive statement items with 4 options. After doing the analysis, it was obtained an average score of 3.27 based on Table 3 criteria for students’ response categories, the score referred to the category “strongly agree”. From the result of the questionnaire which shows the strongly agree categories, it can be assumed that the physics
learning media by using simulations which have been developed is worthy to be used as a medium on physics learning.

Table 3. Result of the average analysis of students’ response assessment

| Statement                                                                 | Score |
|---------------------------------------------------------------------------|-------|
| A Computer simulation can motivate me to learn                            | 3.48  |
| I can learn physics actively and independently by using a computer simulation | 3.13  |
| I can learn along with the speed and intensity of my independent learning | 3.06  |
| I prefer to study physics by using a computer simulation rather than just listening to the teacher’s explanation in classroom | 3.13  |
| I can understand the motion concepts by using a computer simulation       | 3.29  |
| I like the appearance or design of a computer simulation because the color composition is matched. | 3.35  |
| The symbol used is easy to understand                                     | 3.13  |
| Using this learning medium can increase the desire to learn                | 3.23  |
| I can use a computer simulation to study everywhere and every time         | 3.23  |
| **Average Score**                                                         | **3.27** |

According to Table 3, we assume that developed a computer simulation was practicality in use, using case examples in everyday life so that it is easier to understand. It can also be used every time and everywhere, it is a medium support for independence learning, and it can increase knowledge about physics concepts [10-11].

By using a computer simulation, users can witness the phenomenon of motion that are occurred. In addition, users can put in different input of scores so that the result obtained can be compared with the previous one. Thus, users who have previously experienced a misconception can form a new concept that follows the physical theory [9-11].

By applying this computer simulation, it is found that the misconception of the students is decreased from 40% to 15% as reported in Table 4. On the other hand, students’ conception is increased from 40% to 80%. Table 4 also shows clearly that less conception of the students is decreased from 20% to 5%. We conclude that the use of a computer simulation improves students’ conception [12-15].

Table 4. Application of a computer simulation in physics learning

| Category            | Pretest (Before Applying CS) | Posttest (After Applying CS) |
|---------------------|------------------------------|------------------------------|
| Understand the Concept | 40%                          | 80%                          |
| Less Conception     | 20%                          | 5%                           |
| Misconception       | 40%                          | 15%                          |

4. Conclusion
We have successfully developed a computer simulation to minimize misconceptions in motion concept by using Borland Delphi 7.0. This simulation is designed for students who have a misconception in motion concept. In the implementation of a computer simulation, it is found that the use of this simulation in physics learning is effective to increase students’ conception. It is also found that the misconception of the students is reduced by using a computer simulation as a tool in studying physics.

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