Detecting and Reducing Science Teacher Candidate’s (STC) Misconception About Motion and Force By Using Force Concept Inventory (FCI) and problem Based Learning (PBL)

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Abstract. This study has been done to 34 science teacher candidates of Teachers’ Training and Education Faculty of Sultan Ageng Tirtayasa University at their first year of study during 2015-2016 school years. This research focused on student’s misconception about motion and force and how Problem Based Learning (PBL) reducing it. Diagnostic test of misconception about motion and force has been detected by using Force Concept Inventory (FCI). FCI had been used in pretest and posttest, and to find the reducing of students’ misconception N-Gain pretest and posttest of each student had been calculated. Quasi experiment one group pretest and posttest had been used as the research method, and Problem Based Learning (PBL) used as the treatment of manipulation. After two weeks learning motion and force with PBL approach, N-gain which obtained prove that misconception about motion and force had been reducing.

1. Introduction

In science education, research on conceptual change has been a central topic in science education literature for more than two decades. Student’s native intelligence mostly has effected by student’s experience in daily life. Mainly student’s conceptual about motion and force come from their common sense belief, which influenced by their daily experience of motion and force itself. Students tend to explain every case of their environment from their own learning perspective. Misconception arises when the intuitions and impression of students are being used to process the information from their environment.

Mostly, students common sense belief about motion and force inappropriate with Newtonian concepts in most respect (Hestenes et al., 1992; Muller and Sharma, 2012). When scientific information or concepts clarified improper way, this could lead to wrong understanding and misconception (Kartal et al., 2011). Based on observation in some of high schools, most of the students learned the most basic Newtonian concepts in wrong way, it making students failed to comprehend the next material in physics course. In the world of science teaching, some research has been done to detect and reduce misconception. In 1992, David Hestenes et al, design an instrument to probe students belief on Newtonian concept, this instrument called Forced Coencept inventory (FCI). Although this instrument was made more than two decades ago, it is still cab be used to detect students’ misconception about motion and force. FCI had been given to more than 1500 high-school students and more than 500 universities in United States (Hestenes et al., 1992). Based on experienced on what had been done in United Stated in using FCI for detecting misconception about motion and
force, it will be interesting if FCI also used to detect misconception about motion and force to science teacher candidates in Indonesia. Banten province as a part of Indonesia had been selected to be a subject for this study because the test to identifying misconception about motion and force never had been done yet.

2. Material and Method
The data of the Misconception about motion and force had been detected by using multiple choices in Force Concept Inventory. Force Concept Inventory (FCI) can be used in three purposes, firstly as diagnostic tool; secondly, to evaluate instruction, for evaluating instruction and finally for final exam. In the first year of FCI had been used 1500 high schools and more than 500 university students in America to identify their misconception about motion and force (Hestenes et al., 1992). In general FCI consist of several topics, which are force, kinematics, Newton’s first law, Newton’s second law, Newton’s third law, principle of action-reaction and kind of force (Poutot and Blandin, 2015). FCI almost had been used in detecting student’s misconception more over two decades and it is still can be used until now because the validity and reliability of FCI had been at very good level (Hestenes et al., 1992).

Method of this research is quasi experiment one group pretest posttest. This research method often described by giving pretest, implementing treatment and giving posttest (Cohen and Ledford, 1994). In this study, the test had been taken before learning process and after the learning process, so that every science teacher candidate followed two test, pretest and posttests. Quasi experiment had been chosen because the aim of the study was to see the reducing of misconception a group of science teacher candidate before and after implementing problem-based learning. 34 Science teacher candidates from Science Education Department school year 2015-2016 had been answering 29 questions from FCI which are given by the lecturing who taught Basic Physics. After two weeks learning process by implementing Problem Based Learning as the teaching method the FCI had been used again to see the reducing of misconception of science teacher candidate.

The performance of science teacher candidate in reducing their misconception in pretest and posttest the normalized gain had been used (Bao, 2006; Wiyono et al., 2012). Since its introduction, the normalized gain has been widely used in assessing students’ performance in pretest and posttest (Bao, 2006). How far the STC’s misconception decreasing after implementing Problem Based learning will be described at result discussion.

$$n - \text{gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Score} - \text{Pretest Score}}$$

3. Result and Discussion
The misconception about motion and force of Science Teacher Candidate (STC) in pretest and posttest had been grading by calculating correct and incorrect answer. Incorrect answers gave information about misconception regarding motion and force of science teacher candidate. In pretest only one question of FCI got the score higher than 50%, the rest of the questions got the score lower than 40%. The description about the number of student answering correct and incorrect answer along with STC’s most common misconception is on table below.
Table 1. STC’s most common misconception along with correct and incorrect answer.

| Item No | Correct Answer | Incorrect Answer | STC’s Most Common Misconception |
|---------|----------------|------------------|---------------------------------|
| 1       | 0              | 34               | Heavier objects fall faster     |
| 2       | 1              | 33               | Greater mass implies greater force |
| 3       | 0              | 34               | Heavier object fall faster      |
| 4       | 4              | 30               | The heavier object exerts greater force |
| 5       | 0              | 34               | Gravity increases as objects fall |
| 6       | 1              | 33               | Last force to act determines motion |
| 7       | 6              | 28               | Last force to act determines motion |
| 8       | 1              | 33               | Gradual/delayed Impetus build up |
| 9       | 1              | 33               | Impetus supplied by “hit”       |
| 10      | 12             | 22               | Circular impetus                |
| 11      | 1              | 33               | Most active agent produces greatest force |
| 12      | 8              | 26               | Only active agents exerts force |
| 13      | 2              | 32               | Most active agent produces greatest force |
| 14      | 10             | 24               | Most active agent produces greatest force |
| 15      | 9              | 25               | Only active agents exerts force |
| 16      | 5              | 29               | Impetus dissipation             |
| 17      | 2              | 32               | Acceleration implies increasing force, gravity increase as objects fall |
| 18      | 1              | 33               | Largest force determines motion |
| 19      | 17             | 27               | Force compromise determines motion |
| 20      | 5              | 29               | Position-velocity un discriminated |
| 21      | 4              | 30               | Velocity-acceleration un discriminated |
| 22      | 20             | 14               | Impetus supplied by “hit”      |
| 23      | 2              | 32               | Force compromise determines motion |
| 24      | 0              | 34               | Last force to act determines motion |
| 25      | 6              | 28               | Force causes acceleration to terminal velocity |
| 26      | 0              | 34               | Loss/recovery of original impetus |
| 27      | 4              | 30               | Impetus dissipation             |
| 28      | 3              | 31               | Motion when force overcomes resistance |
| 29      | 6              | 28               | Mass makes thing stop, motion implies active force |

Almost all of STC have misconception in every topic, which asked by FCI. In topic Gravity which had been appear in number 1, 3, 5, 9, 12, 16, 17 and 22 all of these questions had score below 30%. All of the STC candidate taught that heavier object will fast faster than light object. In kinematics topic which had been appeared in 5 questions which are number 7, 20, 21 23, 24 and number 25 the score gotten also below 30%. Most of STC couldn’t discriminate position, velocity and acceleration. In first law of motion, which is in number 4, 6, 8, 10, 18, 26, 27 and 28, the science teacher candidate taught that largest force determines motion. In second law of Newton, which is appeared in number 6, 7, 24 and 25, the entire STC taught that the last force to act determines motion. In third law of Newton, which is appeared in number 2, 14, 11 and 13, STC taught that greater mass implies greater force.

After detecting misconception of STC about motion and force the learning process continued by doing problem based learning. Science teacher candidate had been given a problem and they did the discussion to solve the problem given. Problem based learning had been chosen due to its successfully implementation in some studies(Poutot and Blandin, 2015). In two weeks learning process, problem based learning successfully in reducing misconception of STC.
One way, which had been done by STC in investigating which one goes faster, heavy object or light object. By dropping the heavy object and the light object at the same amount of height and recorded the time consuming by both objects with video tracker STC proved that both of the objects consuming same amount of time. STC used two objects with different mass but same shape. Video tracker had been used to show the time used for both objects is the same.

![Figure 1](image1.png)

**Figure 1.** Problem Based Learning done by STC

After doing Problem Based Learning in two weeks, STC had been done posttest to see the reducing of misconception about motion and force. Figure 2 below shows the difference amount of the correct answer in answering FCI.

![Figure 2](image2.png)

**Figure 2.** The Recapitulation of correct answer in pretest and posttest STC

Figure above shows the reducing in misconception about force and motion of STC. In posttest most of the questions in FCI had gotten score above 70 %. The decreasing of misconception STC had been reducing after implementing Problem Based Learning as the method. After getting pretest of STC, the
next step, which had been done to calculate the reducing misconception of STC is N-gain. The figure above shows the n-gain for 34 Science Teacher Candidate.

![Figure 3. N-Gain 34 Science Teacher Candidates](image)

Each student had positive N-gain, misconception of every Science teacher candidate had been decreasing. The average of N-gain is 0.67, it means problem based learning which had been implemented successfully to reduce misconception. Most of the problem in FCI had been investigated by STC with doing experiment and prove the hypothesis which mad by them. Some of the question hard for them to investigate by doing the experiment since the case given is hard to visualization. Beside that the lack of time also become the main factor why STC couldn’t maximize the implementation of problem based learning.

4. Conclusion
In this study Force Concept Inventory had detected misconception of science teacher candidate (STC). Most of SCT had misconception in all of the topic cover by FCI. STC still taught that heavier object fall faster than light object. Couldn’t discriminate position, velocity and acceleration also describe misconception of STC. Not only in gravity but also in Law of Newton STC shows misconception, which can be seen from the result in pretest.

Problem based learning method can be used to reduce misconception of STC, because by this method STC can prove their hypotheses, which had been predicted as the solution of the problem. But because most of STC solved the problem given by doing the experiment, not all of the problem given could solved by the student with problem based learning.

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