Effectiveness of implementation interactive conceptual instruction (ICI) with computer simulation to overcome students’ misconceptions about newton’s law of gravitation

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Abstract. Misconceptions caused by many factors, based on previous observation is the difficulty of students in visualizing or imagining the concept given, thus obstructing students to achieve the goal of physics learning. Misconceptions can occur in a variety of physics matter such as newton’s law of gravitation. This research aimed to know the effectiveness of implementation interactive conceptual instruction (ICI) with computer simulation to overcome students’ misconceptions about newton’s law of gravitation. The sample of this research are 35 students in 10th grade which choose by using purposive sampling, and the instrument used to identify students’ misconceptions is four-tier diagnostic test. The method research used is quasi-experiment with research design is one group pretest-posttest design. The results show that the value of n-gain is in moderate range. So, it can be concluded that the effectiveness of implementation ICI with computer simulation can overcome students’ misconceptions about newton’s law of gravitation.

1. Introduction

Physics education research has made significant progress over the past several years. This study deals with the issue in many different perspectives: theories of learning, investigation of student concepts and student attitudes toward physics lessons, factors influencing physics learning, instructional methods, and so on. Students were not coming to instruction as blank slates. They had developed durable conceptions with explanatory power, they are consistent with their own understanding of the world and have served them effectively as a means to understand, and make predictions about phenomena [1], but those conceptions were inconsistent with the accepted scientific concepts present in the lessons, it’s called misconceptions. Misconceptions caused by many factors, based on previous observation is the difficulty of students in visualizing or imagining the concept given, thus obstructing students to achieve the goal of physics learning.

Misconceptions are highly resistant to change by traditional interventions. Physical learning traditionally with the main characteristics: not emphasizing the first cultivation of the concept at the beginning of learning, the lack of active involvement of students in the learning process, the learning process is centred on the teacher, students receive the lesson passively, and the interaction between students with teachers and with each other in the learning process is very rare. One of the learning models designed with a focus on conceptualization among students is interactive conceptual instruction (ICI). This model has four main features, the first is focusing on the conceptual side,
prioritizing classroom interactions, the third is using research-based teaching materials, and the last is using text [2]. Implementation of this model, indicates that the use of this learning model significantly improves students’ understanding of concepts rather than the use of traditional learning.

When ICI is implemented, the introduction and conceptualization sessions commonly used props (demonstrations) to show the various physical symptoms associated with the concepts studied. But such props have limitations, which can only show the symptoms of macro. To overcome these limitations, nowadays has developed a lot of media based on computer simulation. Computer simulations offer an excellent opportunity for conducting scientific inquiry, allowing students to develop their scientific literacy [3] and allow interaction with the learners that lets them use the simulation as a source for genuine inquiry activities. The virtual simulation media in learning can be used for the means to sharpen the explanation of the demonstration activities of phenomena by using props, or even to replace the role of props especially not possible in the classroom either because the equipment is difficult to construct or because the tool is very expensive and rare.

In Newton’s law about gravity some students’ misconceptions that occur include: students assume there is no gravitational force on the moon, students assume that the weight of objects in the moon is equal to the weight of the object on earth, students consider when the radius is longer then the object will be heavier, the student considers the acceleration of the same object when the mass is the same, and each planet moves around the sun at the same speed [4].

Every particle in the universe pull towards to every other particle with a force that is straight relation to the product of their masses and inversely relational to the square of the distance between them. If the particles have masses $m_1$ and $m_2$ and are split by a distance $r$, the amount of this gravitational force is:

$$F = G \frac{m_1 m_2}{r^2}$$

(1)

Where $G$ is a constant and its value in S1 unit is $G = 6.673 \times 10^{-11}$ Nm$^2$/kg$^2$. Another significant fact is that the gravitational force used by a finite-size, spherically symmetric mass spreading on a particle outside the spreading is the same as if the entire mass of the distribution were concentrated at the centre [5]. The moon has a radius smaller than the radius of the earth, therefore the gravitational force on the moon will be smaller than the gravitational force of the earth, so that the weight of a person when on the moon will be smaller too. We have evidence that the gravitational force acting on an object is directly proportional to its mass from our observations of falling objects. All objects, regardless of mass, fall in the absence of air resistance at the same acceleration $g$ near the surface of the earth. According to Newton’s second law, this acceleration is given by:

$$g = \frac{r}{m}$$

(2)

Where $m$ is the mass of the falling object. If this proportion is to be the same for all falling objects, then $F$ must be directly proportional to $m$, so that the mass cancels in the proportion. If we ruminate the more general condition of a gravitational force between any two objects with mass, such as two spheres, this same case can be useful to show that the gravitational force is proportional to one of the masses.

This research aimed to know the effectiveness of implementation interactive conceptual instruction (ICI) with computer simulation to overcome students’ misconceptions about newton’s law of gravitation. Since there is a lack of published work investigating the misconceptions that physics education students’ have about gravity and mass, this research thought to be worthy of carried out.

2. Methods

2.1. Research design

To consider the efficacy of implementation interactive conceptual interaction with computer simulation, research activities have been done by compelling the focus of high school students and the topic is newton’s law of gravitation. From that used by Savinainen, the interactive conceptual learning method
in this study has four steps. First step is emphasize the student’s conceptual focus at the beginning of learning. The second step is monitoring the level of conceptual understanding, as facilitator the teacher asked students to read a book before participating in the study so they can take part in discussion with their own knowledge. The next step is using the demonstration, students must be explore the computer simulation about Newton’s law of gravitation because it can provide an overview of a phenomenon that cannot be presented in the classroom, and the last step is small group collaboration, the student divided into small group and make group discussion about the topic. The steps of ICI can be imagined on the Figure 1.

![Steps of ICI](image)

Figure 1. Steps of ICI.

The method used in this study is quasi experimental method and research design is one group pretest-posttest design. Quasi experimental method has been selected with the purpose of research only want to see the impact of a treatment on the needy variable, not a judgement to other treatment [6]. The purpose of this study is to get a picture of the advance of students' understanding about newton's law of gravitation.

As the effect of applying interactive learning conceptual instruction with computer simulation in physics learning, the test is done twice before and after treatment. The research design used in this research is one group pretest-posttest design that is offering pretest, then giving the treatment purposely (the treatment is use a computer simulation during a lesson of physics) and at the end of learning given the assessment of posttest.

| Pretest | Treatment | Posttest |
|---------|-----------|----------|
| O       | X         | O        |

Figure 2. One group pretest-posttest design.

2.2. Participants
The participants in the study are 35 students in 10- grade from one of senior high school in Bandung, whose get a second semester in school year 2017/2018. The sampling technique that research using purposive sampling method, and samples are selected with certain criteria and considerations.

2.3. Instruments
The research instrument used four tier diagnostic test, it is consisting of four tier multiple choice questions are able to decrease the rate of estimating and further explore student hidden understanding of science concepts. The instruments in this research are a set of conceptual tests of topic material newton’s law of gravitation to evaluate student conceptions before and after learning [7,8]. For diagnosis student’s misconception, researcher used four tier test which validated by two physic lectures and one physics teacher.

2.4. Data analyze
To measure changes in student misconceptions after being given treatment, can use the assessment adopted from the N-Gain equation. N-Gain is a measure of increasing student understanding, calculated
from the difference in the number of students who experience a change from not understanding the concept or misconception to understanding the concept. In this study, N-Gain used was N-Gain which was adopted from Hake [9].

\[
< \Delta M > = \frac{% \text{pretest} - % \text{posttest}}{% \text{pretest} - \text{ideal} %}
\]  

(3)

where,
- \( \Delta M \) : The learners whose number decreased have misconceptions
- % Pretest : The percentage of learners whose have misconceptions given before treatment
- % Posttest : The percentage of learners whose have misconceptions given after treatment
- Ideal % : The ideal misconceptions (0%)

To determine the percentage decrease in student misconceptions the criteria adapted from Hake used and presented in Table 1.

| \(< \Delta M >\) | Criteria |
|------------------|----------|
| \((< \Delta M >) \geq 0.7\) | High |
| \(0.3 \leq (< \Delta M >) < 0.7\) | Moderate |
| \(< \Delta M >) < 0.3\) | Low |

Before calculating N-Gain, first classify student conception. There are student conception criteria shown in Table 2 [10].

| Criteria Concept | Tier 1 | Tier 2 | Tier 3 | Tier 4 |
|------------------|--------|--------|--------|--------|
| Misconception (MC) | False | Sure | False | Sure |
| Sound Understanding (SU) | True | Sure | True | Sure |
| | True | Not Sure | True | Not sure |
| | True | Sure | True | Not sure |
| | True | Not sure | True | Sure |
| | True | Not sure | False | Not sure |
| | False | Not sure | True | Not sure |
| | True | Sure | False | Not sure |
| | True | Not sure | False | Sure |
| Partial Understanding (PU) | False | Sure | True | Not sure |
| | False | Not sure | True | Sure |
| | True | Sure | False | Sure |
| | False | Sure | True | Sure |
| | False | Not sure | False | Not sure |
| No Understanding (NU) | False | Sure | False | Not sure |
| No Coding (NC) | Respondent doesn’t fulfil all or part of tier in instrument test items |

After being grouped according to the criteria above, it is necessary to score students' answers based on their conceptions. The following is the score for each student's conception.
Table 3. Student’s criteria concept score.

| Student’s criteria concept   | Score |
|------------------------------|-------|
| Sound Understanding (SU)     | 2     |
| Partial Understanding (PU)   | 1     |
| Misconceptions (MC)          | 0     |
| No Understanding (NU)        | 0     |
| No Coding (NC)               | 0     |

30. A climber is at the top of the Himalayan mountain, he wants to know the effect of the height of a place on the gravitational acceleration of objects. Then, he experimented with dropping a ball from the top of the Himalayan mountain. When the ball moves down, ignoring the air's frictional force, the spherical acceleration is \( g = 9.8 \text{ m/s}^2 \).

A. Depending on the speed of the ball being thrown.
B. The acceleration is 0 m/s
C. The acceleration is less than 9.8 m/s
D. The acceleration is greater than 9.8 m/s
E. The acceleration is the same as the earth's gravity acceleration 9.8 m/s

Are you sure?
A. Yes
B. No.

The reason you chose the answer:
A. If the distance of an object is farther from the surface of the earth, the gravitational acceleration will be greater;
B. If the distance of an object is closer to the surface of the earth, the gravitational acceleration will be lower;
C. Gravitational acceleration on the earth's surface will always be the same which is 9.8 m/s;
D. The closest object to the center of the earth has the greatest acceleration of its gravity.
E. The closest object to the center of the earth has the lowest acceleration of its gravity.

Are you sure?
A. Yes
B. No.

Figure 3. Four tier diagnostic test.

| Newton's Law of Gravitation Simulation |
|---------------------------------------|
| Gaya pada m2 oleh m1 = 0.000 000 003 960 N |
| Gaya pada m2 oleh m1 = 0.000 000 003 960 N |

Figure 4. Computer simulation about Newton’s law of gravitation.
3. Result and Discussion

To regulate the percentage reduction in student misconceptions the criteria modified from Hake used and presented in Table 1. From the treatment that has been done, the average value of the normalized gain is 0.32 which means having a moderate criterion.

Table 4. Decrease number student misconception

| No. item | %M<sub>pre test</sub> | %M<sub>post test</sub> | ∆M | Interpretation |
|----------|-----------------------|-----------------------|-----|----------------|
| 1        | 19                    | 3                     | 0.8 | High           |
| 2        | 39                    | 11                    | 0.7 | Moderate       |
| 3        | 43                    | 43                    | 0.0 | Low            |
| 4        | 15                    | 7                     | 0.5 | Moderate       |
| 5        | 11                    | 11                    | 0.0 | Low            |
| 6        | 15                    | 7                     | 0.5 | High           |
| 7        | 15                    | 7                     | 0.5 | Moderate       |
| 8        | 47                    | 47                    | 0.0 | Low            |
| 9        | 19                    | 15                    | 0.2 | Low            |
| 10       | 23                    | 3                     | 0.8 | High           |
| 11       | 47                    | 55                    | 0.16| Low            |
| 12       | 23                    | 19                    | 0.16| Low            |
| 13       | 23                    | 19                    | 0.16| Low            |
| 14       | 23                    | 19                    | 0.16| Low            |
| 15       | 23                    | 11                    | 0.5 | Moderate       |

Based on data in Table 4, the calculation of students is decrease who have misconceptions when the pretest and posttest. The failures in the quantity of students who have misconceptions happen in the whole concept about newton’s law of gravitation. Percentage of true conception of the number of students increased in every concept of gravitation force. This shows that the treatment which given to remediate misconceptions students become true conception. This advises that the use of an interactive conceptual learning approach that uses computer simulations can significantly improve students' understanding of the newton's law of gravity. In other words, the use of interactive conceptual learning approach using computer simulation is more actual in improving students' conceptual understanding.

The above results show the effectiveness of implementation ICI with computer simulations. The use of virtual simulation media can imagine the physical mechanism model of a phenomenon down to a micro level that is not possible by using real props. Visualization of microscopic behavior of a phenomenon can help students in constructing its conception, thus evasion the error of concept. The simulation media can also be used to describe abstract concepts that cannot be demonstrated with visual tools (demonstration tools). Evidence devices can only show physical symptoms of a fact but are unable to show how physical quantities related to phenomena interact with each other so that physical symptoms appear as observed. With this media students are invited to observe the physical mechanism of a physical phenomenon. Learning through observation is believed to be more meaningful than just hearing the story. In addition to avoiding mistakes, student conceptions will also be steady and will be more permanently attached. It is these advantages that enable interactive conceptual learning methods to be aided by the use of virtual media can extra enhance the effectiveness and understanding of conceptions, as well as minimalize the quantity of misconceptions.
4. Conclusion
Based on research data and analysis it can be concluded that the use of virtual simulation media can further improve the effectiveness of conceptual learning approach in improving concept understanding and minimize the quantity of misconception. This is indicated by the average normalized gain value of 0.32, which means it belongs to the moderate category.

5. References
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