Reducing Eleventh-Grade Students’ Misconceptions on Gravity Concept using PDEODE*E-Based Conceptual Change Model

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Abstract. Students’ misconceptions as one of learning problems that able to inhibit their learning achievement. One of the fundamental subjects in the physics learning is the force concept, such as gravity. This study was conducted to reduce students’ misconceptions on gravity concept through Predict-Discuss-Explore-Observe-Discuss-Explore*-Explain-based PDEODE*E-based Conceptual Change Model (PDEODE*E-based CCM). The gravity concept in this study is on the falling ball in several different cases. The participants of this study consisted of 33 eleventh-grade students of Senior High School in Bandung. The students’ misconception was detected using Four Tier Test -formatted Force Concept Inventory (4TT-FCI) as the diagnostic instrument test. The result of this study shows that students’ misconception on gravity had been reduced from 56.82% to 15.91% after using PDEODE*E-based CCM in the learning process. It can be concluded that the utilizing of PDEODE*E-based CCM is able to reduce students' misconception on gravity concepts.

1. Introduction

There are various issues concerning students’ conceptions that could hinder achievement in the learning physics. One of the problems about students’ conceptions that often conducted as the research issue is misconceptions. Misconceptions are unchanging, unscientific conceptions in students' cognizance that the concepts tangible impediment learnings [1]. The misconception is that is consistent conceptions, contrary to the conception of the experts, and inhibit students' understanding of phenomena and scientific explanations [2]. The consistency or stability of the students' misconception because the students embrace the conceptions based on their learning experiences that happened, even if the conceptions are not appropriate scientifically. Thus, the misconception is a conception which is believed but not in accordance with the scientific concept of truth.

The misconception is able to be a barrier for students in the study of the subject in physics. The misconception is able to consequence in students’ difficulties when faced the learning material with the basic scientific concepts. This is due to its basic concept that contrary/inconsistent with the students’ perception/idea/view as their conceptions.
One of the subjects in physics which often found the misconceptions is the gravity concept [3-9]. Therefore, this study was conducted to identify students’ misconceptions on the gravity concept gravity as well as an attempt to overcome these misconceptions.

The misconception is able to be rectified through the reconstruction as a form of conceptual change [10]. Reconstruction of the misconception is able to be done in the learning activities that facilitate students’ conceptual change. Therefore, as an organizer of learning activities, teachers have a very important role in encouraging conceptual change as the reconstruction of misconceptions students become the enhanced conceptions.

The efforts to facilitate students’ conceptual change be able to be done by applying Predict-Discuss-Explore-Observe-Discuss-Explore*-Explain-based Conceptual Change Model (PDEODE*E-based CCM). The PDEODE*E-based CCM is a learning model that was developed by combining the CCM and PDEODE*E. The CCM is a model that was developed with the aim to facilitate the conceptual change [11] [12]. This model is supported by a strategy PDEODE*E which facilitates students to learn actively. Learning strategies PDEODE*E is a learning strategy that includes seven instructional activities which are Predict, Discuss, Explain, Observe, Discuss, Explore*, and Explain [10]. The implementation of the PDEODE*E strategy has the potential to facilitate the students’ reconstruction of misconceptions [13] [14]. The amalgamation between CCM with PDEODE*E hereinafter referred to PDEODE*E-based CCM. The phases of PDEODE*E-based CCM is given in Figure 1.

![Figure 1. The Phases of PDEODE*E-based CCM](image-url)

The implementation of PDEODE*E-based CCM learning is conducted in four main phases. The first phase is expressing students’ conceptions to get a representation of students’ conceptions on the certain concepts. In the second phase, namely describing students’ conceptions were conducted with the aim to destabilize the fallacy misconception, given the misconceptions are stable and consistent so it is difficult to reconstruct. The third phase that constructs the conceptual conflict with the aim to make students aware of the mistake conceptions. This phase is carried out through a strategy PDEODE*E that is in the step of Predict, Discuss, Explain, Observe and Discuss. The last phase namely supporting students’ conceptual change made through Explore* and Explain activities as learning activities that facilitate active learning by students. Thus, the students are expected to acquire knowledge of his own experience and were able to reconstruct their misconceptions.

In this study, the PDEODE*E-based CCM is implemented as an effort to the improve students’ conceptions on the gravity concept, especially in reconstructing students’ misconceptions become enhanced conceptions. Thus, this study was conducted to determine the students' conceptual change (misconceptions reconstruction) on the gravity concept through the application PDEODE*E-based CCM.
2. Methodology

This study has been conducted on 33 eleventh-grade high school students in one of the Schools in Bandung City. This research were conducted by using the One Group Pre-test Post-test Design. The Pre-test and post-test was conducted to measure the students’ conceptions on the gravity concept which the instrument that utilized is the Four Tier-formatted Test Force Concept Inventory (4TT-FCI), which contains questions about the concept of gravity. The example of the 4TT-FCI item is shown in Figure 2.

10.1 A bowling ball accidentally falls out of the cargo bay of an airliner as it flies along in a horizontal direction. As observed by a person standing on the ground and viewing the plane as in the Fig. 6, which path would the bowling ball most closely follow after leaving the airplane?

Options:
A. Path (1)  D. Path (4)
B. Path (2)  E. Path (5)
C. Path (3)

10.2 Your sureness level about the answer on the question 10.1:  
A. Sure  B. Not Sure

10.3 Your reason related to the choice that you choose in the question 10.1:  
A. The bowling ball moves very quickly in the direction of the plane motion before the ball landed.
B. The bowling ball falls freely without any force that causes a change in the direction.
C. The bowling ball pushed by the reaction force of the air movement.
D. The bowling ball moves due to the resultant force of the vertical and horizontal direction.
E. Another reason: .................................................................

10.4 Your sureness level about the answer on the question 10.3:  
A. Sure  B. Not Sure

Figure 6

This instrument has been validated by three experts consisting of two physics lecturers and one high school physics teacher. The validation fallouts showed that the instrument 4TT-FCI is a valid instrument with an index of 0.96. This interpretation was based on the provisions of that the instrument is thought to be valid if obtained the validation index score greater than 0.7 [15]. Besides, the coefficient of reliability was found as 0.89 for the 4TT-FCI.

In the 4TT-FCI instrument consists of four tiers. At the Tier-1 contained about FCI that conclude the gravity concept in the form of multiple-choice and including 5 answer options (4 wrong answers choices and one correct answer choice). Furthermore, the Tier-2 given questions about the confidence level of students’ response options in the Tier-1. There are two options on the Tier-2 of "Sure" and "Not Sure". At the Tier-3 loaded questions about why the student to answer choices in the Tier-1. The Tier-3 is presented in the form of semi-open-ended questions. That is, there are five answer choices with options A, B, C, and D in the form of multiple choice, while the selection of E in the form of the open-ended field which aims to enable the students to write other reasons that are not listed on the A to D selection.
The students’ conception had been identified by the students’ answers were obtained from the pre-test and post-test on the students’ answer sheets with codification. The codification of students’ conceptions based on the results of pre-test and post-test with the 4TT-FCI instrument is based on Table 1.

### Table 1. The Codification of conception based on the students’ answers to the instrument 4TT-FCI

| Category            | Symbol | Tier-1 Sureness | Tier-2 Sureness | Tier-3 Sureness | Tier-4 Sureness |
|---------------------|--------|-----------------|-----------------|-----------------|-----------------|
| Understanding       |        | O               | S               | O               | S               |
| Partial Understanding | O      | O               | NS              | O               | S               |
|                     |        | O               | NS              | O               | NS              |
|                     |        | O               | S               | X               | S               |
|                     |        | O               | S               | X               | NS              |
|                     |        | O               | NS              | X               | S               |
|                     |        | O               | NS              | X               | NS              |
|                    | X      | S               | X               | S               |
| Misconception       |        | X               | S               | X               | S               |
| Not Understanding   |        | X               | NS              | X               | NS              |
|                    | X      | NS              | X               | S               |
|                    |        | X               | NS              | X               | NS              |

If there is the tier(s) of missed/multiple answers/ the question is not answered at all.

Based on Table 1, there are five students’ Level of Conception (LC) that used in this research is Understand, Partial Understanding, Misconception, Not Understanding, and Un-Code. The profile of students’ CL revealed in order to gain an idea of the percentage of students’ misconceptions as the focus of discussion.

The Understand category (fully understand) symbolized by a fully circular shape represents. It’s been on the premise that students’ conceptions should be rounded and complete, also fully scientific. The Partial Understanding (understood in part) is encoded with a half-filled circle symbol. This illustrates that the conception of the students was only partially fulfilled, which means students do not understand the concept fully. While the Misconception is represented by the symbol of the circle in which there is full octagonal. This illustrates that there is a mistake in the conception of students regarded as the true conception. The Not Understanding (do not understand the concept) is represented by an empty circle symbol illustrating that the students’ thinking at all not occupied by the conception of the concept of style. While the Un-code described by circle form with the dotted line, which means that students’ conceptions cannot be determined.

The treatment in this study was the implementation of PDEODE*E-based CCM. The implementation of this learning model is supported by PDEODE*E worksheets and PDEODE*E Exploration Sheets.

### 3. Finding and Discussion

Based on the results obtained pretest and posttest percentage of students for each LC are presented in the form of a diagram in Figure 3.
Figure 3. Percentage of Students’ Level of Conceptions

Based on Figure 3, the students’ conceptual change on the gravity concept showed the good change that indicated by the reduction percentage of misconceptions. The misconception percentage change is 40.91% (from 56.82% to 15.91%) and as the highest change. This shows the impact of the PDEODE*E-based CCM implementation in the learning activities that against students’ misconceptions on the gravity concepts. The students’ conceptual changes on the concept of gravity based on the pretest and posttest results are shown in Figure 4.

Figure 4. The students’ Level Conception changes on the gravity concept based on results of pretest and posttest.
Based on Figure 4, the highest conception changes contained in the change misconceptions become Partial Understanding that is equal to 31.1%. That is, there are about 10 of the 33 students who have the misconceptions reconstruction into the better conceptions.

For an example, one of the students who have misconceptions on the concept of gravity. The student’s misconceptions stated that the mass of the ball the first two times larger than the second ball will be up first on the ground when dropped freely at the same time and altitude (the roof of a building). The first ball till the soil surface with a time of two times less than other balls. The reason these students is the ball I had two times the acceleration of gravity is greater than the second ball. This is clearly wrong because the acceleration of gravity to a height close to the earth’s surface has the same great for any objects [3].

The student’s misconceptions are also present in student’s PDEODE*E worksheets in the Predict section (Figure 6). The student claimed that the ball with greater mass will arrive first at the surface than a smaller ball. This can occur even if the ball has the same size and dropped freely at the same time and altitude as well. The reason these students are balls with a mass greater experience greater acceleration of gravity as well so that the ball more quickly reaches the surface. This assumption is also found in the PDEODE*E worksheets in the activities of the prediction.

![Figure 5](image5.png)

**Figure 5.** The findings of Students’ misconception on the gravity concept based on students’ prediction in PDEODE*E worksheets.

![Task 1](image1.png)

**Task 1:** Two Balls with Different Mass that Fall Freely on varied Height

1) How time at the tennis ball and the clay ball when it fell to the floor? Predict! Indicate and explain the reason for your prediction!

The clay ball up on the floor first rather than the tennis ball as clay is heavier so that the acceleration of gravity is greater.

![Figure 6](image6.png)

**Figure 6.** The findings of student’s misconception on the gravity concept based on the Prediction in student’s PDEODE*E worksheets (has been translated)
The implementation of PEODE*E-based CCM in the learning process facilitating the reconstruction of student’s misconceptions through the integrated learning activities. In addition, there is a form of experimental exploration activity dropped two balls that have the different mass at the same time and the same height. Based on the exploration results, the student found that the time it takes the ball to reach the ground surface is relatively the same. It is found also in PDEODE*E worksheets, which indicate the reconstruction of misconceptions.

Figure 7. The finding of students’ conceptual change on the gravity concepts based on the conclusions in the PDEODE*E worksheets.

Figure 8 shows the reconstruction of student’s misconceptions on the gravity concept, to be exact about the magnitude of the force of gravity on objects that are close to the surface of the earth. The students have the conception that objects that were located close to the earth's surface have a relatively large gravity equal. This is an indication of the reconstruction of the students' misconceptions on the concept of gravity after applying PDEODE*E-based CCM in the learning process. However, not all students have misconceptions reconstruction as expected. This is because of misconceptions that are stable and consistent [1]. In addition, the limitations of the study in the control of students' psychological factors such as patterns of thinking, teamwork, and motivation in learning activities [10]. It has the potential to affect the process of reconstruction of the students’ misconceptions in learning activities.

4. Conclusion
Although misconceptions are stable and consistent, misconceptions can be overcome by making efforts through the reconstruction process of conception. The findings in this study indicate that students’ misconceptions on the gravity concept have decreased by 40.91%, from 56.82% (pretest) become 15.91% (post-test) after the implementation of the PDEODE*E-based CCM in the learning process. The reconstruction of misconceptions into Partial Understanding is the major conceptual change with a percentage of 31.1%, or about 10 students. Thus, it can be said that students’ misconception on the gravity concept can be reduced through the implementation of PDEODE*E-based CCM in learning activities.
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