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ENHANCING K-10 STUDENTS' CONCEPTIONS THROUGH COMPUTER SIMULATIONS-AIDED PDEODE*E (CS-PDEODE*E) ON NEWTON'S LAWS

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ABSTRACT

The aim of this study was to enhance K-10 students' conceptions through Computer Simulations-Aided PDEODE*E (CS-PDEODE*E) on Newton's Laws. The PDEODE*E is a worksheet consisting of seven stages, which are Predict (P), Discuss (D), Explain (E), Observe (O), Discuss (D), Explore (E*) and Explain (E). The computer simulations could support learning via PDEODE*E worksheet by presenting physics' phenomena. The Newton's Laws focused on forces and Newton's First Law. The research method used the 4D (Define, Design, Develop and Disseminate). The research sample included 30 K-10 students (15 boys and 15 girls, with the average age of 16 years-old). The students' conceptions were identified through a Four-Tier Newtonian Test (FTNT) as pre- and post-test. In the developing phase, we acquired the product of computer simulations and PDEODE*E worksheet. In the disseminating phase, the value of effect size was 0.85 in the "large effect" of classification and tcount>ttable, thus, CS-PDEODE*E was more effective than CS-POE. The decisions succumbed that the students' conceptions could be enhanced via PDEODE*E based computer simulations.

Keywords: CS-PDEODE*E, Newton's Laws, students' conceptions

INTRODUCTION

In excess of the past two periods, a countless arrangement of educational investigation has been focused concerning the study of concepts and complications of physic concepts (e.g. Gunstone et al., 2009; Wenning, 2008; Rutten et al., 2012), keeping in mind that concepts are essential construction slabs of understanding (e.g. Can & Boz, 2016; Majidi, 2014; Seung & Bryan, 2010). A compacted understanding of concepts results in a consequential deed in facilitating students improve their understanding, spreading over accurate concepts to problematic explaining, and consequently progressing students' knowledge and capability (e.g. Liu & Fang, 2016; Rahmawati et al., 2017). Nevertheless, students repeatedly have misguidedly shaped conceptions or incomprehension the rudimentary understanding they study formerly using different concepts (Saifullah et al., 2017). Therefore, conceptual misunderstanding is an actual matter for students, particularly apprentice students and frequently consequences in deprived or incorrect understanding and construction. Studying students' conceptual misunderstandings can be a strong and challenging way to the solution (e.g. Oliver et al., 2017; Liu & Fang, 2016; Larkin & Jorgensen, 2016; Waldrip & Prain, 2012).

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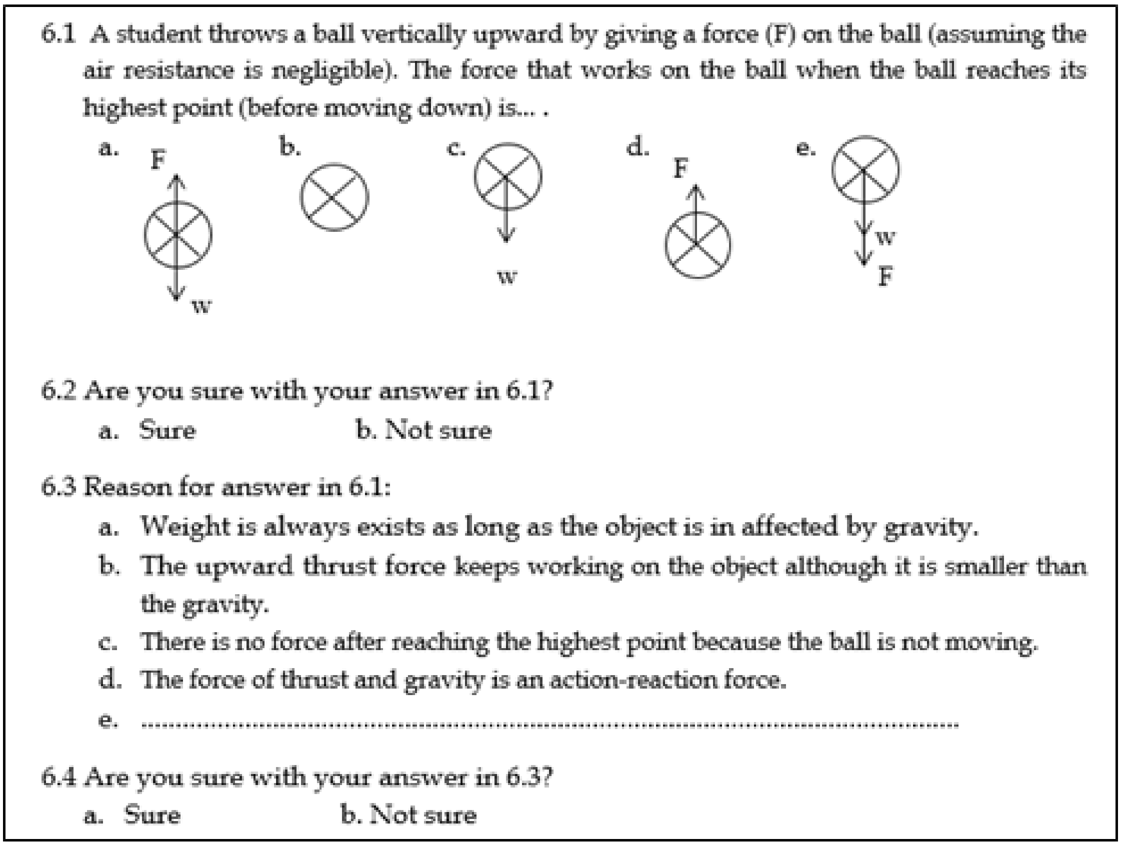
In physics education, students' misunderstandings have been found out in numerous concepts of physics such as force, acceleration, adiabatic, motion, series and parallel circuits, mass, weight, hydrostatic pressure, and mechanics (e.g. Liu & Fang, 2016; Wijaya et al., 2016; Poutot & Blandin, 2015; Leinonen et al., 2012; Bayraktar; 2009; Ipek & Calik, 2008; Bharambe, 2014). Force, acceleration, motion, mass, and weight are the concepts employed in the learning of Newton's Laws. This research gripped the forces (gravity force, normal force, friction force) and Newton's First Law. These concepts are imperative because Newton's Laws are rudimentary concepts in physics. These fundamental concepts must be taught to students to learn further physics.

To accomplish that resolve, teachers must diminish students' misunderstandings. Ipek & Calik (2008) elucidated that students' misunderstandings have been overcome through insufficient sources such as tutoring in which there was no linkage between the taught concepts. This old teaching method is an extent to convert concepts and modify imperfections of students' understanding in physics yet they incline to disregard the possibility that the students' insight is perhaps dissimilar than that of the educators (e.g. Al-Amoush et al., 2014; Kurki-Suonio, 2011; Von Glasersfeld, 2012). Further investigation on these concerns could be substantiated very useful for improving instructional forms, also, for planning and increasing different learning situation (e.g. Caleon et al., 2018; Anderson & Moeed, 2017; Boyer, 2016; Nieminen et al., 2013; Rutten et al., 2012). The fee was recognized by tutors as an obstacle in directing students to comprehend a linkage between their scientific understandings and everyday environment (e.g. Mangiante, 2018; Samsudin et al., 2017; Dudu, 2017; Jamieson & Radick, 2017; Anderhag et al., 2015; Costu, 2008). In fact, generating a connection between scientific understanding and everyday surrounding might heighten students' understanding.

Aiming for that reason, an investigation by Samsudin et al., (2017) revealed that PDEODE*E worksheet was successful in civilizing students' conceptual understanding and changing their misunderstanding on the magnetic field. The PDEODE*E is a worksheet involving seven stages, which are Predict (P), Discuss (D), Explain (E), Observe (O), Discuss (D), Explore (E*) and Explain (E). Through tallying Explore (E*) in PDEODE*E, it was more beneficial particularly to deliver conceptual change and to improve conceptual understanding of physics students. Consistently, we employed examination sheet distinctly to explore concepts in instruction to change students' misconception concerning scientific conception correctly. In advance of exploration activities, students could find their own misconceptions. The exploration activities could be supported by using computer simulations. Computer simulations had an accommodating effect on students' capability to estimate and designate phenomena. Computer simulation assistance picked as the observation object considering its advantage to expedite the learning of abstract concepts, which heightened the students' achievement implicitly (e.g. Gunawan et al., 2017; Samsudin et al, 2016; Chen et al., 2013; Bayrak, 2008). The K-10 students have studied Newton's Laws at Junior High School, however, 89.07% of them had misconceptions. This could be problematic for the K-10 students to study the more complex Newton's Laws in Senior High School. In addition, they might not be able to learn further physics concepts. Therefore, the purpose of this study was to enhance the K-10 students' conceptions through Computer Simulations-Aided PDEODE*E (CS-PDEODE*E) on Newton's Laws.

METHODS

The Research and Development (R & D) method was adopted for this research. Moreover, the 4D model (Define, Design, Develop and Disseminate) was used as one type of R & D (Samsudin et al., 2017; Fratiwi et al., 2017). The 4D model was an unpretentious method in the procedure of evolving a product (Irawan et al., 2018). At the phase of Define and Design, the PDEODE*E worksheet and computer simulations were defined and designed. At the stage of Develop, we established the worksheet and computer simulations based on the design. Moreover, at the Disseminate phase, we estimated the dissimilarities between CS-PDEODE*E and CS-POE to distinguish which was more in effect. The PDEODE*E and POE worksheet were validated by four experts in physics education. The value of PDEODE*E validity was 1.00 and the POE validity was 0.96. Before the learning process, the students had a pre-test of sixth Four-Tier Newtonian Test (FTNT). After the pre-test, treatments (CS-PDEODE*E) were done. Next, the students undertook a post-test with the identical problem as the pre-test. The FTNT practice was to record the students' conceptions. The evaluation tool was established in Fratiwi et al. (2017) before being adopted for the pre-test and post-test (see Figure 1). The test items were schematized in the formulation of four-tier test items recognized as the two-tier test. The FTNT was validated by the four experts in physics instruction.


6.1 A student throws a ball vertically upward by giving a force (F) on the ball (assuming the air resistance is negligible). The force that works on the ball when the ball reaches its highest point (before moving down) is... .

a. b. c. d. e.

6.2 Are you sure with your answer in 6.1?

a. Sure b. Not sure

6.3 Reason for answer in 6.1:

a. Weight is always exists as long as the object is in affected by gravity.
b. The upward thrust force keeps working on the object although it is smaller than the gravity.
c. There is no force after reaching the highest point because the ball is not moving.
d. The force of thrust and gravity is an action-reaction force.
e. ....

6.4 Are you sure with your answer in 6.3?

a. Sure b. Not sure

Figure 1. The example of FTNT

The samples were 30 K-10 senior high school students (15 boys and 15 girls having their average age of 16 years-old). The students completely took into the pre-test and post-test, moreover, they were divided into two groups. One group using CS-PDEODE*E and the other employed the different practice CS-POE with the identical scoring system on the pre-test. We chose the POE worksheet since it is the origin of the PDEODE*E. In other words, the PDEODE*E was developed from the POE. Therefore, we expected to compare the effect of the original worksheet (POE) with the modified worksheet (PDEODE*E). The students' conceptions classified into five types of students' answers on the FTNT. The types and scores of each student'S conceptions are presented in Table 1. We graded the students' conceptions after the pre-test and post-test (Samsudin et al., 2017).

Table 1. The Score of Students' Conception

Students' Conception	Score
Sound Understanding (SU)	2
Partial Understanding (PU)	1
Misunderstanding (MC)	0
No Understanding (NU)	0
No Coding (NU)	0

RESULTS AND DISCUSSION

For the results and discussion, we divided on behalf of four phases as the 4D model (Define, Design, Develop and Disseminate). As of the study, the results and discussion section designated as follows.

Define

The POE has queried students' understanding by demanding students to accomplish three errands, which are Predict, Observe, and Explain (e.g. Haysom & Bowen, 2010; Costu et al., 2010). Grounded on the POE, Susto & Krstic (2010) has been advanced the PDEODE. Furthermore, Samsudin et al. (2017) have been settled the PDEODE*E by tallying Explore (E*) stage to be a beneficial addition especially to afford conceptual change and to improve students' conceptual understanding. The PDEODE*E worksheet comprised seven steps as shown in Table 2 (Samsudin et al., 2017).

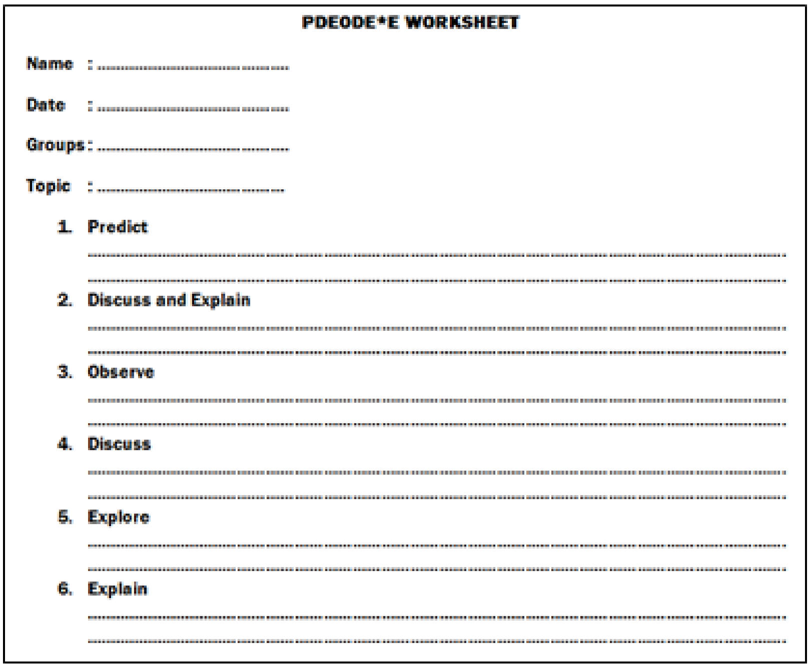
Table 2. The Step Description in PDEODE*E Worksheet

Steps of Worksheet	Descriptions
Predict (P)	The teacher reached a conceptual field of the students through the worksheet and asked them to predict self-sufficiently as to what should enhance.
Discuss (D)	The determination gifted to discuss and picket students discriminated in their group.
Explain (E)	The students in individual group discovered to scrunch a pacification and assumption of the matter, and to current their concepts to other groups. Therefore, those who finished working in their groups commenced an applied investigation and individually predicted their observations coarsely.
Observe (O)	The students observed deviations in the incidence and the teacher pointed them to the importance of observations applicable to the learned concepts.
Discuss (D)	The students tried to prove their predictions through the unpretentious observations accomplished in the preceding step. At this step, the students were demanded to investigate, subordinate, difference, and criticize the findings with their group mates.
Explore (E*)	Students explored the problem by themselves to deliver conceptual change and to improve conceptual understanding.
Explain (E)	The students dared totally discrepancies in the mid of observations and predictions.

In favor of the use of PDEODE*E worksheet, the researchers employed the computer simulation. The computer simulation is a media director to assist students' vigorous contribution in overcoming problematic circumstances in terms of cost and time allotment both in the classroom or the physics laboratory (Rutten et al., 2012). The simulations delivered an association between students' prior understanding and the learning of innovative physical concepts (Osman et al., 2017; Mattheis, 2015), students' progress of scientific understanding reorganized their misconceptions.

Design

According to the seven steps in PDEODE*E (Predict, Discuss, Explain, Observe, Discuss, Explore and Explain), the worksheet design is shown in Figure 2.



PDEODE*E WORKSHEET

Name : ....

Date : ....

Groups : ....

Topic : ....

1. Predict
2. Discuss and Explain
3. Observe
4. Discuss
5. Explore
6. Explain

Figure 2. The Design of PDEODE*E Worksheet

The computer simulations designed by the researchers were adjusted with the students' misconceptions. This was due to many computer simulations' incapability to enhance students' conceptions and change their misconceptions. The design of computer simulations or storyboard is shown in Figure 3.

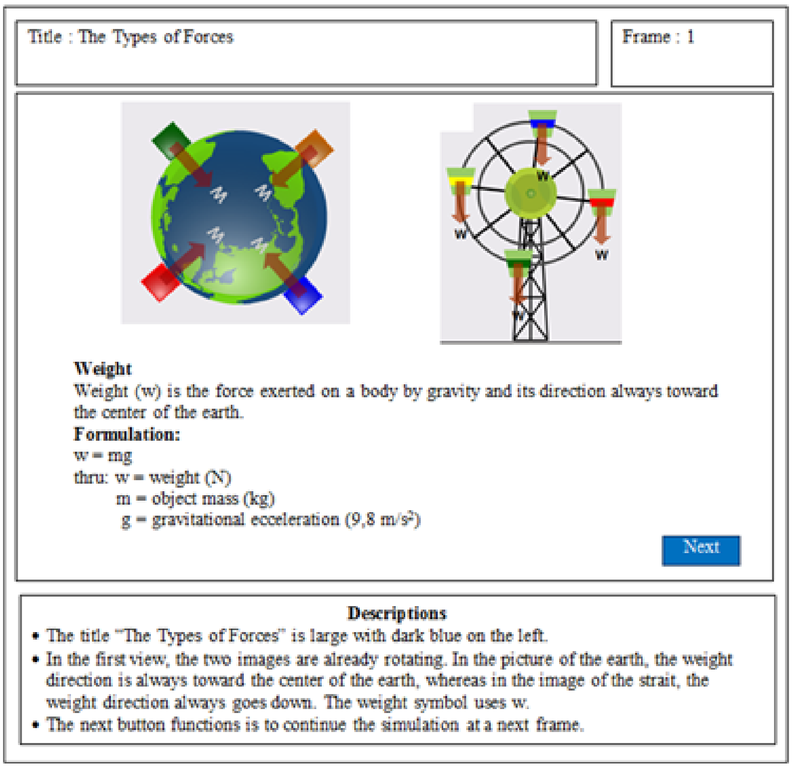
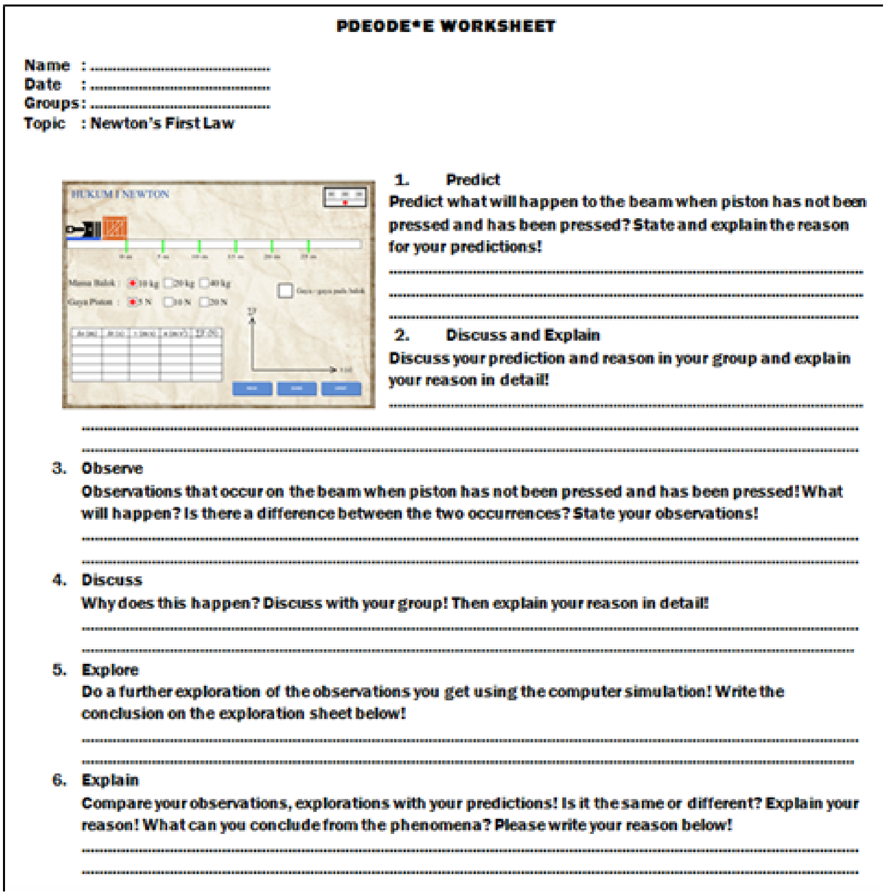


Figure 3. The Design (storyboard) of Computer Simulation

Develop

The design of PDEODE*E worksheet and computer simulations were developed. The developed of PDEODE*E worksheet and computer simulations are presented in Figure 4 and Figure 5.



PDEODE*E WORKSHEET

Name : ....
Date : ....
Groups: ....
Topic : Newton's First Law

1. **Predict**
Predict what will happen to the beam when piston has not been pressed and has been pressed? State and explain the reason for your predictions!
....

2. **Discuss and Explain**
Discuss your prediction and reason in your group and explain your reason in detail!
....

3. **Observe**
Observations that occur on the beam when piston has not been pressed and has been pressed! What will happen? Is there a difference between the two occurrences? State your observations!
....

4. **Discuss**
Why does this happen? Discuss with your group! Then explain your reason in detail!
....

5. **Explore**
Do a further exploration of the observations you get using the computer simulation! Write the conclusion on the exploration sheet below!
....

6. **Explain**
Compare your observations, explorations with your predictions! Is it the same or different? Explain your reason! What can you conclude from the phenomena? Please write your reason below!
....

Figure 4. The Example of PDEODE*E Worksheet

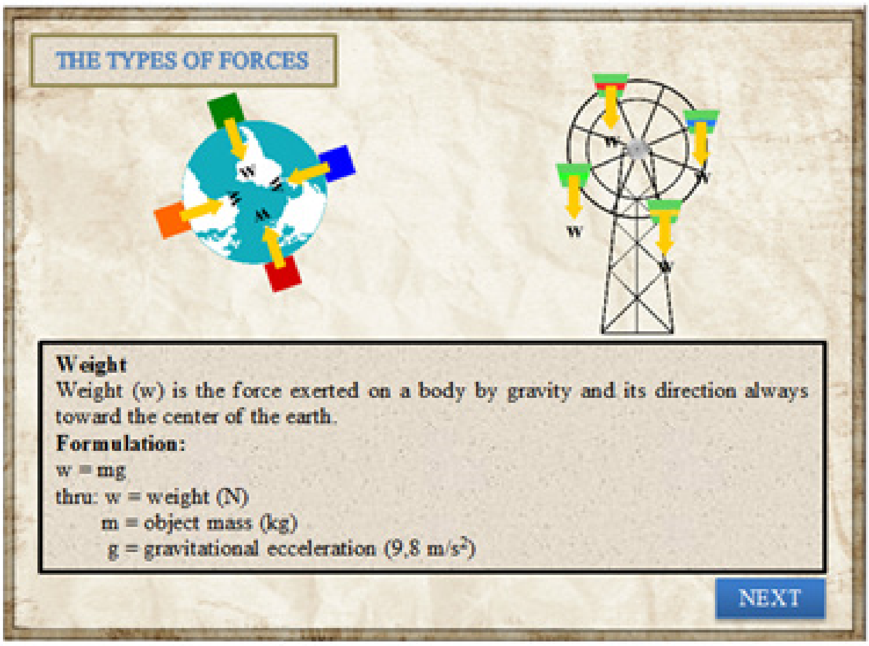
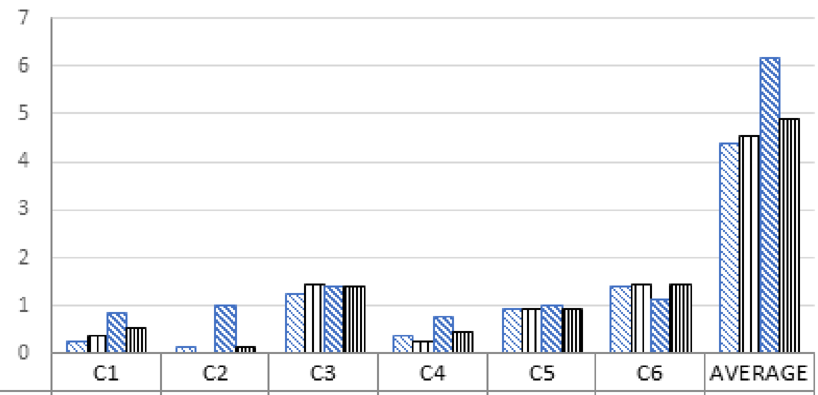


Figure 5. The Example of Computer Simulations

Disseminate

In the disseminate phase, the researchers described the result of this research. The researchers created the graph to show the students' scores at the pre-test and post-test for each sub-concept (C1-C6) and the all of the sub-concepts. The graph shows in Figure 6.



	C1	C2	C3	C4	C5	C6	AVERAGE
PRETEST PEDODE*E	0,27	0,13	1,27	0,4	0,93	1,4	4,4
PRETEST POE	0,4	0	1,47	0,27	0,93	1,47	4,54
POSTTEST PEDODE*E	0,86	1	1,4	0,8	1	1,13	6,19
POSTTEST POE	0,53	0,13	1,4	0,47	0,93	1,47	4,93

Figure 6. The Graph for Students' Scores at Pre-test and Post-test

The sub-concept of C1 and C2 were about the balanced forces, the C3 was about inertia, and the C4-C6 was about types of forces. Figure 6 is the graph of pre- and post-test after using the CS-PDEODE*E and CS-POE. At the post-test, the students' understanding in every sub-concept using CS-PDEODE*E was higher than those adopting the CS-POS, especially in the C2. For example, at the pre-test, most students assumed that there was no force after reaching the highest point because the ball does not move (Figure 1). For that case, when the ball reaches its highest point (before moving down), weight always exists as long as the object is in affected by gravity.

In Figure 6, as seen in the pre-test, the average scores of students' understanding were almost same (4.40 and 4.54). After the treatment used the CS-PDEODE*E and CS-POE, the average scores increased. The students employing the CS-PDEODE*E obtained the score of 6.19 and those using CS-POE obtained the score of 4.93. At the post-test, the students with the CS-PDEODE*E got a bigger average score than those with the CS-POE. To know more about the impact of different treatments on enhanced students' conceptual understanding, the researchers employed the effect size. Correlated to Sinaga & Feranie (2017) and Samsudin et al (2017), the effect size aided recognized the effect of differences in worksheet between the experimental and control class on enhanced students' conceptions. The Glass' delta was used to calculate the effect size as presented in Table 3.

Table 3. The Effect Size of the Data

Treatment	Average Scores	Std. Deviation	Glass's Delta
CS-PDEODE*E	6.19	2.01	0.85
CS-POE	4.93	1.49	

At Table 3, the significance of effect size was 0.85 classified as "large effect". This significance indicated that the CS-PDEODE*E was more effective than the CS-POE to enhance the students' conceptual understanding. Furthermore, the researchers tested the hypothesis using the t-test. It aimed to prove the differences in conceptual understanding between the CS-PDEODE*E group and CS-POE group. Based on the calculation, acquired the t_{count}=5.339 and t_{table}=2.048 (α =.05). We could see that the tcount>ttable, thus, there was a significant difference between the students with CS-PDEODE*E and those with CS-POE. The outcome is correlated with Samsudin et al (2017) who stated that the PDEODE*E worksheet was an effective aid for overcoming various misunderstandings and enhancing students' understanding. Moreover, Kaniawati et al. (2016) concluded that computer simulations could increase students' conceptions. Nevertheless, there was still less significant improvement in students' conceptual understanding. This is correlated to Oliver et al. (2017), Liu & Fang (2016), Larkin & Jorgensen (2016) and Waldrip & Prain (2012) that students' misconceptions can be strong and be challenging on the way to truthful.

CONCLUSION

Based on the research findings, we could associate the CS-PDEODE*E with CS-POE to enhance the students' conceptions of Newton's Laws, especially in the concept of balanced force. The outcome was an indication that value of effect size was 0.85 categorized as "large effect". Furthermore, the result of the t-test showed that the tcount>ttable. This indicated that the CS-PDEODE*E was more effective and had significant differences than the CS-POE. Although the CS-PDEODE*E provided a large effect on enhancing the students' conceptions, the PDEODE*E worksheet and computer simulations remained to have insufficiencies essential to be overcome. Moreover, the CS-PDEODE*E could be developed by other researchers for other physics concepts. The CS-PDEODE*E could be used as a media of learning to show the physics phenomena to students and foster them to discover new concepts.

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