Overcoming students’ misconceptions about simple harmonic oscillation through interactive conceptual instruction (ICI) with computer simulation

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Abstract. Physics is a part of science that contains many concepts. To understand a physics concept student often experience misconceptions, including on simple harmonic oscillation subject. One way to overcome students’ misconceptions is to conduct teaching instruction that can facilitate students to promote their conceptual understanding. Interactive Conceptual Instruction (ICI) was developed to promote conceptual understanding. The data were obtained through 60 10th grade student that selected by simple random sampling. They were divided into two group which is 30 students in the experimental group taught ICI with computer simulation and 30 students in the control group followed traditional classroom instruction. The instruments utilized to determine students’ misconceptions were pre-test and post-test in the form 20 items four-tier diagnostic test related to simple harmonic oscillation. The results show that the value of effect size is in the "large effect" category. It can be concluded that the implementation of ICI with computer simulation effective in overcoming student’s misconception on simple harmonic oscillation subject.

1. Introduction
The important aspect that students realize in their lessons are conceptions, however, most of which differ from scientists’ conceptions [1-3]. The different students’ conceptions and scientists’ conceptions called misconceptions [4]. Students become misconceptions can be called by relatively a few reasons; teaching instruction, student previous conception, unusual connecting among conceptions, and other [5]. Based on the reason tells above, one way to overcome students’ misconceptions is to conduct teaching instruction that can facilitate students to promote their conceptual understanding. Interactive Conceptual Instruction (ICI) was developed to promote conceptual understanding and was based on the premise that developing an understanding requires an interactive process in which there is an opportunity for ideas to be talked through, and thought through, between teacher and students. In other words, the process should be consequent upon ongoing teaching and learning dialogues [6].

Since 2012, researchers have been developing an integrative learning model about Interactive Conceptual Instruction (ICI) based Multimedia. Direct practice with physical phenomena is not permanently sufficient for rising suitable models of perceptive about scientific phenomena. In fact, experts themselves cannot make significant development only by observing at phenomena in the world. Scientific perceptive and modelling rely strongly on the wide and erudite use of external representations [7]. Nowadays, one of the popular external representations is interactive computer simulations.
Interactive computer simulations have been progressively integrated into the learning of the sciences and have contributed substantial enhancements in the teaching-learning practice. As Calik et al, 2015 point out, technology tools can enable the students and teachers to (a) extend their thinking, (b) create multiple representations of their understanding, (c) communicate with each other, (d) experience scientific phenomena, and (e) conduct investigations to perform scientific inquiry [8]. Computer simulation can help concretize abstract, difficult concepts and phenomena in physics, that can make students learn more effectively. The ICI based multimedia is more emphasis on the meaningful learning of physics to re-conceptualize students' conceptions [9]. Therefore, the implementation of ICI model with computer simulation might be effective for overcoming student misconception.

The ICI model, we have applied in this research involves four phases; 1) Conceptual focus 2) Use of texts 3) Research-based materials 4) Classroom interactions [10]. The first phase (Conceptual Focus); takes account of teacher’s activities: explaining learning objective, presenting physics phenomena through simulation which were achieved from computer multimedia, and encouraging students to join enthusiastically during the learning course. The second phase (Use of Texts); involves teacher's activities: requesting students to study textbooks then requesting them to create a concept map interrelated to a concept that they have learned. The third phase (Research-Based Materials); contains teacher's actions: requesting students to make a group entails of four to five students, encouraging students to accumulate the data which is required to investigate experimental result of a worksheet and organizing the students to discover according to their conceptions' level with an exploration sheet. The fourth phase (Classroom Interactions); contains the teacher's activities: observing students' discussion in each group and helping the students to solve their difficulties through confronting the exploration sheet.

In this article, researchers concentrated on simple harmonic oscillation concepts, mostly the concepts about restoring force, characteristic of simple harmonic oscillation, velocity, acceleration, period, and energy. The example of applications simple harmonic oscillation showed on Figure 1 and Figure 2.

![Figure 1](image1.png) **Figure 1.** Simple pendulum as an example of simple harmonic oscillation.

![Figure 2](image2.png) **Figure 2.** Simple harmonic oscillation on grandfather clock.

The concept of simple harmonic oscillation is very important in physics because it is essential for considerate phenomena of mechanical oscillation, sound and light, as well as quantum theory. An earlier study has initiated that students run into a variety of problems inconsiderate harmonic oscillation [7,11]. Simple harmonic oscillation concepts have been reached through ICI model which founded to experimental exploration which was guided by various learning sources such as textbooks, computer simulation, and worksheet task as a research-based material. On that description, it was expected that students showed a sound understanding of simple harmonic oscillation and related to the concepts.

The aim of this research was to investigate the effectiveness of ICI model with computer simulation to overcoming student’s misconception of simple harmonic oscillation concept.
2. Method

2.1. Subjects
Participants in this research involve 60 10th grader students (whose ages were ranged from 15 to 16 years) at a secondary school in West Bandung, Indonesia. The participant divided into two groups which are the experimental group and control group by simple random sampling technique. 30 students in the experimental group taught by ICI with computer simulation and 30 students in the control group followed traditional classroom instruction.

2.2. Data collection
In order to diagnostic students’ misconception, a simple harmonic oscillation diagnostic test designed. The concept This test was developed by the researchers. The instrument test items consisted of 20 question in form four-tier test item. The first tier is a multiple-choice test with its distractors addressing specific misconceptions. The second tier asks for the confidence of the answer in the first tier. The third tier asks for the reasoning for the answer in the first tier. The fourth tier asks for the confidence of the answer in the third (reasoning) tier. For example, in Figure 3.

The reliability of the test was found to be 0.71 which is considerably medium for a misconception test [12]. The test was validated by two physics lecturer and one physics teacher. The final form of the test was administered to the sample on pre-test and post-test. It is assumed that duration between application of the same test as pre- and post-test is sufficient for students to forget the items.

To categorize the students’ responses, the test items were analyzed using five criteria as shown in Table 1 [13] and then each conception criteria was scoring as shown in Table 2 [4].
Table 1. Students’ conception criteria based on the combination of answer on the four-tier test.

| Conception criteria            | Tier I       | Tier II      | Tier III     | Tier IV     |
|--------------------------------|--------------|--------------|--------------|-------------|
| Misconception (M)              | Wrong        | Sure         | Wrong        | Sure        |
| Understanding (U)              | Correct      | Sure         | Correct      | Sure        |
| Partial Understanding (PU)     | Correct      | Not sure     | Correct      | Not sure    |
|                                | Correct      | Not sure     | Correct      | Not sure    |
|                                | Correct      | Sure         | Wrong        | Sure        |
|                                | Correct      | Sure         | Wrong        | Not sure    |
|                                | Correct      | Not sure     | Wrong        | Sure        |
|                                | Correct      | Not sure     | Wrong        | Not sure    |
|                                | Wrong        | Sure         | Correct      | Sure        |
|                                | Wrong        | Sure         | Correct      | Not sure    |
| No Understanding (NU)          | Wrong        | Sure         | Wrong        | Not sure    |
|                                | Wrong        | Not sure     | Wrong        | Sure        |
|                                | Wrong        | Not sure     | Wrong        | Not sure    |
| Uncodable (UC)                 | Respondent does not fulfill (response) all or part of tiers in instrument test items. |

Table 2. Scoring for each students’ conception criteria

| Students’ Conceptions         | Score |
|--------------------------------|-------|
| Misconception (M)             | 0     |
| Sound Understanding (SU)      | 2     |
| Partial Understanding (PU)    | 1     |
| No Understanding (NU)         | 0     |
| No Coding (NC)                | 0     |

2.3. Research design
This study used a quasi-experimental method with research design control group pre-test post-test design showed in Figure 4.

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E O1 X O2
C O1 O2
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Notes: E (Experiment group), C (control group), O1 (pre-test), X (treatment ICI model with computer simulation), O2 (post-test)

Figure 4. Control group pre-test post-test design.
2.4. Data analysis procedure

In order to evaluate the effectiveness of ICI model with computer simulation to overcoming students’ misconception, we use glass delta effect size [14]. We compared the difference between a control group ($X_{\text{con}}$) and an experimental group ($X_{\text{exp}}$), the means of both groups are compared, and that difference is divided by standard deviations of the control group ($SD_{\text{con}}$) which is identified by the Greek symbol $\Delta$.

$$\Delta = \frac{\bar{x}_{\text{exp}} - \bar{x}_{\text{con}}}{SD_{\text{con}}}$$

(1)

Table 3 below shows the use of Effect Size according to the type of research, null hypothesis statistical tests and their interpretations [14].

**Table 3. Interpretation of effect size**

| Type of Research | Indices of effect size | NHST       | Effect Size   |
|------------------|------------------------|------------|---------------|
| Differences between 2 groups | Cohen’s d | Student t | 0.20 small     |
|                   | Glass’s $\Delta$      |            | 0.50 medium    |
|                   |                        |            | 0.80 large     |

3. Result and Discussion

The aim of this research was to investigate the effectiveness of ICI model with computer simulation to overcoming students’ misconception on simple harmonic oscillation concept. To investigate the effectiveness of ICI model with computer simulation to overcoming students’ misconception on simple harmonic oscillation, first of all, we classified conceptual area that frequently most of the student have a misconception. After that, we design a four-tier diagnostic test to reveal students’ misconception on simple harmonic oscillation consist of several concepts on the simple harmonic oscillation in 20 corresponding items. The conceptual area and corresponding item of the test shown on Table 4.

**Table 4. Conceptual areas and corresponding items of the test.**

| Conceptual area                          | Item     |
|------------------------------------------|----------|
| Restoring force (C1)                     | 1,2      |
| Simple harmonic oscillation definition (C2)| 3,4      |
| Velocity (C3)                            | 5,6,7    |
| Acceleration (C4)                        | 8,9,10   |
| Period (C5)                              | 11,12,13,14,15,16,17,18 |
| Energy (C6)                              | 19,20    |

The test is given to students on pre-test and post-test. The percentage of students who have misconception from both groups on each conception area shown in Figure 5 and Figure 6. The percentage misconception on pre-test not much different in both experimental group and control group. But the difference shows on post-test. In the experiment group percentage misconception decrease more than in the control group as shown in Figure 5 and Figure 6. It can indicate that ICI with computer simulation is more effective in overcoming students’ misconception on the simple harmonic oscillation.
After the test, we scoring each student’s conception using Table 2 and then finding the mean, standard deviation and effect size on both control group and experiment group as shown in Table 5.

### Table 5. Data analysis using effect size

|     | N  | M    | SD  | Glass’s delta |
|-----|----|------|-----|---------------|
| E   | 30 | 18.30| 4.34| 0.99          |
| C   | 30 | 14.57| 3.82|               |

From the data analysis, found that the value of effect size is 0.99 that on category large effect. This value shows that the ICI model with computer simulation is more effective in overcome students' misconception on simple harmonic oscillation subject. The result is related to previous research [9,10] that state ICI model with computer simulation was effective in overcoming students' misconception.

4. Conclusion

The results show that value of effect size was 0.98 with interpretation “large effect”. The effect size has facilitated recognized effectiveness of The ICI with computer simulation to overcoming students' misconception on the simple harmonic oscillation. Therefore, the use of ICI with computer simulation is effective in overcome students' misconception on the simple harmonic oscillation.
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