Learning media free fall motion to reduce misconceptions and improve students' understanding of the concept

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Abstract. Has been made free fall learning media for class X students in Physics subjects. Students always think that the amount of mass affects the acceleration of vertical falling objects downward. Media was created to reduce student misconceptions. This research uses demonstration method. This media is proven to reduce misconceptions and can improve students' conceptual understanding.

1. Introduction
Technology development presented a challenge to educators in developing the students' ability to use information technology and media as learning tools and learning resources. The challenges of the 21st century is essential to equip learners in mastering the technology to work in the future. Mastery of Information and communications technology (ICT) and information literacy is a must. Without ICT-based resources and all sources can be hard person develops his work [1].

ICT developments provide an opportunity to use computer simulations to learning. The computer is able to simulate the material is difficult to be presented, especially regarding physical phenomena that are abstract [2]. Integrating ICT in learning is an instructional component of the 21st century to improve inventive thinking skills, effective communication, high productivity, and spiritual [3].

Physics is recognized as conceptually difficult because physics learning consists of concepts related to real life [4]. In addition, students also think that the study of physics is very boring. It has been confirmed by researchers that students consider the concept in physics is too abstract to be understood [5]. Therefore, need their media to be able to explain difficult understanding becomes easier.

Free fall motion, is a matter that must get in grade 1 secondary school. Comprehension motion free fall on the students often encountered problems due to their misconceptions, among which the acceleration of falling objects. Students often think that if mass affects vertical acceleration of the object falls down. Before the time of Galileo it had occurred, people believe in the idea that heavier objects fall faster than lighter objects, and that the rate of fall of the object is proportional to the body weight [6]. One way to provide a correct understanding of the acceleration of motion in objects through experimentation.
2. Experimental method

This research was conducted at a high school in the city, as the data collection, data analysis, and interpretation of research results. Students as the subject of research class X academic year 2017/2018. This study teaching methods demonstration, implementation is done by using the one-group pre-test post-test design.

The basic framework of free fall motion media created as in Figure 1:

![Figure 1. The basic framework of making media.](image)

To find out how big the impact of learning media to reduce misconception and increase understanding of student done in three ways that is:

2.1. Normalized gain

To determine how much to increase the competence of students in the understanding of the concept, analyzed using Normalized Gain. Calculation described in equation 1[7],

$$g = \frac{S_{post} - S_{pre}}{100\% - S_{pre}}$$

With:

- $g$ = Magnitude factor (%)
- $S_{pre}$ = The average score pretest
- $S_{post}$ = Average score of posttest

2.2. Test average difference between pretest to posttest

To test whether there are differences in the average score of students between pretest to posttest (hypothesis testing), test the average difference by using statistical test t test for correlated samples at significance level $\alpha = 0.05$ and degrees of freedom $df = n-1$ (n is the number of samples). With hypothesis formula:
Ho: there is no difference in the average score of students significantly between learning before using media learning media free fall motion with learning after using media learning media free fall motion.

Ha: there is difference of mean score of student which is significant between learning before using learning media free fall motion with learning after using media learning media free fall motion.

2.3. Determination of effectiveness by measuring the effect size
The effect size is used to determine whether there is an impact of increased understanding of concepts resulting from learning using media free fall motion. To see the impact, the effect size analysis is used as in the following equation 2.

\[ \text{Effect Size (d)} = \frac{\text{mean posttest} - \text{mean pretest}}{\text{standard deviation}} \]  

(2)

3. Results and discussion

3.1. The result of making free fall movement media
Has been made free-fall learning media to determine the acceleration/speed of objects on the symptoms of free fall motion. Media results have been created as shown in Figure 2.

![Figure 2. Free fall learning media that has been created.](image)

Figure 2 above is a free fall frame learning system that has been created. To know the travel time of falling objects between coil 1 and coil 2 then in visual need, in this case the audacity program that is displayed using a laptop, as in picture 3.
Figure 3. Free fall learning media that has been connected to a laptop that displays the waves of the audacity program.

3.2. Increasing students' mastery of physics concepts
Learning is done starting with apperception students on the students' understanding of how the influence of the mass of the velocity reaches the ground when dropped simultaneously from the same height. All students have the perception that things which have a larger mass will reach the ground faster than objects whose mass is smaller. This is a misconception experienced by students to the concept of motion in free fall. This misconception is also revealed when students answer the pretest number one which reads "The three objects of different mass, respectively M1, M2, and M3. Massa M1> M2> M3. If the three things dropped from the same height at the same time in a vacuum, then the object that hit the ground first in a row is ... "

Mastery of concepts analyzed in this report is the result of cognitive learning, consists of eight questions both on the question about the pretest and posttest. On the matter of pretest and posttest differ in the location of numbering. Learning media free fall motion to reduce these misconceptions can be said to be successful one from the calculation of average pretest and posttest showed an increase in N-Gain. Increasing students' mastery of concepts portrayed as figure 4.

Figure 4. The results of pre and posttest.
Of the total number of 28 students, there was an improvement in the concept of pre-test with an average of 31.25% and post-test with an average of 64.28%, a significant increase of 105.71%. To more clearly see the increase in mastery of the concept of students to the misconceptions that often appear on the material free fall motion can be seen in Figure 5 N-Gain increase as follows:

Results mastery of concepts using the N-Gain score showed an increase moderately N-gain = 0.45, N-gain with a scale of values 0.4-0.7 middle category [8]. However, there is one student who declined, as alleged this happened because the student in question is not serious nature taking the test is given, the students answered only original test without reading the questions. Because before the tests submitted by students that the test will not affect a student's grade. In general, researchers considered that students are very enthusiastic and concentrated in learning and more understanding of the material using free falling media that has been made, it is in line with research [9] who said that the media can reduce misconceptions student learning. Research [10] concluded that learning using media can improve learning outcomes and mastery of student concepts.

Based on the average difference test with a test at the 0.05 significance level and degrees of freedom n-1, obtained $t_{count} = 8.46$, while $t_{table}$ for $d = 27$ at $\alpha = 0.05$ is 1.703. It is seen that $t_{count}$ does not lie in between $t_{table}$ with $t_{table}$. Then based on the criteria of rejection and acceptance of the hypothesis can be seen that $t_{count}$ there is a region of rejection of the null hypothesis (Ho). So that $H_a$ accepted which means that there is a significant difference between the mean score before the learning with media learning free fall and with after learning with media learning free fall. These differences suggest that the students’ understanding after learning to use the media learning free fall better than before not using media learning free fall.

Based on the calculation of the price obtained effect size is $d = 1.18$. It indicates that the use of learning media free fall in free fall motion learning has a great impact on students' understanding of the concept of motion in free fall.

### 3.3. Student response

This student response is student’s response after applied media of free fall movement. Student responses as Table 1.

![Figure 5. N-Gain (student understanding scores increase).](image-url)
Table 1. Student response to learning using free falling media.

| No. | Statement                                                                 | STS | TS | S  | SS | Tot |
|-----|---------------------------------------------------------------------------|-----|----|----|----|-----|
| 1   | Learning physics of motion of matter falling freely use this medium more comfortable and enjoyable | 0   | 0  | 25 | 3  | 28  |
| 2   | You become aware that physics is real, because the media is delivered directly demonstration in front of the class | 0   | 1  | 14 | 13 | 28  |
| 3   | You are motivated to learn physics with other media, and different materials | 0   | 2  | 21 | 5  | 28  |
| 4   | Media physics learning need to be developed for other materials           | 0   | 3  | 14 | 11 | 28  |
| 5   | Media motion free fall easily understood and has been explained well      | 0   | 1  | 15 | 12 | 28  |
| 6   | Learning to be a very interesting and not boring                           | 0   | 1  | 23 | 4  | 28  |
| 7   | You are more motivated to learn                                           | 0   | 1  | 22 | 5  | 28  |
| 8   | Be able to remember the concept of the subject matter much longer because it is explained using the media | 0   | 2  | 16 | 10 | 28  |
| 9   | The principles, concepts and processes of free fall motion are easier to understand | 0   | 1  | 12 | 15 | 28  |
| 10  | You have a high willingness to follow the lesson                          | 0   | 2  | 24 | 2  | 28  |
| 11  | You do not depressed/tense in learning                                    | 0   | 3  | 19 | 6  | 28  |

Information:
STS : If they absolutely do not agree with the statement that there is
TS : If they do not agree with the statement that there is
S  : If they agree with the statement that there is
SS : If they absolutely agree with the statement that there is

In Table 1 students showed a positive response to the teaching of physics using free fall motion media, the response agrees look to dominate with a score of 3. The positive response of students needed to build student motivation. Motivation is an internal process in a person to continue to maintain a certain behavior, therefore the motivation is a most important element in learning. From some students' responses are recorded in the student response sheet, they want a learning model that applied to other subject matter and highly motivated to learn physics.

4. Conclusions
During this time the students assume that the mass of the Earth's gravitational influence. Free fall motion media used in teaching physics to explain to students visually on the concept of motion in free fall. This media is proven to reduce misconceptions and increase understanding of physics concepts.

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