Increasing Students’ Understanding in the Concept of Projectile Motion with Modelling Instruction Accompanied by Embedded Formative E-Assessment

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Abstract. This study aims to analyze the understanding of the concept of projectile motion of students in class X who studied with modeling instruction accompanied by embedded formative e-assessment. An embedded experimental design was used in this mixed method study. This study involved 30 students of Malang public high school consisting of 12 male and 18 female students. The main instrument of this research was 9 materials (items) with multiple choice questions. N-gain and effect size analysis were carried out on the test results, while the student’s answers and reasons were analyzed qualitatively. The results showed that the average of pre-test value was 18.87 which increased to 49.93 in the post-test, the N-gain value was 0.50 (upper medium) and effect size was 2.09 with a category greater than the standard. This means that with modeling instruction accompanied by formative e-assessment could improve students’ understanding of the concept of projectile motion. It was also found that there is some difficulties in describing the direction of acceleration each time in moving an object with a parabolic path.

1. Introduction
Projectile motion is one of the physics concept that is not yet mastered by Indonesian students. This concept is related to vectors, and it allows students to have various conceptions. Although this material is used in daily life learning, students still often have some difficulties to understand this concept [1]. [2] found that students have difficulties in describing speed vectors, velocity components in horizontal and vertical directions. Students also faced difficulties to understand the travel time of objects which are only influenced by height rather than mass or trajectory of objects [3]. Another difficulty faced by students was, students didn’t understand that the acceleration of a projectile moving object is rather negative than positive [4]. In addition, Students also got difficulties to understand the relationship between speed and acceleration [5]. Furthermore, students still had difficulties to find out the relationship between the concept of motion of objects and their similarities [6].

Various efforts were made by researchers to improve students' conceptual understanding. A study was conducted by [4] using tracker as a pedagogic tool in order to understand projectile motion, and with this tool students could hypothesize and relate it to life every day. The use of Angry Birds’ game and tracker could increase the understanding of the concept of projectile motion and students’ enthusiasm in learning [7]. This learning models which make students active in learning could improve students' understanding of the concepts of projectile motion material rather than conventional learning model [8].

One model that is predicted to improve students' understanding concepts is modeling instruction. This learning model can correct the weaknesses of conventional learning models such as partial knowledge, passive students in learning, and immature knowledge that is trusted in physics concepts [9]. This learning model also has the potential to change the way of learning science and make
students’ learning achievements better [10] Modeling instruction makes students feel more excited in learning science directly, they can do their own experiments so that to be able to compare the results obtained and actual theories [11]. This will increasingly make students more interested in learning physics, and understand the concepts that are in it.

Some improvement of students’ understanding concepts during learning process can be done with formative assessment. Formative assessment can assess students’ abilities based on their skills and knowledge said by [12]. This mature knowledge can be obtained by students through the feedback given by teacher after working on the formative assessment during the learning process[13]. A feedback can be given by teacher after finishing examining all student's formative e-assessment results, so to give a feedback to each student takes long time[14]. A feedback can also be given to students in a continuous and targeted manner with computer-based assessment. Formative e-assessment provides opportunities to students to get feedback diagnoses continuously, and this helps students to improve their knowledge because feedback is done electronically [15].

This study aims to analyze the understanding of the concept of projectile motion of students who studied with embedded formative e-assessment in modeling instruction. The questions asked in this study are as follows. 1. How do students understand the concept of Projectile Motion material with embedded formative e-assessment in modeling instruction? 2. What difficulties do students still experience after learning?

2. Method
This study used a mixed method approach with embedded experimental design. The research subjects included 30 students consisting of 12 male and 18 female students in class X MIPA 3 in the SMA in Malang city in 2018/2019. The high school which used in this study is classified as a middle school. The measurement instrument used was 9 materials (items) for multiple choice questions. Question indicators for each item can be seen in Table 1.

| Item Indicators                                                                 | Item Numbers |
|--------------------------------------------------------------------------------|--------------|
| Determine the vector component of the object's velocity in the horizontal and   | 1, 9         |
| vertical direction in the projectile motion                                    |              |
| Describe the instantaneous vector of objects in projectile motion              | 10, 14       |
| Explain the acceleration of objects in projectile motion                       | 8, 12        |
| Find the time needed for objects on the projectile motion path                 | 3            |
| Determine the position of objects in projectile motion                         | 6            |
| Differentiate projectile motion characteristics based on the elevation angle   | 2            |

The stages in this study are as follows: Before learning, students work on diagnostic tests in the form of questions that are completely wrong online. during learning teacher gives a video or picture in which students give comments (Pre-lab discussion) in group discussions with the LKS guide which is given by teacher (lab investigation). After group discussion students discuss with other groups and then together they discuss in class (post-lab discussion). Finally, teacher gives a training problem that must be done (deployment model). Learning is closed by drawing conclusions and teacher also reminds students to take formative and diagnostic tests for the next meeting.

Data analysis was carried out quantitatively and qualitatively. Quantitative analysis is used in pre-test and post-test score data which is then tested with N-gain to find out an increase of concept of understanding and effect size determine the impact of learning. Student’ answers and reasons were shown with qualitative data analysis.

3. Result
The class average scores of both pre-test and post-test can be seen in Table 2. The average of pre-test score was 18.87 (SD = 15.64), while the average of post-test score was 49.93 (SD = 14.05).
Table 2. Descriptive Statistics

|                | Pre-test | Post-test |
|----------------|----------|-----------|
| N              | 30       | 30        |
| Mean           | 18,87    | 49,93     |
| Std. Deviation | 15,64    | 14,05     |
| Variance       | 244,61   | 197,40    |
| Minimum        | 0        | 22        |
| Maximum        | 56       | 78        |

The results of calculation of d-effect size and N-gain could be seen on Table 3.

Table 3. Statistic of N-gain and d-effect size

| Statistic          | Grade | Category     |
|--------------------|-------|--------------|
| d-Effect size      | 2,09  | Very Big     |
| N-gain             | 0,50  | Medium Upper |

The strength of the increase in pre-test to post-test was measured by 2.09 which was in the very large category and the N-gain value was 0.50 (upper medium category). The distribution of correct answers of the pre-test and post-test is presented in Table 4. The data show that a high increase occurs in indicators 2, 4 and 6 while in indicators 3 and 5 increase is low.

Table 4. Percent Correct of Pre-test and Post-test.

| No | Question indicator                                                                 | Percentage of correct answers (%) |
|----|-------------------------------------------------------------------------------------|----------------------------------|
|    |                                                                                     | Pre-test | Post-test |
| 1  | Determine the vector component of the object's velocity in the horizontal and vertical direction in the projectile motion | 23,3     | 53,3      |
| 2  | Describe the instantaneous vector of objects in projectile motion                   | 15       | 63,3      |
| 3  | Explain the acceleration of objects in projectile motion                            | 15       | 31,7      |
| 4  | Find the time needed for objects on the projectile motion path                      | 16,7     | 70        |
| 5  | Determine the position of objects in projectile motion                              | 0        | 16,7      |
| 6  | Differentiate projectile motion characteristics based on the elevation angle        | 43,3     | 63,3      |

An evidence of increasing in students’ understanding concepts can be seen from the students' responses to the questions as shown below.
Concept of Horizontal Speed on Projectile Motion

Pay attention to the picture below!

Comparison of the horizontal speed of objects at points B and D is ...
A*. 1 : 1 (Pre: 30%; Post: 70%)
B. 1 : 2 (Pre: 6.7%; Post: 13.3%)
C. 2 : 1 (Pre: 3.3%; Post: 13.3%)
D. 2 : 3 (Pre: 6.7%; Post: 0.0%)
E. 4 : 1 (Pre: 6.7%; Post: 0.0%)
Reason...

The distribution of student’s answers to above questions can be seen in Table 5.

|        | POST-TEST | Didn’t answer | Total |
|--------|-----------|---------------|-------|
| A*     | 5         | 3             | 1     | 9     |
| B      | 2         | 0             | 0     | 2     |
| C      | 0         | 0             | 1     | 1     |
| D      | 1         | 0             | 1     | 2     |
| E      | 2         | 0             | 0     | 2     |
| Didn’t answer | 11     | 1             | 2     | 14    |
| Total  | 21        | 4             | 4     | 30    |

After learning with embedded formative e-assessment in modeling instruction, students' correct answers increased to 21 students. However, there are still 9 students who are wrong. Four students answered the choice B, 4 students answered the choice C and 1 student did not answer. Student's correct answer can be seen in Figure 2.

Figure 1. Example of student answer at Post-test.

Because they have equal velocity, constant velocity

Students who answered B assume that objects at point B are slowed and objects at point D are accelerated, then the horizontal speed at point D will be (2) two times greater than the horizontal speed.
at point B. While students who chose C assume that objects at point B are slowed while objects at point D accelerated, the vertical velocity component at point B is shorter than the vertical velocity component at point D), and there will be a causal relationship between objects at point B and objects at point D then the horizontal velocity component will be longer because students still have difficulties to understand vector concepts according to research done by [16]. Students also do not understand that acceleration occurs only in vertical components[2].

Modeling instruction learning is accompanied by formative authentic e-assessment successfully to enhance the concept of understanding. This can be seen from the increase of students’ answers and right reasons. Modeling instruction changes the way of learning, so students can represent answers to graphics, diagrams, verbal, and mathematical model [11]. Difficulties that still experienced by students after learning are indicated through student’ answers in one of the questions.

Velocity Vector Concept on Projectile Motion

Table 6. Pre-test Post-test Crosstabulation

| PRE-TEST * POST-TEST Crosstabulation |
|-------------------------------------|
| Count                               |
After learning with embedded formative e-assessment in modeling instruction, students’ correct answers increased to 10 students. During the pre-test there were 5 students who chose option D, but they still could not give reasons why they chose that answer. There were 13 students who chose B, 6 students who chose C and 1 student who chose E.

Students who answered B assume that the person is plunging, so he will move with parabolic path and acceleration must also go to the right, so in that way people will not fall down freely. However, students who answered C said that people will fall down at accelerated direction, but they still do not understand the concept of the relationship between speed and acceleration. Students also assumed that the person accelerated and then the acceleration vector will be longer when it’s down. That is testified by the student’s reasons and answers shown in Figure

![Figure Image]

Because the body is accelerated Students who answered E admitted that the objects will stop shortly after touching the ground, then the acceleration will be shorter and further down. Similar to students who chose option D. students who chose option E also still have difficulties in determining the relationship between speed and acceleration. That is in accordance with the research conducted [5]. That means students have difficulties in determining the relationship between speed and acceleration. That is why students still have difficulties in describing speed vectors and acceleration vectors.

4. Discussion

Based on data analysis, students of class X MIPA 3 who learned with Modeling Instruction along with formative e-assessment experienced have a significant increase. This increase is known by the increase of the results of students' post-test scores. The N-gain results are 0.50 with the upper medium criteria and ones for the d-effect size are 2.09 with a very large category. The results of research conducted [17] show that learning with modelling instruction has a significant impact on students in representing answers, so students can better understand the concept.

The results of qualitative data in the form of students' pre-test and post-test reasons and answers can be seen in understanding the concept of projectile motion material increasing. That increasing can be found from students who initially did not know that the horizontal velocity of objects at each point together they can explain at the horizontal direction of moving objects in GLB, and students also who know the trajectory and mass of objects do not affect the travel time of objects. In addition, students...
can answer with the correct reasons in the post-test time. In fact, Students who learned by using modeling instruction will more easily master the concepts of physics [9].

It found that some difficulties experienced by students after doing research including students who have difficulties in determining the direction of the momentary acceleration vector of objects while moving the satellite dish and the meaning of the given equation. Students assumed that if the object is dropped at horizontal speed, then the object will have an acceleration in the direction of horizontal speed, because the object moves on the parabolic track. This statement is in accordance with the research conducted [5], students have difficulties to determine the relationship between speed and acceleration. This is, because students still got problems to describe the acceleration of vector. If you know the velocity equation of an object at a certain height (point), then the position equation at any time can be searched for objects. Moreover, students have also troubles to interpret that the given velocity equation is a special equation (only the height is valid), to find the equation of the position that must be sought for the initial velocity of the object. Research conducted [6] proves that students have difficulties to determine the relationship between the motions of objects with mathematical equations.

Teacher can provide feedback to overcome student difficulties, so students can more easily understand the concept of projectile motion. Found that giving appropriate and continuous feedback will strengthen student’ understanding of concepts [18]. In addition teacher must also show concrete facts such as, by giving videos about projectile motion concepts so that students will be able to receive information. Giving assignments can also help students better understand the concept of projectile motion, in addition, this assignment provides an opportunity for teacher to know the conceptions got by students. Research conducted [19] shows that students’ understanding can be known by the task. In this study formative e-assessment has been given, but students are less enthusiastic in doing the given assignments. This can be overcome by the formative e-assessment carried out during learning to help improve students’ understanding of concepts and students’ enthusiasm in working on the given tests.

5. Conclusion
Based on the results of the analysis and discussion described above, the following conclusions are obtained. Modeling Instruction learning can improve the concept of understanding of class X MIPA 3 students at SMA Negeri 2 Malang with projectile motion material. That can be seen from the results of the pre-test and post-test. The strength of the increase in the pre-test to post-test score was measured in using by the d-effect size obtained the results of 2.09 which were included in the high category. The increase of the calculation of normalized gain (N-gain) results obtained were 0.50 which are classified as the upper medium category.

But it found that there are still some difficulties in understanding the concept of projectile motion experienced by students (1). Students also assumed that when objects are dropped at horizontal speed, the acceleration vector will have the same direction with horizontal velocity and the same value at each point, (2) then the speed of the object at a certain height is the initial speed of the object at any time.

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