Undergraduate student’s misconception about projectile motion after learning physics during the Covid-19 pandemic era

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Abstract. This research aimed to describe undergraduate students’ misconception about projectile motion after learning physics during the Covid-19 pandemic era. This research was qualitative research with a descriptive method. The subjects were 52 first-year undergraduate students who took physics courses. Data collecting methods used in this research were a test, questionnaires, and interviews. The test was taken from Physics by Giancoli with an additional question about certainty of response index (CRI). Data from the test were analyzed by categorizing it into lack of knowledge, knowledge of correct concepts, and misconception while open-ended questionnaires and interviews were used to help to clarify the condition. The test results indicated that 5.13% of students in lack knowledge, 28.85% the knowledge of correct concepts, and 66.02% in misconception. The questionnaire responses showed that students learned physics via online meeting with direct instruction model and ask-answer method, exercised with only applied problem (C3), and virtual practicum. The interviews showed that only a few of the students learned physics and responded to the lecturer during the online meeting. The results are that the majority of first-year undergraduate students are in misconception after learning physics during the Covid-19 pandemic era and need remedial learning about projectile motion.

1. Introduction

Physics is a part of natural science that plays an important role in the development of science and technology [1]. Physics consists of the concept of electricity, heat, force, energy, fluids, waves, and the kinematics of motion of an object [2]. Physics learning aims to develop thinking skills so that students are able to use the concept of physics to explain phenomena and problems in daily life both quantitatively and qualitatively [3]. Therefore, physics learning needs to be designed in such a way as to hope that students can understand physics concepts.

The method most often used by lecturers in lectures is the discussion method by explaining, giving examples, asking questions, and providing exercises and assignments. Physics learning becomes less meaningful for students. Students must be allowed to explore understanding, build concepts, develop thinking skills and science process skills [4]. Meaningful physics learning can use various kinds of learning models and methods through face-to-face classes [5]. However, face-to-face meetings should not be held during the Covid-19 pandemic era as an effort to prevent transmission of the virus. Face-to-
face learning is being replaced by online learning [6,7]. In these conditions, the selection of models, methods, and learning media are still limited.

Online learning requires teachers to integrate ICT into learning activities. Teachers need to have the skills to use ICT and the internet to be able to develop online learning. Teachers need to master how to use hardware such as computers and smartphones, as well as software such as zoom meeting applications, google meet, social media, and e-learning websites. There are two forms of online learning, namely synchronous learning (real-time such as virtual classrooms through zoom meetings or google meet) and asynchronous (not real-time through social media or websites). For its implementation, online learning has many challenges such as presenting all students at one time, ensuring they pay attention to learning, and assessing their attitudes during the virtual learning process [8]. These challenges need to be overcome so that learning objectives can be achieved, but if not, it can cause students to less understand concepts and experience misconceptions.

Misconception is a term to express the difference between the concepts that someone understands and that which scientists understand. Students who have misconceptions believe that they understand the right concept, but that concept is wrong according to the scientists' understanding [9]. During learning, students connect their initial pieces of knowledge with new knowledge. If new knowledge is formed incompletely due to the limited ability of students or mixing various thoughts from daily experience, it can lead students to misconception [10].

Based on the results of literature studies, students most often experience misconceptions in the field of mechanics [1,11,12,13,14]. One of the misconceptions that need to be investigated in mechanics is the concept of projectile motion. Since there are many examples of projectile motion that occur in everyday life and the discussion involves two dimensions, namely the x and y axes in the Cartesian coordinates. Misconceptions in the concept of projectile motion experienced by students need to be identified, especially for physics or physics education students who will later become teachers. Prospective physics teacher misconceptions need to be identified and corrected so that when they become teachers, they can transfer the correct concepts to their students.

Research on the identification of misconceptions in projectile motion has been conducted on first-semester physics students of the University of Surabaya at the end of 2019 [2] and physics education students at a university in Mataram in early 2020 [9]. Both studies were conducted before the Covid-19 virus broke out in Indonesia. Research on identifying the misconceptions of physics education students on the concept of projectile motion taught through online learning during the Covid-19 pandemic has not been conducted. Therefore, a study was conducted that aims to describe the misconceptions of undergraduate physics education students on the concept of projectile motion after learning physics during the Covid-19 pandemic. Through this research, the researcher also hopes to be able to analyse the possible causes of student misconceptions so that it can be used as material for joint evaluation in developing meaningful online learning for students.

2. Method
This research was qualitative research with descriptive methods. Descriptive research aimed to create a description or description of the data collected based on facts in the field [15]. The subjects of this study were 52 first-year students of the physics education program, University of Bengkulu.

The data collection methods were test, questionnaire, and interviews. The test and questionnaire used were provided through Google forms. Then the interviews were done via WhatsApp. The test used in this study was a misconception test taken from the Physics Book written by Douglas C. Giancoli and published in 2014. This multiple-choice test was equipped with a certainty response index (CRI) to determine the level of confidence of students in choosing answers. This confidence level helps distinguish students who misconception and do not know the concept [9]. The CRI scale used from 0 to 5 is described in Table 1.

The number 0 indicates that the student has no knowledge of the physics concept in question which means that the student is only guessing the answer. Meanwhile, the number 5 indicates that students are fully confident that the choice of answers and the physics concept they understand is correct. If the CRI number is high (3-5) but the answer choice is incorrect, the student may have a misconception [16].
Table 1. CRI Scale and Its Interpretation

| Scale | Interpretation |
|-------|----------------|
| 0     | Totally guessed answer (if answering the question with 100% guessing) |
| 1     | Almost guess (if answering the question with a guessing percentage of 75-99%) |
| 2     | Not sure (if answering the question with a guessing percentage of 50-74%) |
| 3     | Sure (if answering the question with a guessing percentage of 25-49%) |
| 4     | Almost Certain (if answering the question with a guessing percentage of 1-24%) |
| 5     | Certain (if answering the question with a guessing percentage of 0%) |

Analyses of misconception test data using the matrix shown in Table 2. The answer truth with CRI scale levels were used to determine whether students have lack of knowledge the concept, knowledge of the correct concept, or misconceptions [17].

Table 2. Matrix between the Truth of Answers and the CRI Level per individual respondent

| Answer Criteria | Low CRI (<2.5)                              | High CRI (>2.5)                            |
|-----------------|---------------------------------------------|--------------------------------------------|
| Correct         | Correct answer but low CRI means lack of knowledge (lucky guess) | Correct answer but high CRI means knowing of correct concept |
| Incorrect       | Incorrect answer but low CRI means lack of knowledge | Incorrect answer but high CRI means misconception |

Based on Table 2, the categories of students who have lack of knowledge if the CRI is low, knowing of correct concept if the CRI is high and the answer is correct, and misconception if the CRI is high yet the answer is incorrect. After grouping students into these categories, the percentage calculation for each category was performed using the following formula (1).

\[ P = \frac{f}{N} \times 100\% \]

With P is the number of group percentages, f is the number of students in each group, N is the number of all students investigated [18]. The questionnaire with open-ended questions was analysed by looking at the similarities and differences in students' answers. In addition, interviews were conducted with class leaders, lecturers, and lecturer assistants, the results of which were discussed narratively.

3. Result and Discussion

Researchers conducted a misconception test on students in the first year of the physics education program of the University of Bengkulu who had attended the study of projectile motion. The results of the misconception test analysis are presented in Figure 1.

![Figure 1. Results of misconception test analysis on projectile motion.](image)
Based on figure 1, it is readily apparent that students who experienced misconceptions were at the highest percentage of 66.02%, while students who had knowledge of correct concept were at a lower proportion of 28.85%, while students who had lack of knowledge had the lowest percentage of 5.13%. To see more about the ratio of misconceptions in each concept, an analysis of each projectile motion concept was performed is presented in Table 3.

**Table 3. Results of student misconception test analysis on projectile motion concept for each concept**

| Concept | Category | Percentage (%) |
|---------|----------|----------------|
| The length of time in the air is the same for each kick angle if the maximum height of the ball is equal | Lack of Knowledge | 9.62 |
|  | Knowledge of Correct Concept | 15.38 |
|  | Misconception | 75.00 |
| The acceleration of the bullet is always negative if the upward direction is considered positive | Lack of Knowledge | 0 |
|  | Knowledge of Correct Concept | 59.62 |
|  | Misconception | 40.38 |
| The velocity at the highest point is not worth 0. | Lack of Knowledge | 5.77 |
|  | Knowledge of Correct Concept | 11.54 |
|  | Misconception | 82.69 |
| Average | Lack of Knowledge | 5.13 |
|  | Knowledge of Correct Concept | 28.85 |
|  | Misconception | 66.02 |

Table 3 shows the percentage of each category of misconception test on each projectile motion concept tested. The highest ratio of misconceptions experienced by students on the concept of "The velocity at the highest point is not worth 0" was 82.69%, followed by the percentage of misconceptions in the concept of "The length of time in the air is the same for each kick angle if the maximum height of the ball is equal" by 75%, and the lowest percentage of misconceptions is in the concept of "The acceleration of the bullet is always negative if the upward direction is considered positive" by 40.38%. Students had the highest percentage of knowledge of correct concept "The acceleration of the bullet is always negative if the upward direction is considered positive" where no student had lack of knowledge.

In questions related to the concept of "The length of time in the air is the same for each kick angle if the maximum height of the ball is equal ", students were asked to determine the longest ball in the air based on the kick angle of the ball as shown in Figure 2.

![Figure 2](image.png)

**Figure 2.** length of the ball in the air [19]

The answer choices were made based on Figure 2 plus choice (d) that states the same time. The result was: eight students chose the kick (a), one student chose the kick (b), 34 people chose the kick (c), and nine students chose the correct answer at the same time. Based on Table 3, 84.62% of students had lack of knowledge and experienced misconceptions on this concept. The results of this study are following the research which states that students experience misconceptions due to students understanding that the angle of the object in the projectile motion affect the length of the object in the air, therefore they chose answers (a), (b), and (c). This is based on the equation $v_x = v_0 \cos \theta$ and $v_y = v_0 \sin \theta$ [2]. In addition, the results of this study are in line with research conducted by Busyairi and Zuhdi, where most
students who experienced misconceptions chose answer (c) because of the reach of the falling ball [9]. While the length of the ball in the air is determined by the maximum high that ball reached [19,20].

In the concept of "The acceleration of the bullet is always negative if the upward direction is considered positive", students were asked to determine the value of the acceleration of projectile motion of the object whether positive or negative if the upward direction of motion is considered positive. 40.38% of students experienced misconceptions about this concept. Students deal with the object's acceleration to be positive when the object rises, decreases up to reach zero at its highest point, and negative when the object falls. This result is in line with research that states that students think that acceleration is constantly changing, even though the acceleration of an object is the acceleration of gravity (always constant) [1].

In the concept of "The velocity at the highest point is not worth 0", students are asked to determine the value of the velocity at the highest point, whether it is worth 0 or not. As many as 88.46% of students had lack of knowledge and had misconceptions about the concept. Students assumed the velocity at the highest point is 0. Students guessed that the velocity at the highest point is 0 because the bullet stops moving. Even though the object is still moving and it’s velocity at the highest point at the horizontal direction is not 0 [1,9]. Based on Figure 1 and Table 3, 66.02% of students had a misconception of the concept of projectile motion. The results of this study are following the studies that state that the majority of students experience misconceptions on two-dimensional motion [1,21] and on projectile motion [2,9,10]. Student misconceptions may occur due to teacher misconceptions [9,12], how to teach [11,13,22], and the students themselves [2,14].

The results of questionnaires and interviews showed that the lecturer has a correct understanding of the concept of projectile motion, but the teaching method is not quite right. Students wrote that the lecturer sent photos of the material in the form of writing on paper and inside the book, discussed the material and practice questions via online video conference. Practice questions are given in the form of application (C3). Such learning is less meaningful for students. Students only focus on how to solve problems based on the formulas for projectile motion, not concepts that are important to understand. As a result, students could not apply the equation to the concept of projectile motion when answering virtual experiment questions because it is different from what is discussed in class. Even though lecturers need to provide complete information for avoid misconceptions [13]. Lecturers need to know and explain concepts on a projectile motion that might be misunderstood [11].

The large percentage of students who experience misconceptions on projectile motion (66.02%) is not only caused by inaccurate teaching methods, but students' attitudes during learning also influence these results. The lecturer assessed that student did not participate actively in learning. Students also stated that they did not actively ask questions, tended to be silent when asked to ask. Some students were not enthusiastic about learning because they admitted that it was difficult to follow learning that seemed fast. The lecturer said that the majority of students were not in place when the virtual meeting took place, only seemed active, but when called, did not respond.

The influence of unstable connection signals also affected students' focus. While online video conference requires a strong connection signal. This is considered with the research that states that online learning experience challenges such as internet connection, specifications of student gadgets, internet quotas, and learning processes that become lacking communication, activities, time constraints, and controlling student attitudes during learning [8]. Students who experience misconceptions need remediation learning [10,21,23], especially for prospective teachers. Remediation learning in projectile motion can be in the form of real-time experimental video analysis [10] and the use of e-learning with multiple representations [21]. The use of a multi-representative learning approach is effective in reducing misconceptions [9] and increasing understanding of concepts [24].

4. Conclusion
Based on results and discussions, 5.13% of students had lack of knowledge the concept, 28.85% of students had knowledge of the correct concept, and 66.02% had a misconception about projectile motion after online learning during the covid-19 pandemic era. Students learned physics via online meeting with direct instruction model and ask-answer method, exercised with only applied problem (C3), and virtual practicum. Only few of the students learned physics and responded to the lecturer during the online
meeting. In an effort to reduce misconceptions, remediation learning is required. Lecturers need to improve online learning strategies during the covid-19 pandemic era.

5. **Acknowledgments**

We acknowledge to all students, assistants, and lecturers who helped this research.

6. **References**

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