



## JITT with assessment for learning: Investigation and improvement of students understanding of kinematics concept

Akhmad Jufriadi<sup>1, a \*</sup>, Ratri Andinisari<sup>2, b</sup>

<sup>1</sup> Universitas Kanjuruhan Malang. Jalan S. Supriadi No 48, Malang 65148, Indonesia

<sup>2</sup> National Central University. No. 300, Zhongda Rd., Zhongli District, Taoyuan City 32001, Taiwan

<sup>a</sup> [akhmadjufriadi@unikama.ac.id](mailto:akhmadjufriadi@unikama.ac.id), <sup>b</sup> [ratriandini@ncu.edu.tw](mailto:ratriandini@ncu.edu.tw)

\* Corresponding Author.

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**Abstract:** This study aims to investigate and explore students' understanding of the concept of kinematics, particularly in the concepts of acceleration, velocity, distance and displacement. This research used a mixed-method approach with embedded experimental design. The research was conducted by involving 21 students consisting of 7 men and 14 women. This research used reasoned multiple-choice questions and short interviews to determine the students' initial and final understanding. The results showed that, before the intervention was carried out, as much as 42.86% of students did not understand the concept of distance and displacement correctly, as much as 26.99% of students did not understand the concepts of instantaneous velocity and average speed, as much as 45.6% did not understand the concepts of position, velocity and acceleration and as much as 87.31% did not understand about the direction of velocity and acceleration. In addition, the results showed that the application of JITT with assessment for learning could significantly improve students' understanding of concepts, with N-gain = 0.56 and effect size = 2.38. This study explains the difficulties and general understanding of students on the ideas of distance and displacement, and the direction of object acceleration. In addition, the integration of assessment for learning to JITT is an option in the learning process to improve understanding of Kinematics concepts.

**Keywords:** JITT, Assessment, Conceptual Understanding, Kinematics.

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### Introduction

Understanding the concept in Physics is indeed not easy, particularly for novice students. Whereas understanding a concept may influence the understanding of other physics concepts, as many physics concepts interrelate from one concept to another. Clear interpretation of a concept may make comprehension of other concepts simpler for students, and it will help them to understand more complicated concepts. One of the most fundamental concepts in physics is the principle of kinematics, such as distance, displacement, velocity, and acceleration (Clement, 1982; Handhika et al., 2018; Pulgar et al., 2020). This concept is a core principle that needs to be acquired in order to understand Physics concepts, such as dynamics.

Physics education researchers have conducted studies, research and investigations on initial understanding and challenges experienced by the students (Lichtenberger et al., 2017; Planinic et al., 2019; Sutopo & Waldrip, 2014), which could be used to compile a curriculum to support students understand the concepts of Physics, in particular kinematics. Knowing students' initial understanding and challenges in grasping the concept could very well enable teachers, lecturers, curricula designers to develop a strategy and measure to improve and enhance student understanding. Numerous research has shown that students have problems explaining the concepts of velocity and acceleration

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(Barniol & Zavala, 2014; Reif & Allen, 1992; Rosenblatt et al., 2008; Rosenblatt & Heckler, 2011; Sutopo et al., 2012; Trowbridge & McDermott, 1981), challenges in understanding different graphic information in Kinematics (Bollen et al., 2016; Handhika et al., 2019; Maries & Singh, 2013; Planinic et al., 2012, 2019), challenges in understanding the concept of kinematics with different representations (Lichtenberger et al., 2017).

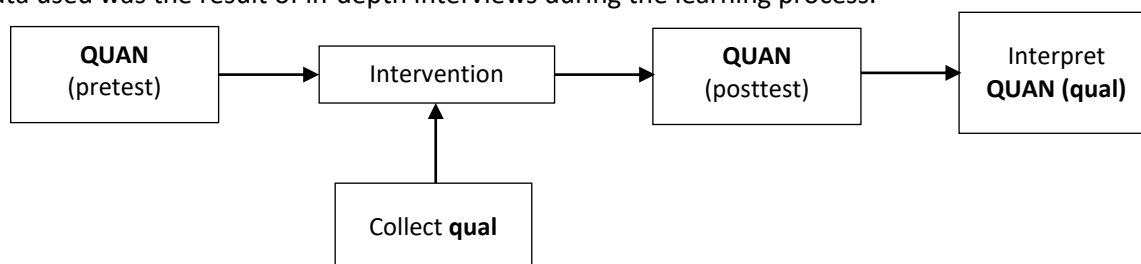
To overcome student's difficulty in understanding the concepts of Physics, numerous learning strategies, models, and approaches were developed along with the development of the instructional media and technology to support the learning process based on the needs of the students; one of them is problem-based learning instructional media and worksheet for Kinematics topic (Kurniawati, 2019; Muliwati et al., 2020; Sari et al., 2020). In addition, the previous research has shown that a well-prepared and well-planned instructional model allows the student to improve their comprehension about the concepts of Physics.

These days, the rapid development of technology and information influences the learning process of students. By integrating technology and information within the instructional media and model in the classroom, commonly called blended learning, it supports students to achieve the desired goal of learning objectives and target. Also, blended learning enables to create a positive learning atmosphere and allows students to communicate their ideas about a certain concept (Dziuban et al., 2018; Setiawan et al., 2019). One example of blended learning development is Just In Time Teaching (JITT) (Wati et al., 2017). Several previous research has shown that JITT instructional model improves students' understanding of the certain concept (Ayu et al., 2019), learning outcomes (Sudarma, 2015), as well as student's critical and analytical thinking (Irwandani, 2014; Wati et al., 2017). In addition, evaluating the development of students' conceptual mastery through learning assessment can help to overcome the difficulties and problems they experience during the learning process (Kusairi et al., 2019).

While most studies have been conducted on the application of the JITT, and the assessment for learning, the integration assessment for learning with the JITT seems to be very limited. As a result, JITT's learning assessment is expected to improve students' ability to understand the concepts of physics that are being learned. This is based on the impact of both the independent implementation of the learning process on student mastery of concepts (Ayu et al., 2019; Kusairi et al., 2019). With such an integration, the impact is expected to result in increased and better mastery. The objectives of this research were to determine the students' initial understanding and challenges of the kinematics concept of distance and displacement, velocity and acceleration before and after the learning process. A further objective is to determine students' mastery of concepts after the learning process is carried out using the JITT with a learning assessment.

## Method

This study employed a mixed-method approach by using an embedded experiment with one phase, as shown in Figure 1 (Edmonds & Kennedy, 2017). The quantitative data used in the analysis were the students' pre-test and post-test scores with the same test instrument. While the qualitative data used was the result of in-depth interviews during the learning process.



**Figure 1.** Mix Method Approaches: Embedded-Experiment (one-phase)

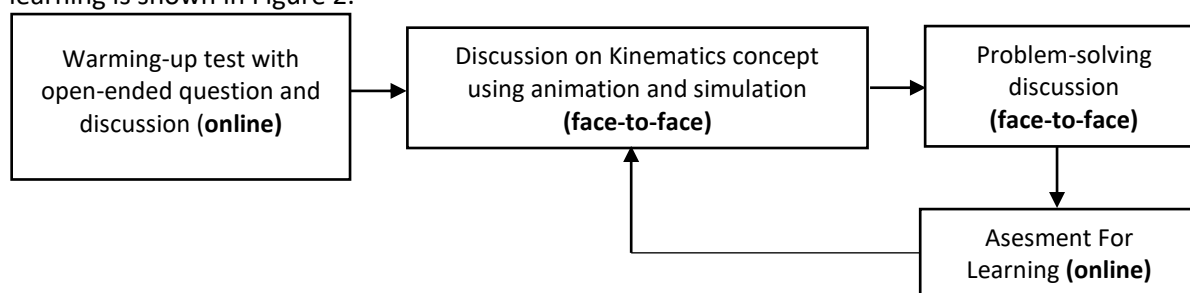
The research subjects were 21 students of the Physics Education study program in the first semester of the 2019-2020 academic year who took Basic Physics course. The research instrument

was 12 items of reasoned multiple-choice questions, which were developed from FCI questions (Hestenes et al., 1992) and questions from textbooks (Serway & Jewett, 2018). An overview of the indicators of each Kinematics test item (Serway & Jewett, 2018), is presented in Table 1.

**Table 1.** Test Instrument Indicator

Test Indicator	Number of Items
Describing distance and displacement	1, 2, 3
Describing instantaneous velocity and average velocity	4, 5, 6
Describing position, velocity and acceleration	7, 8, 9
Describing the direction of velocity and acceleration	10,11,12

The pre-test was carried out at the beginning of the learning to find out the students' initial understanding of the concept of kinematics, and the post-test was carried out at the end of the learning. The Kinematics topics discussed are distance, displacement, position, velocity and acceleration. The learning was carried out using the JITT model, which began by giving warming-up test questions, studying and discussing the Kinematics concepts through online platform. Then, it was continued with face-to-face learning in class by discussing the topics and warming-up test questions and discussing various problem-solving. To control student understanding, an online learning for assessment was carried out. In detail, the JITT learning phase with the assessment for learning is shown in Figure 2.



**Figure 2.** Process flow of JITT with assessment for learning

The data analysis was performed by calculating the normalized effect size and gain (Bao, 2006), according to the students' response on the pre-test and post-test. The data analysis was performed to determine students' conceptual understanding and improvement. Furthermore, to determine the difficulties encountered by the students, it employed qualitative data analysis based on the reasons explained within pre-test and post-test responses.

## Results and Discussion

According to the students' response during the pre-test and post-test, it obtained that the students' understanding increased as presented in Table 2. It further confirms that in general, the students' conceptual mastery about Kinematics topic improved. The average score of conceptual mastery obtained by the students improved from 46.8 to 75.4.

**Table 2.** Descriptive statistics of student mastery concept based on pre-test and post-test

Statistics	Pre-test	Posttest
N	21	21
Mean	46,8	76,6
Maximum	66,6	91,6
Minimum	25	41,6
Standard Deviation	10,4	11,39

To show that there is a significant difference between the pre-test and post-test scores, a paired t-test has been carried out with a significance value of 0.000, which was less than 0.05. This shows that there are differences in students' mastery of concepts before and after the intervention. Based on the calculated N-gain score of 0.56, it is at a medium level score with a fairly effective

category (Hake, 1998), and the value of Cohen's d-effect size (Ellis, 2010) was 2.38 with a very strong category (Cohen et al., 2007; Morgan et al., 2004). This shows that the intervention carried out, JITT with assessment for learning, has a strong and effective effect of changing and improving students' conceptual mastery on the topic of kinematics. These results are consistent with other studies that compare the influence of JITT with conventional models and show that the application of the JITT model to the learning process improves students' conceptual mastery (Ayu et al., 2019; Sudarma, 2015), students' creative thinking (Irwandani, 2014), and students' analytical thinking (Wati et al., 2017). In addition, the JITT application with assessment for learning supports students to build their concepts through the learning, particularly during the initial phase, which is carried out through an online platform. In this initial phase, students are able to discuss, explore to learn everything regarding the topics for the next session and try to give the best response to the test. In addition, the implementation of the assessment for learning has also provided initial information about student difficulties.

Based on the analysis and the comparison of student responses between the pre-test and post-test, it can be seen that in general students experience an increase in understanding of each sub-topic, which is shown in Table 3. Student responses to the pre-test indicate that students' initial understanding was very weak on sub-topics 1, 3 and 4. At the same time, the students' responses to the post-test showed that the students' understanding of sub-topic 4 was still very weak. This shows that students still have difficulty in mastering the concepts of kinematics.

**Table 3.** Students' Responses in Tests

Test Indicator in Each Sub-topic	Correct Answer (%)	
	Pre-test	Post-test
Describing distance and displacement	57,14	93,65
Describing instantaneous velocity and average velocity	73,01	95,23
Describing position, velocity and acceleration	44,4	80,95
Describing the direction of velocity and acceleration	12,69	36,5

In the first sub-topic, especially on item 1 (see Figure 3), at first most students did not understand the difference between displacement and distance travelled. The percentage of students who answered correctly (d. Smaller or same) was 19%. From the arguments presented by the students, it was known that the students' initial understanding was that cars always move in a straight line and do not turn. From the discussion at the initial stage and the conceptual adjustment stage, this understanding was established because on the topic of kinematics there are several sub-topics that discuss the straight motion, regular straight motion and regular changing straight motion.

A car moves from point A to point B. After arriving at the destination, the displacement is ..... with the distance traveled.

(Cars are free to choose the track to be traversed)

- greater or equal
- always bigger
- always the same
- smaller or same
- smaller or larger



Argumentation: .....

**Figure 3.** Item Number 1 ("d" is the correct answer)

The results of the analysis of the students' initial understanding were used as a knowledge to design the intervention process (Docktor & Mestre, 2014), especially at the concept adjustment stage. The post-test results for the first sub-topic of item 1 showed that the students' mastery of concepts, in general, had changed. Therefore the percentage of students who answered correctly was 90.47%. Of the four sub-topics, it is known that the lowest understanding of the concept of students is the fourth sub-topic when explaining the direction of speed and acceleration. From the results of the pre-test and post-test, students who answered correctly only reached 12.69% and 36.5%. Students experienced difficulties on item 11 and 12 (see Figure 4).

Based on diagram, a block sliding along a frictionless path. if air resistances are ignore. Which choice best represents the direction of the acceleration of the box on position I?

a) 2   b) 4   c) 6   d) 7   e) No direction of acceleration  
Argumentation: .....

Which choice best represents the direction of the acceleration of the box on position II?

a) 1   b) 3   c) 5   d) 7   e) No direction of acceleration  
Argumentation: .....

Figure 4. Item number 11 (the correct answer is c) and 12 (the correct answer is a)

In item number 11, 42% of students were able to answer correctly, and the reason was that the direction of velocity is the same as the direction of acceleration. At the same time, the rest of students chose a, b, d, e (each of 14.29%) without conveying their arguments. In question item 12, only one student (4.7%) answered correctly, but the student did not provide an argument for the answer presented. Most of the students chose the answer d (47.6%) and argued that at that position the box is influenced by the force of gravity thus the acceleration of the box is the same as the acceleration of gravity, which is downward. Furthermore, as much as 23.8% of students chose option e. They explained that the box at that point is stationary and has no acceleration; thus, the acceleration of the box has no direction. Then, as much as 14.3% chose option c. They explained that the direction of the acceleration is the same as the direction of the velocity, at that position the speed of the block is towards the left (towards number 7) thus the direction of acceleration is towards the left. Then as many as 9.5% of students chose answer b. They explained that the objects in the right position would go up. Thus there was a force acting in the opposite direction because the acceleration was in the direction of the force. Hence the direction of acceleration was also to the right (towards number 3).

General in-depth discussions and interviews were conducted during the conceptualization phase. From the analysis of student responses confirmed through in-depth interviews, it is known that in general students experience difficulties in several sub-topics, including (1) distinguishing between distance and displacement, this is due to students' understanding that moving objects are always in a straight line; (2) determining the direction of the object's acceleration (case number 12), this is due to the understanding that the object is only affected by the force of gravity or the object at that position is at rest. The difficulties and understanding of these students are also in accordance with the results of investigations and previous research which found that students have difficulty distinguishing distances and displacements, analyzing the direction of acceleration, distinguishing velocity and acceleration (Beichner, 1994; Handhika et al., 2018; Shaffer & McDermott, 2005). From the analysis of students' understanding and conceptual mastery, it is recommended to explain the concepts of distance and displacement, position, instantaneous velocity, average velocity, and acceleration must be accompanied by graphics and visualizations of moving objects.

### Conclusion

When learning the concept of kinematics, the students experience some difficulties, especially in understanding the differences between distance and displacement, velocity and acceleration, and the direction of acceleration of a moving object. Students' understanding and conceptual mastery changed and increased after the intervention was carried out through the application of JITT with assessment for learning. The application of JITT with assessment for learning has a strong influence on Kinematic conceptual mastery. Therefore, JITT with assessment for learning can be applied to improve students' conceptual mastery about kinematics.

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