Implementation of Technology in Physics Learning: Multiple-representation-oriented

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Abstract. This research aims to describe technology implementation in physics learning with multiple-representation-oriented. Technology is limited to using the Learning Management System (LMS) and GeoGebra. Learning is carried out in two phases; in the first phase, students are allowed to study independently through LMS and complete tests; in the second phase, students are accompanied by a facilitator to discuss topics, solve problem findings, and are given the task of creating a video tutorial project to solve multiple-representation based problems with the help of technology and ends with a test. Topics are limited to vectors and kinematics. Implementing technology in multiple-representation-oriented learning provides good results on the quality of learning from the aspect of learning outcomes. More than the material presented in various presentations is needed to stimulate students in representing concepts. The role of lecturers in providing reinforcement and motivation is still needed in the learning process. Multiple-representation-based project assignments can help students achieve the specified learning achievement indicators.

Keywords: Physics Learning, multiple-representation, Technology, Vector, Kinematics.

1 Introduction

Physics is a subject that cannot be separated from mathematical concepts and equations. Mathematical equations are a form of presentation of the language of physics. In learning, facilitators often use mathematical presentations to convey knowledge to students. Physics can be in verbal, mathematical, physical, and visual language [1]. [2] further revealed that in science (physics), concepts can be represented in various presentations (multiple representations) such as text, diagrams, analogies, models, equations, mathematical symbols, and computer simulations. Solving physics problems requires using verbal, pictorial, diagrammatic, and mathematical representations to translate a problem into its underlying mathematical components [3].

Dominant use of mathematical language will provide good results, assuming students also understand the laws and language of physics. However, different conditions are often found where students' mathematical language mastery still needs improvement [4–7]. Students' understanding of the function of physical equations and mathe-

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matical symbols still needs to be better understood. Forcing mathematical language tends to lead students to a system of memorizing equations. Not a few students convey that mathematical equations in physics are called formulas, and this seems inflexible. Tests are given to students to work on physics problems, and they write equations and solve them. Even though they can solve it, they cannot describe the event referred to in the problem.

These various research results reinforce that students must improve their multiple-representation abilities. Multi-representation can be improved through experimental activities, representing concepts using mathematical language, graphs, pictures on whiteboards, textbooks, and/or utilizing technological advances such as simulations. Multi-representation-oriented physics learning can be done by presenting physics concepts in various representations and discussing them with students. Before discussing a problem, students must be able to describe the physical events that occur and then transform them into mathematical language, and/or they can represent them with different representations, for example, mathematically and graphically. Increasing students' representation abilities will have an impact on improving their learning outcomes.

Currently, developing technology supports the representation of physics concepts, from familiar software used in offices [8–11] to other Windows-based software [12–17] websites [18–24] and Android [25]. The software includes Modellus, Electronics Workbench, Electrics Circuit Studio, GeoGebra website, and PhET. This potential is an opportunity for facilitators to integrate technology into the implementation of their learning.

Multiple-representation is an option for physics students to improve their understanding of physics concepts. Physics educators have carried out multiple-representation-based physics learning, focusing on increasing understanding of concepts and multi-representation-based assessments. This research focuses on applying multiple representation strategies in implementing technology-assisted learning and its impact on the quality of learning.

2 Method

This descriptive research describes the implementation of learning using a technology-assisted multi-representation strategy. Learning resources have been provided in the Learning Management System (LMS) in various forms of presentation (books, facilitator explanation videos, simulation use videos). Students can also conduct independent discussions and respond to trigger questions from facilitators, independent discussions, and tests. In the first phase, students can study independently through the LMS and complete tests. In the second phase, students are accompanied by a facilitator to discuss topics and problem findings. They are tasked with creating a video tutorial project to solve multiple-representation-based problems with the help of technology. Topics are limited to vectors and kinematics (position, distance, displacement, and magnitude of displacement). There is material about Velocity and speed in the LMS material, but it was not studied in this research. The software used is GeoGebra with the consideration that it has had an impact on increasing understanding of vector and kinematics concepts [18].

3 Results and Discussion

3.1 First Phase (vector)

In the first phase of vector material, students are asked to study independently the vector material in the LMS. Students can learn the material in PDF form, explain the lecturer in video form, and watch a video simulation using GeoGebra software for vector algebra (see Fig. 1).

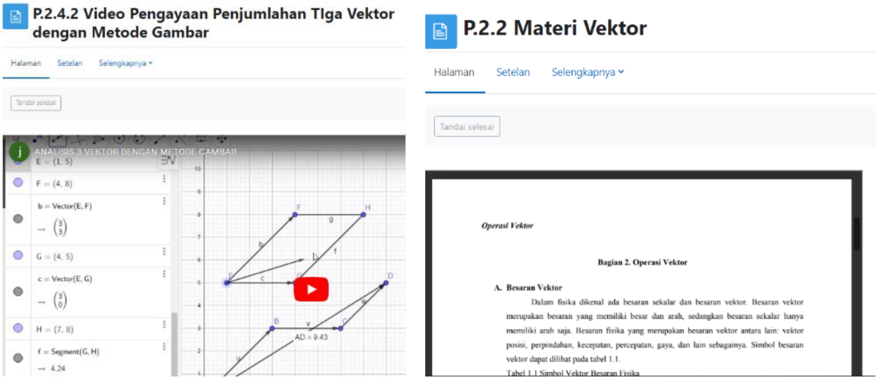

Fig. 1. Vector material presented in multiple presentations.

3.2 Second Phase (vector)

In the second phase, the lecturer reinforced the topic of kinematics and gave assignments to students to solve vector addition problems using the drawing method using GeoGebra software and mathematical methods. Students are asked to analyze and synthesize the two results and then present them. The presentation was done by asking student groups to explain the two methods and recording them, then uploading them to social media. The link is uploaded to the LMS and/or WhatsApp group to get a response from lecturers and colleagues immediately. The results of student explanation videos with various presentations on solving vector algebra problems show that students can represent vector algebra concepts by writing (1) vector symbols, (2) solving using mathematical methods, (4) explaining verbally, (3) and drawing methods.

3.3 First Phase (Kinematics)

Like the first phase of vector material, in the first phase of kinematics material, students are asked to independently study the kinematics material in the LMS (see Fig. 2). Students can learn the material in PDF form, explanations from lecturers in video form, and watch video simulations using GeoGebra software to explain the concepts of position, distance, displacement, and magnitude of displacement.

Fig. 2. Kinematics material presented in multiple presentations.

3.4 Second Phase (Kinematics)

In the second phase of the kinematics material, the lecturer reinforces the topic of kinematics and provides the opportunity to discuss problems related to position, distance, displacement, and magnitude of displacement. Then, students are given the task of explaining verbally and providing images using GeoGebra software related to the concept. The next step is the same as the second phase, which was described in the vector material. In the second phase of kinematics material, students can verbally and visually represent the concepts of position, distance, displacement, and magnitude of displacement (pictures). In each phase, students take tests to measure their learning outcomes—the results of average learning outcomes (see Fig. 3).

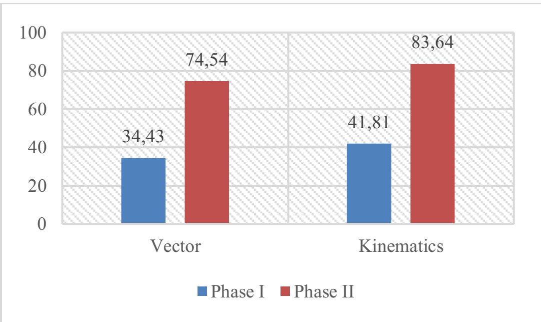

Fig. 3. Average average learning outcomes Phase I and II.

Fig, 3 shows differences in the learning outcomes of phase I and II students. In phase I, students are directed to study independently. Based on Fig. 3, the phase I score has stayed within the minimum standard (less equals 70). More than the material presented in various presentations is needed to stimulate students in representing concepts. Asynchronous discussion forums are also not utilized optimally for discussions with colleagues and lecturers. Student learning styles ideally determine students' cognitive processes in understanding the material [26]. Learning resources that present visual reading/written information help students with a visual learning style, and audio-visuals have also been accommodated with material presented in video form. The kinesthetic learning style has the potential not to be facilitated, considering that there is a chance that students will not try GeoGebra software as a substitute for practical activities. In phase I, more than visual and audio-visual presentations were needed to help students understand the material. These results are supported by research [27], which states a weak relationship between learning styles and students' physics learning outcomes. Of course, different results are likely to emerge if the kinesthetic learning style is accommodated. The research results [28] provide information that learning styles significantly contribute to learning outcomes. Multiple presentations of concepts that are understood independently have the potential to cause cognitive conflict. Excessive cognitive conflict can also cause anxiety in students [29].

In phase II, giving project assignments and having a facilitator (lecturer) who provides reinforcement and motivation can change the value of learning outcomes. Lecturers provide reinforcement of material that students understand and stimulate students to be motivated to solve problems. This argument is supported by research [30], which shows that learning styles influence learning outcomes through learning motivation. Making products in groups has weaknesses in its application. The potential for one or two students in one group not to be active in project creation is still possible. During the implementation, students were not identified who were not active in working on the project. The video project products produced by students provide information that students can represent physics concepts with various representations. Verbal representations can be observed when students explain solving project problems, pictorial/graphic representations can be observed when students use GeoGebra software to solve vector and kinematics problems, and mathematical representations can be observed when students solve mathematical equations. The kinesthetic learning style is accommodated in phase II.

One indicator of improving the quality of learning is student learning outcomes. However, it should be emphasized that learning time is also another indicator. Learning with phase I and II models takes quite a long time. This information can certainly be used as a basis that more than presenting information in various presentations, asynchronous discussions, and tests is needed to stimulate students to learn independently. Not a few students also have good initial knowledge, so it isn't easy to understand the material presented. Learning style and educational background (vocational and non-vocational schools) also determine the initial abilities possessed by students. The role of the facilitator (lecturer) in learning is important in conditions like this. Phase I and II modifications (made into 1 phase) are recommended for future research. Identification of student learning styles is considered for subsequent research.

4 Conclusion

Based on the explanation above, information can be obtained that implementing technology in multiple- representation-oriented learning provides good results for the quality of learning from the aspect of learning outcomes. The material presented in various presentations is not enough to stimulate students in representing concepts; the role of lecturers in providing reinforcement and motivation is still needed in the learning process. Technology support as a substitute for experimental activities can potentially improve student learning outcomes. Multiple-representation-based project assignments by activating verbal representation (explaining the steps to complete the project), visual representation (drawing position, distance, displacement and magnitude of displacement, vector operations), and mathematical representation (solving vector operations mathematically) can help students in achieving the specified learning achievement indicators. Technology implementation (use of LMS and GeoGebra Software) can stimulate students to activate their motoric aspects.

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