International Journal of Advanced Educational Research
ISSN: 2455-6157; Impact Factor: RJIF 5.12
Received: 13-11-2019; Accepted: 16-12-2019; Published: 19-01-2020
www.educationjournal.org
Volume 5; Issue 1; 2020; Page No. 56-59

Use of representation of vectors in learning physics concepts about dot product and applications in work concepts

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Abstract

Research conducted is related to the representation of the use of semiotics in learning physics. The purpose of this study is to study whether there are differences in average learning outcomes using the Work-it-out-teaching strategy (WIOTS) learning model on the use of semiotic representations of scalar multiplication and application in business concepts. This research was conducted in the Department of Physics Manado State University in October 2019. The population in this study were 20 third semester students. This type of research is an experiment. The design used in this study is a pretest-posttest group design. The research instrument consisted of a test of learning outcomes. To test the hypothesis using the One-Sample Test. Data analysis was performed descriptively. The results of testing the hypothesis obtained by t_{count} = 17.491 and t_{table} = 1.729 which means tcount> ttable with a significant level of 0.05, it can be concluded there are differences in average learning outcomes using the Work-it-Teaching Strategy learning model (WIOTS) for students to scalar multiplication material and application in business concepts made a very significant increase in the average post-test learning outcomes higher than the pre-test. In the field of physics studies, Work-it-out-teaching strategy (WIOTS) learning models can be used as learning options that can help lecturers in the learning process.

Keywords: WIOTS, representation, scalar multiplication, dot product, learning outcomes

1. Introduction

Vectors have an important role that is very prominent in many branches of physics. Vector objects that have a size (sometimes called length) direction, and are often visualized as arrows. Lack of understanding about vectors can cause problems when the concept of vectors is embedded in all physical concepts. There are also those who say that students' difficulties in learning physics are caused by lack of skills and understanding of vector drawing.

Most of the concepts of physics covered in introductory physics at university level are represented or expressed by vectors. Therefore, a complete understanding of these concepts of physics requires students to have a good understanding of basic vector concepts. Student misconceptions about vector concepts, properties, and fluency in vector operations are not explored directly. Instead, these concepts are embedded in the application. And to assess student understanding of vector concepts, representations, and operations outside the kinematic or mechanics context presents a new framework for vector conceptualization in college geometry that identifies three vector representations: vectors as translations; vectors as points and points as vectors; and the number of geometric vectors.

Based on Poluakan C research and J Runtuwene (2018) [6] it was found that first year students who incorrectly answered the basic concepts of physics such as draw normal forces not perpendicular to the plane, draw friction on slippery surfaces that shows incomplete information about the concepts of physics learning from high school to university level.

In the research of Joel Van Deventer and Michael C. Wittmann (2007) [1] Students in physics class have difficulty in doing vector tasks. Some topics of difficulty include: vector quantities, directions, addition, subtraction, dot products, cross products, and unit vectors. students who performed very poorly on the question of the size of the dot product, with 4% correct in mathematics and 7% correct in physics. When asked to find the dot product vector A and B, the most common 50% wrong choice, shows that students use the addition of vectors to evaluate the dot product.

Students have limited working memory, and representations must be designed with the aim of reducing unnecessary cognitive burdens. However, cognitive architecture alone is not the only factor to consider. These individual differences, especially prior knowledge, are very important in determining what impact their representation and design has on students' cognitive structures and processes, especially prior knowledge, is very important in determining the impact of representation on cognitive structures and processes. Previous knowledge can determine the ease with which students use to understand and interpret representations in working memory. To understand the role of representations in science teaching and learning, we must consider not only the way they are designed, but also the way they are interpreted by different students. (Michelle Patrick Cook, 2006) [2]

The use of learning strategies has an important role to play in learning. Where the learning strategy is one of the factors that can improve student learning outcomes. One learning strategy used is Work-It-Out Teaching Strategy (WIOTS). The aim is to describe the rationale and pedagogical features

Of the Work-It-Out (WIO) teaching strategy that has been developed to fill gaps in student understanding and to involve them in the basic skills, activities and thought processes that employ experts as a matter of course. Operational elements developed to support WIO teaching strategies, such as videos depicting experts in physics that discuss the basic "why" and "how" of learning in diagrams and formulas. (Christine Creagh, 2014) [3]

2. conceptual framework

Physics deals with countless quantities that have size and direction, and it requires special mathematical language vector language to describe those quantities. This language is also used in engineering, other sciences, and even in general conversation. If you have ever given directions such as "Road five blocks down this road and then on the left," you have used vector language. In fact, any navigation is based on vectors, but physics and techniques also require deep vectors special ways to explain phenomena involving rotational and magnetic forces. Dynamic system movements are usually explained in two basic quantities: scalar and vector. Scalar is a physical quantity that only has magnitude, like the mass of an object. This is entirely determined by a single number, in the appropriate unit. The value does not depend on the coordinates chosen to describe the system's movements. Other common scalar examples include density, volume, temperature and energy. Mathematically, scalars are treated as real numbers. They obey all the normal algebraic rules of addition, subtraction, multiplication, division, and so on.

Scalar multiplication or in other terms called dot product or dot product, is a form of vector multiplication operation that produces a scalar quantity or only produces a large value or also only in the form of numbers / numbers only. In the physics concept there is a physics quantity as a vector quantity which when operated produces a new quantity that only has a large value (scalar), which is the force vector $|\vec{F}|$ and the displacement vector $|\vec{S}|$. Physics magnitude which is a product of two vector operations (force $|\vec{F}|$ and displacement $|\vec{S}|$) which produces a new quantity or quantity that only has a large value, namely the so-called work (work). Because of this, the physical quantity 'effort' is referred to as being classified as a scalar quantity. Why is that? Review Figure 1, a block to be moved from point O to point P along the positive X-axis, in the direction of vector $\vec{S}$.

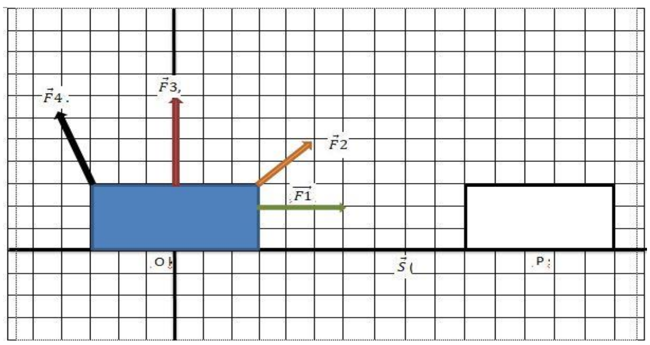

Fig 1: Illustration of the movement of objects in the framework of the Cartesian coordinate system

To get the beam to move from point O to point P, the beam is pulled by a force $\vec{F}$. Fig. 1 shows the four possible attractions given to the beam, namely, the first possibility of attraction $\vec{F}1$, the second possibility of attraction $\vec{F}2$, the possibility of all three attractions $\vec{F}3$, and the possibility of all four attractions $\vec{F}4$.

Basically this scalar multiplication operation is based on the concept of geometry projections in Cartesian coordinates that form vector components. To explain this scalar multiplication operation, then review two arbitrary vectors such as vector $|\vec{A}|$ and $|\vec{B}|$. The two vectors are parallel, and both vectors form an angle ϴ (see Figure 2.a). The geometry projection to each vector is shown in Figure 2.b. [4]

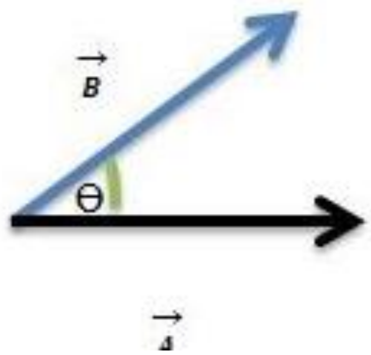

Fig 2a

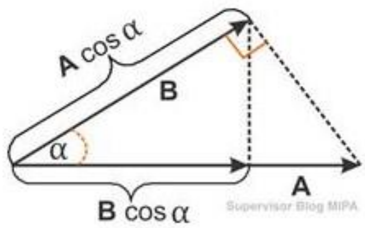

Fig 2.b.

3. Methodology

This research was conducted at the Department of Physics at the State University of Manado in the 2018 students of the 2018/2019 school year. This study uses the WIOTS learning model which consists of 6 steps: Edge of ability, Expert Video, Analysis of the video, focus activity, Finishing, and Group Presentations. 1) Edge of ability: At this stage students form small groups and are given challenges that will be on the edge of their combined capabilities as a group, in the proximal development zone (ZPD). 2) Expert Video: At this stage students watch a video consisting of experts discussing the underlying concepts, and motivations related to the activities requested by students. 3) Analysis of the video: At this stage students are asked to analyze the video and before continuing to the next step students are given a few minutes to find out how they can use what they have just learned to improve their final presentation. 4) Focus Activity: At this stage students are asked to work in pairs and are asked to do concentration to practice what they have just learned. 5) Finishing: At this stage students who are paired are asked to return to the initial group to finish about ZPD. 6) Group Presentations: At this stage the learning group is then given the opportunity to present their challenges in front of the class, while students who watch the presentation have the opportunity not only to learn about the material presented by other students, but also about presentation techniques.

4. Results and Discussion

The results of the pretest showed that all students could not answer correctly this happened because generally students did not understand either about the scalar multiplication material (dot product) and its application. In addition they do not understand, among other things, students still interpret the dot product as a vector size. As found by G. Zavala and Pablo Barniol (2016) in his research the most common error of 23% is to interpret dot products as vectors. Different vector student sketches in their interpretation. About one of these three students connected the dot product by adding vectors, the other third with the bisector vector (vector between A and B) a small portion with vectors in the positive horizontal direction, and found that students used the addition procedure when asked to count dot products. In fact, another common error of 9% is to interpret dot products as vector sizes. [3]

Besides the constraints experienced by students is that they have not been able to distinguish the magnitude and direction of the vector. This is also the same as that done by Pablo Barniol and G. Zavala (2014) in the second administration we find that the most common wrong reason by students is to connect the scalar nature of the dot product with the magnitude of the vector. An example of this wrong reason is "Product dot is scalar, that's why the result is large and not vector." It is interesting to note that the difference in the selection of two options (A and C) is very high (around 20%) and seems to be due to the nature abstract non-contextual items and the fact that students have more resources in business items, as indicated earlier. We also find in this item that the business context item triggers the selection of option E (18% vs 4%). In this option business refers to the interpretation of effort as a vector in the direction of displacement. But when learning is applied to the WIOTS learning model there is an increase in learning outcomes. [7]

Based on data analysis of research results at the Faculty of Mathematics and Natural Sciences UNIMA in semester 3 of the Physics Department students in the 2019/2020 academic year, it shows that there are differences in the average results of studying physics in scalar multiplication material. The average score of learning outcomes using the learning model (WIOTS) shows the average pre-test learning outcomes is 43.21 and the average learning outcomes in the post-test is 66.61.

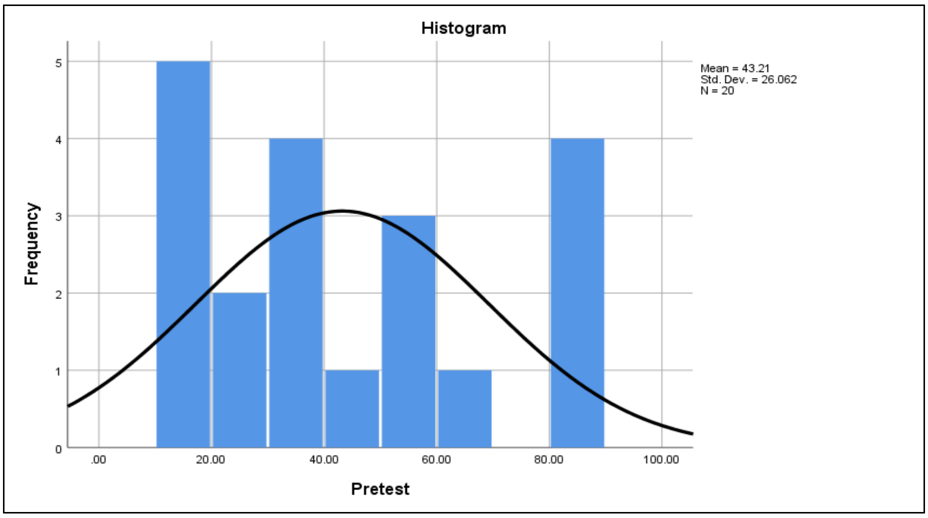

Fig 3: Pre-test Value

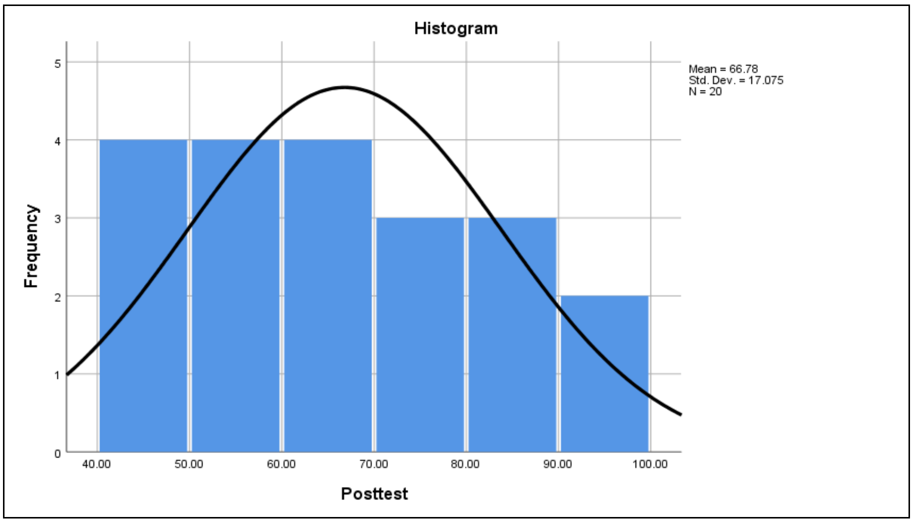

Fig 4: Post-test scores

Using normal distribution statistics (t-test), the pre-test and post-test have significant differences as shown in Table 1.

Table 1: One-Sample Test

One-Sample Test						
	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pretest	7.415	19	.000	43.21407	31.0167	55.4114
Posttest	17.491	19	.000	66.78436	58.7929	74.7758

Based on the results of testing the hypothesis for learning outcomes after being given the treatment, it was obtained t_{count} = 17.491 and t_{table} = 1.729 with a significant level α = 0.05 and obtained 0.000 which means 0.000 <0.05. So it can be concluded accept H1. This means that there is a difference in the average learning outcomes with the use of the WIOTS learning model in students for scalar multiplication material there is a very significant increase in the average post-test learning outcomes higher than the pre-test.

5. Conclusion

Based on the results and discussion obtained it can be concluded that the average physics learning outcomes of students using the learning model (WIOTS) on the use of semiotic representations in physics learning about scalar multiplication material in the application of business concepts in the Post-test is higher than the average yield studying student physics at the Pre-test. This refers to the results of data analysis obtained in this study.

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