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Students' understanding of vector operations: With and without physics education technology simulation

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ABSTRACT

This study aims to investigate the influence of technology integration (physics education technology simulation) in physics learning. A quantitative method with a quasi-experimental post-test-only design was applied to reveal the differences in students' abilities to operate vectors between the group that learned and tested using simulation and the group that learned using graphics only. The test consisted of 16 questions on the addition and subtraction of two vectors divided into one and two dimensions. Student response data were analyzed using descriptive statistics and Kruskal-Wallis test. The analysis results show that the vector operation score for experimental group 1, which learned vector operations through graphic learning using simulation and tested with the same simulation (86.15), is higher than experimental group 2, which learned vector operations through graphic learning using simulation (76.59), and the control group, which learned vector operations through graphic learning without simulation assistance (71.81). All three groups have higher average scores for one-dimensional than two-dimensional vector operations. They also have higher average scores for vector addition compared to vector subtraction operations. Kruskal-Wallis test results indicate a significant difference in the average vector operation scores for the three groups (ρ=0.021). This suggests that integrating technology in the learning and testing processes leads to a significant difference. Moreover, the difference is significant for one-dimensional vector operations (ρ=0.004) and not significant for two-dimensional vector operations (ρ=0.107). These findings could support the implementation of similar approaches at the university and high school levels, especially for vector-related topics, in both learning and testing processes.

Keywords: physics education technology, physics learning, physics test, simulation, vector

INTRODUCTION

The integration of technology in education has become a primary need at all levels of education in the current era. Technology can provide various benefits from various perspectives and for all individuals involved. It can be utilized in designing learning materials such as lesson plans, student worksheets, assessment sheets, and more (Pranata, 2023a). Technology can also be involved as a support in the learning process, such as through inquiry-based learning and as a tool for conducting tests in the groups room (Pranata, 2023b). Furthermore, technology can play a role in reflective activities in learning, such as collecting responses and feedback from students after the learning process. Technology not only aids teachers in teaching but also facilitates the smoothness of students' learning processes. Additionally, content literacy can be enhanced through the involvement of technology in the learning process.

The benefits of integrating technology into education have been widely discussed in various studies and disciplines, including science and physics. In the field of physics, the use of technology in learning has been considered with the development of computers as an essential part of technology. One popular question regarding the involvement of computers (technology) in physics education, raised by Redish in the early 1990s, was "are computers appropriate for teaching physics?" (Redish, 1993). Various responses have been given to this question, indicating that we have now reached an era, where computer (technology) in learning has become essential (Finkelstein et al., 2005). Subsequently, science and physics education have been directed towards a standard form of integration, namely technological, pedagogical, and content knowledge (TPACK) (Mishra & Koehler, 2006). Technology integration continues to draw attention and has further developed into TPACK-practical or TPACK-P (Yeh et al., 2014). The integration of technology into education has proven to support the transformation of the learning process towards higher quality.

Although computers have dramatically improved productivity in many areas, their use for improving education has been slow and difficult. Online interactive simulations may soon change all that (Wieman & Perkins, 2006). The simulation referred to here is

Table 1. Research design

Group	Intervention in learning	Test
Experimental group 1	Vector operation: Graphic representation & PhET (vector addition simulation)	Vector questions in one & two dimensions with PhET (vector addition simulation) assistance
Experimental group 2	Vector operation: Graphic representation & PhET (vector addition simulation)	Vector questions in one & two dimensions
Control group	Vector operation: Graphic representation	Vector questions in one & two dimensions

physics education technology (PhET) simulation. PhET simulations are developed by a team from University of Colorado and have quickly become popular in the field of physics education, especially for physics learning, as they can be easily accessed and are free of charge through the link https://phet.colorado.edu/.

The collection of simulations is also diverse, allowing teachers to choose simulations according to the physics topics they want to teach. Initially, around 2006, about 50 simulations were developed, and now there are more than 100 simulations ready to be used and applied in science and physics learning in the groups room. The number will continue to grow according to user needs. Some examples of simulations include vector addition, projectile motion, force and motion, gravity and orbits, and more. Physics learning can make use of PhET simulations according to the topics being taught, starting from the simplest to the most complex. Simulations have evolved into useful tools for various contexts that can enhance student learning (Finkelstein et al., 2005), including lectures, in-groups activities, group activities, homework activities, and lab activities Mulai dari lecture, in groups activities, groups activities, homework activities, and lab activities (Wieman et al., 2010).

In physics learning, even when students reach complex topics, they often have misconceptions related to simple topics such as vectors. Students still struggle with operating vectors, both in the process of adding and subtracting two vectors. Previous studies have also revealed various misconceptions and difficulties in both operations. When comparing mathematical and graphical operations, it was found (Knight, 1995). The causes vary, including vector placement or position, direction, and more (Barniol & Zavala, 2010; Knight, 1995). Furthermore, misconceptions in vector subtraction are found to be more dominant than vector addition (Barniol & Zavala, 2014; Pranata & Seprianto, 2023).

However, vectors are the most fundamental concept in physics. Understanding vectors, both in one and two dimensions, is crucial for students. Understanding vectors becomes the basis and foundation that will determine students’ success in studying further physics topics such as kinematics, dynamics (translation and rotation), and all other topics related to vector quantities. Superficial understanding of vectors becomes a source of difficulty for students in one-dimensional kinematics and becomes more serious in two dimensions (Shaffer & McDermott, 2005). Students’ understanding of vectors can also facilitate their analysis of systems consisting of many forces at work (Knight, 1995; Nguyen & Meltzer, 2003), such as producing a well-constructed free-body diagram (Pranata & Lorita, 2023). A free-body diagram based on vector understanding in the form of arrow representations has been proven to help students understand the concepts of dynamics, both in translation (Pranata & Lorita, 2023) and rotation (Pranata et al., 2017). Therefore, students’ success in physics topics, especially kinematics and dynamics, depends on their understanding and ability to operate and reason using vector concepts (Flores et al., 2004).

To ensure that students can accurately understand basic vector concepts and operations and apply them to subsequent physics concepts, the implementation of an appropriate learning approach for vector topics that is beneficial for students is needed. In other words, modifications and improvements are needed in the learning process (Flores et al., 2004). Previous studies have also emphasized the importance of significant treatment and assistance in vector learning (Nguyen & Meltzer, 2003). Other studies recommend using technology as a tool for vector learning (Knight, 1995; Wutchana & Emarat, 2011). To address these misconceptions and problems, physics learning about vectors can be integrated with available technology, specifically PhET vector addition simulation. The use of PhET has been proven to help students acquire and understand physics concepts (Pranata, 2023a). The simulation can be integrated not only during the learning process but also when testing vector operation questions. Previous studies have revealed that PhET simulations can serve as a confirmation tool (Pranata, 2023b), especially regarding students’ views on vector operations. Additionally, teachers can utilize simulations to design lesson plans, worksheets, and assessments accordingly.

Based on the exposition of technology integration through PhET vector addition simulation into physics learning, testing will be conducted to prove whether there is a difference in students’ ability to operate vectors between the group that learns and tests using the simulation and the group that learns using only graphics.

MATERIALS & METHODS

The study employs a quantitative method with a quasi-experimental design involving three student groups, as outlined in **Table 1**.

Each groups consists of 17 students participating in a basic physics course. Special treatment is provided to the experimental groups. Experimental group 1 and group 2 undergo the learning process related to vector operations using both graphic methods and PhET vector addition simulation. The simulation can be accessed through the link https://phet.colorado.edu/en/simulations/vector-addition. The difference between the two experimental groups lies in the test. Experimental group 1 answers test questions with the assistance of PhET simulation, while experimental group 2 does not. Lastly, there is one control group following vector learning through graphic methods and testing without PhET simulation, similar to experimental group 2.

Table 2. Vector operation rubric*

Variable	0 (missing)	1 (inadequate)	2 (need improvement)	3 (adequate)
Vector operation accuracy	Did not respond	Responded to question, but there is a major misconception in process like reversing direction of vector arrow or operational errors	Responded to question, no fatal errors, but not visually accurate or there are completeness issues with arrow or vector	Responded to question correctly & accurately

Note. *Rubric was modified from arrow language rubric (Pranata & Lorita, 2023)

Table 3. Statistic descriptive results

Groups (score)	n	Range	Minimum	Maximum	Mean	SD	Variance	Skewness	
								Statistic	SE
Experimental group 1 (average)	17	37.50	62.50	100.00	86.15	12.08	145.90	-0.99*	0.55
Experimental group 2 (average)	17	54.17	45.83	100.00	76.59	20.14	405.57	-0.27*	0.55
Control group (average)	17	29.17	58.33	87.50	71.81	9.20	84.70	0.60*	0.55
Experimental group 1 (1 dimension)	17	29.17	70.83	100.00	91.91	9.14	83.50	-1.09	0.55
Experimental group 1 (2 dimensions)	17	58.33	41.67	100.00	80.39	19.53	381.43	-0.80*	0.55
Experimental group 2 (1 dimension)	17	50.00	50.00	100.00	76.72	19.60	384.23	-0.12*	0.55
Experimental group 2 (2 dimensions)	17	58.33	41.67	100.00	76.47	22.29	496.81	-0.30*	0.55
Control group (1 dimension)	17	50.00	50.00	100.00	74.02	15.77	248.57	-0.15*	0.55
Control group (2 dimensions)	17	41.66	41.67	83.33	69.61	9.29	86.26	-1.46	0.55

Note. *Data normally distributed; SD: Standard deviation; & SE: Standard error

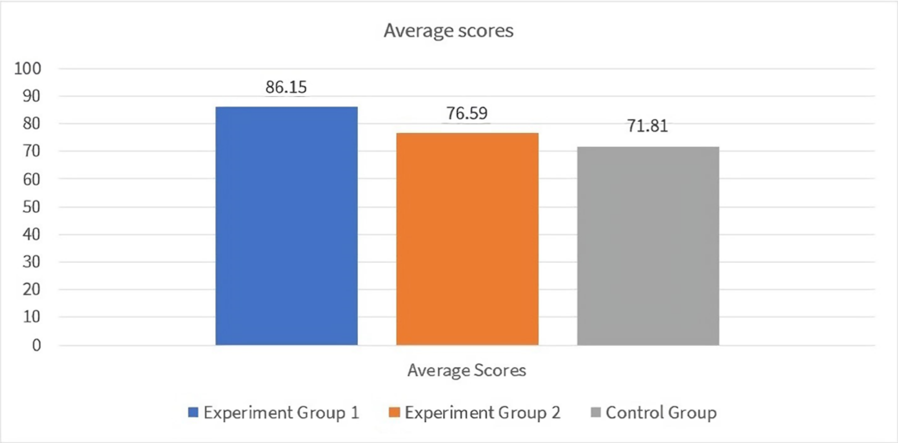

Figure 1. Average score for each group (Source: Author's own elaboration)

As knowledge of vector operations (addition and subtraction) relies on the content or physics domain, the quasi-experimental design involves only a post-test. This design is implemented to determine the comparison of vector operation abilities among students in the three groups. The test questions for all three groups are identical, comprising 16 questions on adding and subtracting two vectors. The vector questions are divided into two dimensional groups: vectors in one dimension and two dimensions. Each dimension consists of eight questions, further divided into four vector addition and four vector subtraction questions. However, experimental group 1 answers questions assisted by PhET simulation. Vector addition and subtraction in the questions use a visual representation in the form of arrows. The length and direction of the arrows become crucial indicators in determining accuracy in vector operations (Pranata & Lorita, 2023). Student responses are converted into quantitative data based on a modified rubric, as shown in **Table 2**.

The gathered data, in the form of numerical scores within the range of zero-three, is converted to a scale of 100. Subsequently, the data is descriptively analyzed to gain an overall understanding and distribution of information regarding the accuracy of vector operations under different treatments. Statistical analysis is then conducted using ANOVA or Kruskal-Wallis test to compare the average scores between the three groups, depending on the normality and homogeneity of the data (Morgan et al., 2004). The same comparison is also carried out for vector operation questions in one and two dimensions separately. Data collection and conversion are performed with the assistance of Microsoft Excel, and the subsequent analysis is conducted using SPSS software.

RESULTS & DISCUSSION

Descriptive Statistic & Checking Assumptions

The results of the descriptive statistical analysis are presented in **Table 3**. Descriptively, we can understand the conditions of each data, both in terms of averages and one- and two-dimensional data for all three groups.

Based on the averages, it can be observed that the score for experiment group 1 (86.15) is higher than experiment group 2 (76.59) and the control group (71.81), as shown in **Figure 1**.

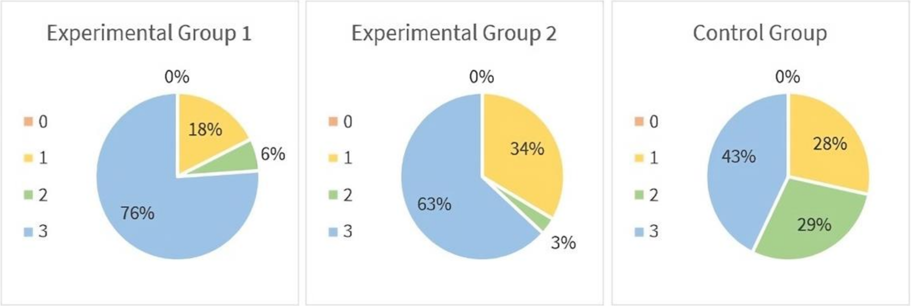

Figure 2. Data distribution on vector operations for each group (Source: Author's own elaboration)

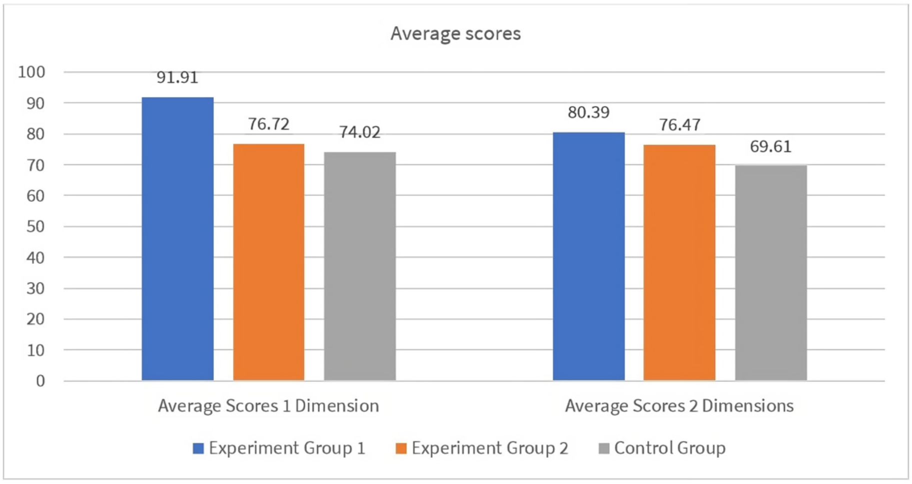

Figure 3. Average vector operation scores in one dimension compared to two dimensions (Source: Author's own elaboration)

Experiment group 1 received treatment through learning and tests assisted by PhET simulation. Meanwhile, experiment group 2 used PhET simulation only during the learning process. On the other hand, the control groups did not receive support from PhET simulation. This finding can be further explored from a different perspective, namely the distribution of the vector operation score for each group, as shown in **Figure 2**.

Based on the summarized answer data in the form of a data distribution, as shown in **Figure 2**, it can be observed that no students left answers blank or unanswered in all groups. For answers with a score of three, the same order is found starting from the highest percentage, namely experiment group 1 (76%), experiment group 2 (63%), and control group (43%). Interestingly, data for answers with a score of one are found to be highest for experiment group 2 (34%) compared to the other groups. This data indicates that 34% of student answers are inaccurate or involve misconceptions. The learning process using PhET is believed to influence students' thinking. Specifically for experiment group 2, the learning process is provided with the assistance of PhET simulation, but during the test, there is no support from PhET simulation. In contrast, the distribution of the score data in the control group appears to be proportional between the percentage of answers with a score of one and two. This means the number of student answers that are inaccurate or involve misconceptions (score one) is almost the same as the number of student answers that are incomplete or need little improvement (score two).

Next, the same pattern or sequence is also found for the average vector operations in one dimension and two dimensions. The scores for experiment group 1 are always higher, followed by experiment group 2 and the control group. This finding can be observed more easily in diagram form, as shown in **Figure 3**. Another interesting pattern to discuss is that all three groups have higher average vector operation scores in one dimension compared to two dimensions, as shown in **Figure 3**. The largest difference between one and two dimensions is found in experiment group 1, reaching 11.52. Interestingly, experiment group 2 has almost the same ability in vector operations for one dimension and two dimensions. In other words, a small difference between the average vector operations in one and two dimensions is found in experiment group 2, which is 0.25. Finally, the control group has a difference of 4.41. This means there is a significant gap in the ability to operate vectors in one and two dimensions in experiment group 1. However, even so, the average scores for vector operations in one and two dimensions for experiment group 1 are still higher than the other groups.

This finding aligns with previous research that revealed vector operations in two dimensions are more challenging due to the involvement of additional possible directions in addition and subtraction (Pranata & Seprianto, 2023). However, contrasting findings have been reported by other studies, indicating that students are more accurate when answering vector operation questions in two dimensions compared to one dimension (Wutchana & Emarat, 2011). The difficulty students face in one-dimensional vector operations is associated with operations involving negative signs or vector subtraction. In other words, common errors found in one-dimensional vector operations are related to the vector direction in subtraction operations. Therefore, the comparison between addition and subtraction operations becomes interesting to discuss further.

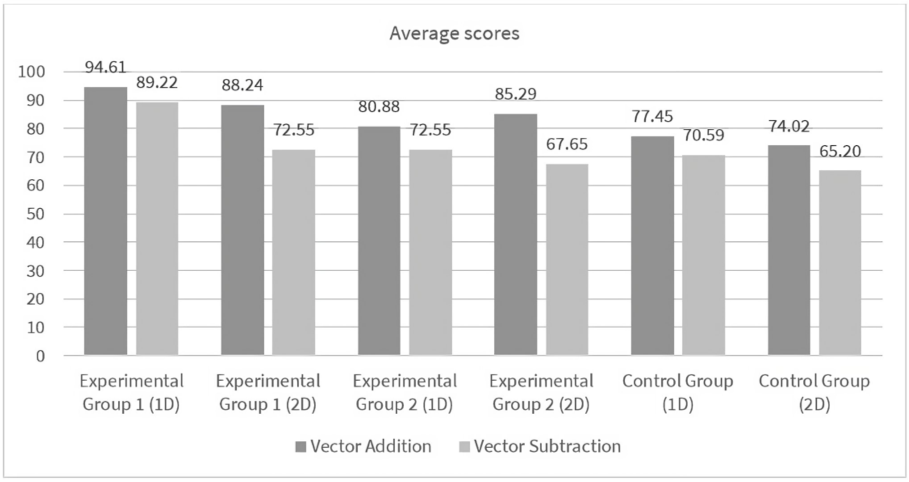

Figure 4. Average vector operation scores (addition & subtraction) (Source: Author's own elaboration)

Table 4. Test of homogeneity of variances

Levene statistic	df1	df2	Significance
6.652	2	48	0.003

Table 5. Kruskal-Wallis test

Group	n	Mean rank
Control group	17	18.79
Experimental group 1	17	32.94
Experimental group 2	17	26.26

Regarding the comparison of addition and subtraction operations, an interesting pattern was found based on the collected data. Students' ability to operate vectors differs in adding and subtracting two vectors. Students' scores in subtracting two vectors are always lower than their scores in adding operations. This finding applies to all groups and each dimension, as shown in **Figure 4**. These results indicate that subtracting vector operations is always more challenging for students compared to vector addition operations. Similar findings have also been revealed by other studies, showing that subtraction vector operations pose a more dominant challenge (Barniol & Zavala, 2014; Pranata & Seprianto, 2023; Wutchana et al., 2015). Subtracting vectors using arrow representations is quite unique and requires additional explanation. Students need to be aware that subtracting vectors is equivalent to adding the first vector to the second vector, which has been reversed in direction. The length of arrow or magnitudes of both vectors remain the same, only the second vector has the opposite direction. Studies on students' abilities to operate arrows become crucial to emphasize in learning, especially in physics (Pranata & Lorita, 2023).

Furthermore, the results of descriptive statistical analysis can also indicate whether the data are normally distributed or not, based on the scores in the skewness column (statistic), as shown in **Table 3**. The average data for all three groups are normally distributed, with skewness scores ranging from -1.00 to 1.00 (Morgan et al., 2004). Sets of data that are normally distributed have been marked with asterisks for their skewness scores. The average scores for all three groups are normally distributed. However, there are two data groups that are not normally distributed, namely the experimental group scores for one-dimensional vector operations and the control group scores for two-dimensional vector operations

The distribution of data serves as the basis for determining the type of test or analysis to compare scores. For now, the assumption for using ANOVA has not been violated for the comparison of overall average scores for all three groups. However, comparisons for each dimension cannot use ANOVA. Nonparametric analysis is used, namely Kruskal-Wallis test. Further assumption tests for ANOVA in the comparison of average data are conducted through the Levene statistic. This test aims to determine the homogeneity of variance in the data. The results of Levene statistic are shown in **Table 4**.

Homogeneity of variances can be determined based on Levene statistic. The results show that the Levene test statistic is significant ($\rho<0.05$). This means that variances are significantly different. The assumption for ANOVA is violated. Therefore, the test for comparing overall averages and averages for each dimension for all three groups will use the same test, namely Kruskal-Wallis test.

Comparing Group: Nonparametric Test (Kruskal-Wallis Test)

The results of the comparison of average student scores for vector operations (addition and subtraction) based on Kruskal-Wallis test are shown in **Table 5** and **Table 6**.

The mean rank scores in **Table 5** can serve as the basis for comparing the average scores for vector operations for all three groups, where the highest mean rank is for experimental groups 1, followed by experimental groups 2 and the control groups. Furthermore, the statistical test results in **Table 6** indicate that the difference in average scores for vector operations among the three groups is significant ($\rho=0.021$)). This result indicates that the treatment with the assistance of PhET simulations has a

Table 6. Test statistic$^{a \& b}$

	All data
Chi-square	7.758
df	2
Asymptotic significance	0.021

Note. ^{a}Kruskal Wallis test & ^{b}Grouping variable: Group

Table 7. Kruskal-Wallis test

	Group	**n**	**Mean rank**
One dimension	Control group	17	19.50
	Experimental group 1	17	35.38
	Experimental group 2	17	23.12
	Total	51	
Two dimesions	Control group	17	20.21
	Experimental group 1	17	30.71
	Experimental group 2	17	27.09
	Total	51	

Table 8. Test statistic$^{a \& b}$

	One dimension	**Two dimensions**
Chi-square	10.976	4.473
df	2	2
Asymptotic significance	0.004	0.107

Note. ^{a}Kruskal Wallis test & ^{b}Grouping variable: Group

significant effect on students' ability to operate vectors. The effect is found to be greater when PhET simulation is integrated into both learning and testing (experimental groups 1) compared to the effect of integrating PhET simulation only in learning (experimental groups 2).

This finding can be explained by the features embedded in PhET vector addition simulation, which facilitates students in operating vectors. The vector addition simulation can assist in visualizing vectors in arrow form. In general, all PhET simulations can provide simulations so that the visual perception between teachers and students can be aligned regarding the learning material, facilitating communication and the learning process (Wieman et al., 2010). Additionally, there is a feature that allows vector dragging, which can facilitate vector operations. This feature has been proven to help improve the basic understanding of vectors (Siu-Ping & Chak-Him, 2020). Another useful feature of the simulation for students studying vectors is the grid. The grid can help students visualize vectors accurately. The use of the grid has been proven effective for students in learning and completing vector operations (Nguyen & Meltzer, 2003). However, other studies have not found differences in outcomes when learning with or without a grid (Hawkins et al., 2010). Further research on the comparison of using grids is worth exploring. With or without a grid, students should be given the opportunity to practice vector operations without using a grid (Nguyen & Meltzer, 2003).

These features of PhET sims enable students to pose questions and answer them in ways that may not be supported by more traditional educational materials (Podolefsky et al., 2010). In addition to confirming the finding that there is a significant difference in the ability to operate vectors, it is essential to note that the three groups differ in their treatments in two situations, namely the learning process that uses simulation assistance and the test that uses simulation assistance. The simulation not only impacts the learning process but also during the test. In learning using PhET simulations, students can utilize various controls/variables available to explore the material (Wieman & Perkins, 2006) and then leverage the learning experience in the test using the same simulation. Previous studies have revealed that the use of PhET simulations as assistance during tests can be a confirmation tool for students (Pranata, 2023b).

Further exploration was conducted with the same test to compare the average scores for vector operations separately for one and two dimensions, using Kruskal-Wallis test. The test results are shown in **Table 7** and **Table 8**.

The mean rank scores in **Table 7** show the comparison of the average scores of the three groups for vector operations in one and two dimensions. The same mean rank order is found, namely experimental groups 1, experimental groups 2, and the control groups (from highest to lowest). Furthermore, the results of the statistical test shown in **Table 8** indicate that the difference in average scores for vector operations among the three groups is significant for one dimension (ρ=0.004). However, the difference in average scores was found to be not significant for vector operations in two dimensions (ρ=0.107).

These results serve as the basis for understanding the treatment's influence more deeply. Although treatment with the assistance of PhET simulations has a significant effect on students' ability to operate vectors overall, the effect is only significant for vector operation ability in one dimension and not significant for two dimensions. In the ability to operate vectors in one dimension, the same pattern of influence is found. The effect is found to be greater when PhET simulation is integrated into both learning and testing (experimental groups 1) compared to the effect of integrating PhET simulation only in learning (experimental groups 2).

Difficulties in adding vectors in two dimensions have been a common problem among students. Previous studies have revealed that more than 50% of students cannot accurately operate vectors (Knight, 1995; Nguyen & Meltzer, 2003). Similar findings have also been uncovered, where only 65% of 512 students were able to accurately operate vectors and accurately sum vectors graphically (Barniol & Zavala, 2010). With a graphically focused learning approach like in the control groups, it was found that 28% of students had misconceptions, and 29% of students were not accurate in operating vectors. Student scores or abilities were found to be better when vector learning was graphically focused with the help of simulations, as in experimental groups 2 (34% of students had misconceptions, and 3% of students were not accurate in operating vectors), and with additional testing assisted by simulations, as in experimental groups 1 (18% of students had misconceptions, and 6% of students were not accurate in operating vectors).

Although the vector operation scores in all three groups (control, experiment 1, and experiment 2) were found to be different, the results of the difference test using Kruskal-Wallis test show that the difference is not significant in student scores for vector operations in two dimensions. In contrast, vector operations in one dimension were found to be significantly different for all three groups. Differences in student abilities in vector operations in one and two dimensions have also been revealed in other studies. Graphic vector operations in two dimensions are more challenging than in one dimension in learning that focuses on representing vectors as arrow language and its correlation with free-body diagrams (Pranata & Lorita, 2023), blended learning (Pranata & Seprianto, 2023). This condition indicates that whatever approach or treatment is given in the learning process, the difficulty level of the material always influences the grades obtained by students.

In general, the use of simulations can encourage students to pay attention to deeper structural relationships of material that may not stand out before using simulations. In this way, instructors can use simulation features productively to connect students to deeper conceptual learning. Then the use of simulations can help students answer conceptual questions (Podolefsky et al., 2009). Furthermore, for instructors, PhET simulations can be used to direct learning towards inquiry, even self-directed inquiry (Podolefsky et al., 2010) and create more enjoyable and effective learning (Wieman et al., 2010).

CONCLUSIONS

The vector operation scores (addition and subtraction) for experimental groups 1 through vector learning using PhET vector addition simulation and a test assisted by the same simulation (86.15) are higher than experimental groups 2 through graphic vector learning using PhET vector addition simulation (76.59) and the control groups through graphic vector learning without PhET simulation assistance (71.81). Despite the different treatments, all three groups share a commonality, which is related to the score patterns indicating proficiency in vector operations. They all have average scores for addition operations that are consistently higher than subtraction operations of two vectors. They also have average scores for one-dimensional vector operations that are consistently higher than two-dimensional vector operations.

Then, the data and analysis results indicate a significant difference in the average scores of vector operations for all three groups (ρ=0.021). This result shows that the integration of learning using technology (PhET vector addition simulation) in the learning and testing process provides a significant difference. Furthermore, the difference is significant for one-dimensional vector operations (ρ=0.004) and not significant for two-dimensional vector operations (ρ=0.107).

The findings in this study can be utilized in the physics learning process at the college and high school levels, especially for vector materials. The use of the vector addition simulation is not an issue as it is available in open access. Teachers can study and utilize various features embedded in the simulation. Additionally, teachers can also apply the same simulation in tests.

Although it has shown important comparisons in vector learning, this study still has various limitations. First, PhET vector addition simulation used is limited to vector addition and subtraction operations. With the same approach, the study can be extended by involving similar operations but mathematically or by comparing students' abilities in operating vectors graphically and mathematically. Moving forward, it can explore students' understanding related to vector components and vector multiplication, both dot product and cross product. Second, this study requires confirmation with a larger sample size, even with more experimental groups with more varied treatments. Third, the study may also be limited to the vector concept without a physical context. Thus, these results can serve as a basis and recommendation for expansion towards vector operations in physics concepts such as force, momentum, fields, and so on.

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Ethical statement: The authors stated that the study did not require ethics committee approval. The study was conducted as part of an academic engagement which has gone through departmental scrutiny. Participants were informed about the study's objectives, procedures, potential risks, and benefits, and assured that their participation was voluntary, and they could withdraw at any time without negative consequences. The author further stated that the results of this study were used solely for educational research purposes and reported in a way that ensures participant anonymity, adhering to ethical standards in all dissemination of findings.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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