Activity of My Vector in Improving Vector Resolution Skills Among Pre-University Students

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Abstract

Visual skills are important mathematical process skills that need to be applied in more complex fields such as physics. Students need to be trained to visualize vector concepts. Therefore, this paper aims to discuss the potential of the My Vector activity in helping students solve vector arithmetic operations by visualizing them in the physical world. This study uses the Kemmis and McTaggart model in one cycle. An initial review was conducted through a topical test on subtopic 5.1 which is introduction to vectors. Then, students' marks and achievement levels of learning objectives were analysed to design and act to address the problem of students only achieving one out of four learning objectives of subtopic 5.1. Backgrounded by the integration of the 5E model of learning and flipped classroom learning method, activities involving 11 students from Labuan Matriculation College encouraged students to visualize and practice vector operations to solve vector arithmetic operations in three dimensions. Data was collected through observation, document analysis, and interviews. The study's findings show a significant improvement, with the average student score increasing from 55% before the intervention to 85% after the intervention. In addition, interview results showed that the My Vector activity had a positive impact on students' attitudes towards learning vector processes. Reflection results concluded that changes in more active teaching practices had a positive effect on the teaching practice of the researcher and the learning of students in mathematics, especially in the vector topic.

Keywords: Arithmetic Operations, Vectors, Visual And Practical

1.0 Introduction

The vector topic is the fifth topic in the second semester of the SM025 Mathematics course in matriculation. This topic contains four subtopics and 15 learning objectives. Among them, in subtopic 5.1, four learning objectives that students need to achieve are a) stating the types of vectors, b) finding the magnitude and unit vector, c) performing addition, subtraction, and scalar multiplication, and d) finding the angle between two vectors (KPM, 2022). Vectors not only test students' conceptual knowledge but also demand them to translate it into more complex algebraic and geometric skills in matrices and other fields such as physics. In the context of mathematics learning in matriculation, students need to master 6 mathematical process skills, namely cognitive, practical, interpersonal, communication, digital, and numeracy skills (KPM, 2022). During the teaching and learning process, students should be exposed to non-routine questions to enable them to apply the algebraic concepts learned in class to daily life, thus appreciating the uniqueness of vector itself (Ridzuan & Lian, 2019). Cognitive and practical skills can be well translated if students receive various representations such as visual,

symbolic, numerical, and graphical (Niess & Mack, 2009). Therefore, educators need to be creative in designing activities in teaching and learning to develop the necessary skills. Furthermore, NCTM (2000) emphasizes the diversity of teaching practices needed to develop various problem-solving skills. Therefore, improvements in teaching practices have been implemented in the My Vector activity by actively applying visual and practical methods outside the classroom.

2.0 Literature Review

The significance of visualization techniques in mathematical education has garnered substantial attention in recent research. Gavita (2016) emphasizes the pivotal role of visualization in establishing a robust understanding of abstract concepts by grounding them in sensory perception. Moreover, at Anwar and Juandi (2020) assert that visualization transcends mental constructs when individuals can effectively translate imagined structures into tangible representations or other forms that help to communicate information. Building upon these notions, Halil and Mahmud (2022) highlight the efficacy of visualization in problem-solving within mathematical contexts, underscoring its importance as a pedagogical tool. Similarly, Ishartono et al. (2021) provide empirical evidence suggesting that students inclined towards visual learning styles exhibit enhanced systematic problem-solving abilities. Furthermore, neurological insights from Marks et al. (2024) elucidate the cognitive mechanisms behind visualization, indicating that activating the dorsal visual pathway can augment mathematical cognition. Despite these advancements, Taqwa and Rahim's (2022) study reveals persistent challenges among students in effectively applying vector concepts to practical contexts. This discrepancy in understanding, as demonstrated by respondents with varying interpretations of visual representations, underscores the need for a comprehensive approach to vector learning. Aligning with this sentiment, AlAli (2023) advocates for the integration of visual aids to facilitate conceptual comprehension, emphasizing the multifaceted nature of learning reception.

3.0 Methodology

3.1 Research Focus

In the era of the Covid-19 pandemic transition, the teaching and learning sessions in matriculation are conducted in a hybrid mode where lectures are conducted online and tutorial classes are conducted face-to-face. Researchers face limitations in delivering knowledge to students because the vectors discussed are in 3 dimensions. Researchers can only draw vectors in 2 dimensions during online classes via Google Meet. This makes it difficult for students to imagine vector movements and the results of vector operations such as addition, subtraction, multiplication, dot product, and cross product. As a result of self-reflection, the researcher feels disappointed because they cannot fully convey vector concepts in line with learning objectives. Furthermore, researchers experience problems with effective communication between lecturers and students during online classes. Observations found that students attending Google Meet classes were less responsive and some remained silent when their names were called. The use of *Jam board* is also

less effective because only a few people share ideas and write answers. This indicates a low level of student understanding of the topics being studied. In addition, I have observed a declining attendance of students in mathematics online classes. An analysis of student attendance reports reveals a consistent decrease in the number of students attending Google Meet sessions each week. This trend indicates a potential problem in student engagement and participation in online mathematics classes, necessitating further investigation into the underlying causes and possible solutions. Interviews with students indicate that they experience internet connectivity problems that often disconnect in hostel areas. Therefore, researchers have made alternatives by providing videos on the Edpuzzle application to allow students to learn independently at any time. However, only a few students watch the videos. This has an impact on students' understanding and skills in problem-solving. Discussions in tutorial classes seem like lectures where lecturers need to repeat the teaching that has been delivered online before. Discussion sessions become one-way where most questions asked will be answered again by the lecturer. Findings from past studies show that students' understanding of vector concepts is not coherent with their visual and graphic skills (Taqwa & Rahim, 2021). This makes it difficult for students to apply vector concepts in solving other vector application questions. Therefore, the implementation of interventions through the implementation of the flipped classroom teaching method consisting of out-of-class learning (OCL) and In-class Learning (ICL) should be strengthened to achieve optimum learning outcomes. Therefore, the focus of this study is to enhance mastery of vector arithmetic operation skills through visualizing and practicing vectors in the physical world. This action research is based on the flipped classroom learning approach and implements the 5E learning model for visualization and practical processes.

3.2 Research Objectives

i. To assess students' learning attitudes towards the vector topic after participating in My Vector activities based on flipped classroom learning.

ii. To enhance and improve students' skills in solving vector arithmetic operation questions through visualization methods in My Vector activities.

3.3 Research Participants

This study involved 11 first-year students from the class taught by the researcher during Semester 2 of the 2022/2023 Session at Labuan Matriculation College (LMC). A total of 8 female students and 3 male students were selected. The participants shared a commonality, that is, they had basic knowledge of vectors based on their previous experience in mathematics classes and were selected based on their scores in topical exams, scoring 5 marks or below out of the full 12 marks.

3.4 Pre-Survey

During the in-class learning session (PDK), the researcher found that students still did not master the concepts and skills of solving vector

problems. Referring to the initial survey through the topical test of subtopic 5.1. This test consists of 4 questions representing one question for each learning objective. Most students only mastered one learning objective. However, there were students who could provide general responses due to the existing knowledge of vectors acquired from watching videos on Edpuzzle.

Table 1: Pre-Survey Through Topical Test

Student	Score	Objective Achievement
Student 1	1	1
Student 2	1	1
Student 3	1	1
Student 4	1	1
Student 5	1	1
Student 6	1	1
Student 7	1	1
Student 8	1	1
Student 9	1	1
Student 10	1	1
Student 11	1	1

This can be demonstrated through the students' work, where some students incorrectly perform vector addition. The students' answers indicate confusion, particularly in performing the cross-product operation. To find the vector $\overrightarrow{PQ}$, students should correctly add vectors $\overrightarrow{PO}$ and $\overrightarrow{OQ}$.

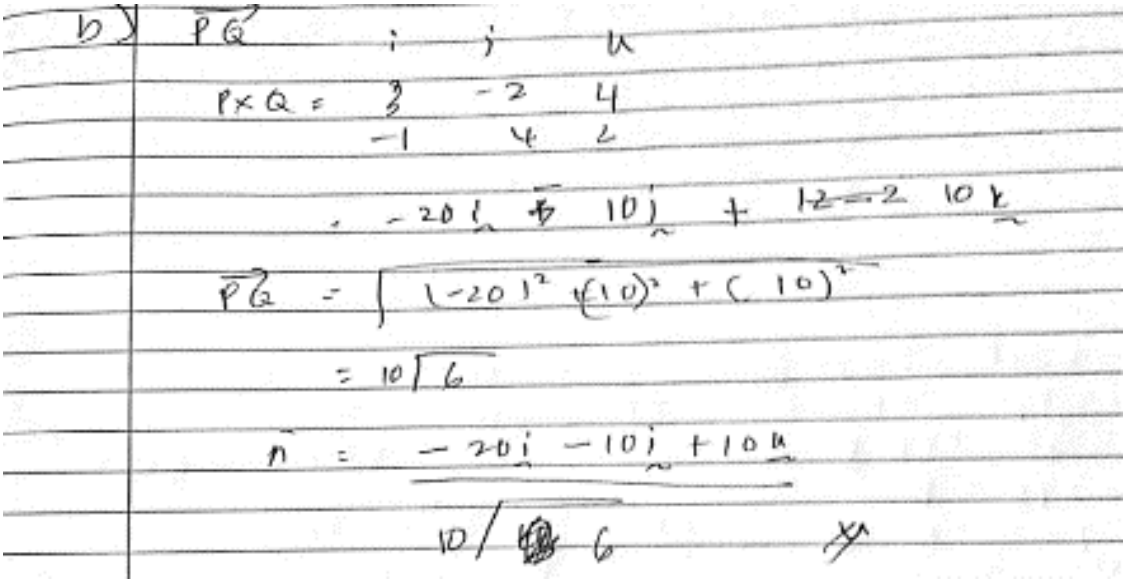


Figure 1: Students' work

To address the issues mentioned above, a specific initiative was implemented as an intervention measure to prevent the ongoing problems. The approach taken can help to make mathematics instruction more engaging and significantly aid in building students' understanding more effectively, compared to instruction that solely focuses on delivering burdensome information to students (Hofman & Hayes, 2019).

3.5 Planning

3.5.1 Action Research Model

This study follows the steps proposed in the Kemmis and Taggart model (1988). This model is aligned with the main goal of this study, which is to seek solutions to identified problems for the improvement of teaching practices and quality. The study involves the processes of planning, acting, observing, and reflecting. At the beginning of the study, the researcher reviewed the students' learning problems. Then, intervention actions were planned by conducting the My Vector activity with the study participants. The implementation of the intervention was planned for two hours of asynchronous classes and two hours of synchronous classes. The flipped classroom approach was chosen because it aligns with the teaching and learning mode at KML, which allocates three hours of asynchronous classes and two hours of synchronous classes per week. For the implementation of the action, students conducted the My Vector activity in stages following the 5E learning model, which involves engagement, exploration, explanation, elaboration, and evaluation. It started with watching videos on Edpuzzle, answering 8 basic vector questions, finding the vector distance between two points, and then sharing and reflecting on the activities they had carried out. Subsequently, the researcher observed and collected data throughout the activity, then assessed the impact on self-teaching practices and student learning changes.

3.5.2 Data Collection

Data collection involves three methods based on the research objectives as outlined in Table 2 below:

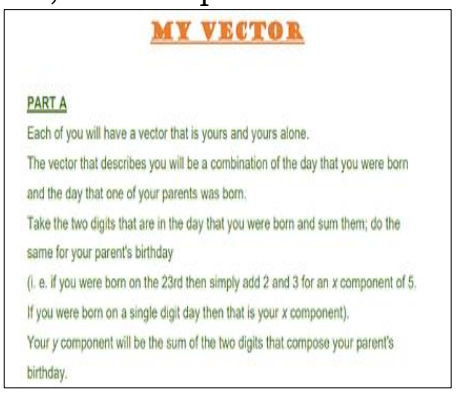
Table 2: Data Collection Methods

Objective	Data collection method	Purpose
1	Interviews Observation	To assess changes in students' attitudes toward the vector topic and obtain feedback regarding the implementation of activities
2	Document analysis Observation	To observe the improvement of students' skills in solving problems. To assess students' ability to visualize vector concepts in the physical world

3.6 Actions

Based on the flipped classroom teaching method, the My Vector activity was implemented using the 5E Learning Model. This model was chosen because of its proven effectiveness in mathematics education as demonstrated by studies conducted by Bakri and Adnan (2024). The implementation of activities is illustrated in Table 3:

Table 3: Implementation of My Vector Activity

Flipped Classroom Teaching Mode	Learning Activity based on the 5E Model
Out-of-Class Learning (OCL)	Engagement Students watch vector-related videos on Edpuzzle and answer a few short questions related to the content of the video presentation.
In-Class Learning (ICL)	Exploration Students find their own vectors by solving 8 vector questions related to vector arithmetic operations such as addition, subtraction, scalar multiplication, and dot product.  MY VECTOR PART A Each of you will have a vector that is yours and yours alone. The vector that describes you will be a combination of the day that you were born and the day that one of your parents was born. Take the two digits that are in the day that you were born and sum them; do the same for your parent's birthday (i. e. if you were born on the 23rd then simply add 2 and 3 for an *x* component of 5. If you were born on a single digit day then that is your *x* component). Your *y* component will be the sum of the two digits that compose your parent's birthday. Figure 2: Instructions and Questions for My Vector Activity

	Explanation Students share their own vectors with their peers.
Out-of-Class Learning (OCL)	Elaboration This activity is conducted in pairs. Using a smartwatch or Google Maps, starting from their own vectors on the campus plane, students need to add their own vectors with a new vector to find the vector distance from the campus plane to four different destinations: the squash court, parking lot, resource centre, and lecture hall. Students need to cleverly visualize in determining the distance and direction of movement from one place to another, either horizontally, vertically, or diagonally, where this direction will determine the i, j, and k components of the new vector. For example: if a student's own vector is 2i + 3j + 0k, the student needs to move two steps to the right and three steps forward to start this activity. Next, using a smartwatch or Google Maps, students need to move and calculate the distance steps from the campus plane to the squash court. If the new steps taken are 20 steps to the right and 10 steps forward, this results in the vector distance from the campus plane to the squash court as (2i + 3j + 0k) + (20i + 10j + 0k) = (22i + 13j + 0k).
In-Class Learning (ICL)	Evaluation Students reflect and present the vectors they have produced. The lecturer collects student work and assesses assignments.

4.0 Results and Discussion

4.1 Document Analysis

The researcher collected student work after the activity to assess students' understanding and skills in vectors. This assessment refers to the learning objectives of the vector subtopic 5.1, which is the introduction to vectors in three dimensions. This assessment was conducted twice, before and after the intervention session. Before the intervention session, all students only achieved 1 learning objective. Whereas after the intervention, through the answers and work shown by the students, all students were able to achieve all 4 learning objectives in subtopic 5.1. The study showed a significant improvement, with the average student score increasing from 55% before the intervention to 85% after the intervention.

Table 4: Level of Achievement of Student Learning Objectives After Intervention

Student	Test score and level of achievement of learning objectives	
	Before intervention	After intervention
Student 1	1	4
Student 2	1	4
Student 3	1	4
Student 4	1	4
Student 5	1	4
Student 6	1	4
Student 7	1	4
Student 8	1	4
Student 9	1	4
Student 10	1	4
Student 11	1	4

The data above also supports the finding that students' visual skills have improved because they were able to solve vector problems given, while also raising awareness among students about the importance of connecting mathematical concepts, especially vectors, with everyday life and the environment.

4.2 Interview

To obtain feedback, the researcher conducted a structured interview session with the students. The interview session was conducted with three students during the final intervention session, where they were asked three questions related to the implementation of the My Vector activity in learning vector topics.

For the first question, students were asked about their feelings after undergoing the activity. Here are the responses from the students:

Student 1: "Excited because I didn't expect my date of birth could become a vector." Student 2: "Enjoyable because I could move around the college." Student 3: "I feel happy because I can relate vectors to the environment instead of just sitting in class."

The second question was "What did you learn from this activity?" Here are the responses from the students:

Student 1: "I was able to recall how to find magnitude and angle." Student 2: "During the activity, I was able to enhance my understanding of vectors, for example, I could use addition and subtraction operations while heading to the squash court." Student 3: "I could recall all the vector concepts asked without referring to notes."

For the last question, the researcher asked the students to tell about the changes in their attitudes and perceptions towards vectors after performing the My Vector activity. Here are the results of the interview:

Student 1: "I am interested in applying vectors. After this, I want to try calculating steps from my room to class." Student 2: "Vectors are useful and need to be used in various aspects. I am more interested in delving into vectors after this." Student 3: "I am very interested in this topic because I can relate vectors to everyday life."

Based on the interviews with these three students, the researcher found that they provided positive feedback when asked about their experience conducting the My Vector activity. Their attitudes and interest in vectors are increasing.

4.3 Observation

The researcher has conducted observations while the students were engaging in the My Vector activity. These observations aimed to examine the progress of the students in visualizing and translating three-dimensional vectors in real situations. The students were observed to be more engaged and actively participated in determining vectors from one point to another. They were seen to be able to associate steps to the right with positive $\underline{i}$ vectors, while steps to the left referred to negative $\underline{i}$ vectors. When reaching the final checkpoint, the students were able to state the vector distance from the starting point (the stage) to all four required checkpoints. For example, a student found the vector distance from the stage to the squash court to be $57\underline{i} + 3\underline{j} - 2\underline{k}$. This indicates that the student has moved 57 steps to the right, 3 steps forward, and 2 steps downward.

5.0 Conclusions

Throughout this research session, the researcher found that the implementation of the My Vector activity provided many advantages to both the researcher and the students in learning the topic of vectors, especially in solving vector arithmetic operations more effectively. This activity serves as a teaching approach that encompasses a variety of vector concept representations through visual, manipulative, and movement aspects as stated in the criteria for good mathematics teaching by NCTM (2000). Students were engaged in student-centred activities through the 5E inquiry learning experience (Goldman et al., 2021). The determination of different vectors for each student during the exploration phase made this task flexible and encouraged students to be more creative in solving mathematical problems (Walia, 2012). The answers obtained by the students are more meaningful learning than perfection (Agbo et al., 2021). However, it is still subject to mathematical thinking and soft skills (KPM, 2022). The development phase in this activity supports the improvement of students' visualization skills. Vectors in three dimensions consisting of the *i, j,* and *k* components can be visualized through steps and movement directions to determine the vector distance between two places. The visualization results translated into the physical world have been evidenced in the work displayed

by the students. This simultaneously indicates an increase in the level of achievement of learning objectives for the students. Students successfully determined the vector distance between two places by describing the answer in three dimensions. After assessment, students showed improvement in solving and applying vector addition and subtraction in finding distance. This finding is consistent with the study by Jazuli et al. (2019), which found that respondents showed significant improvement in mathematical achievement after engaging in visualization activities, thus providing evidence of the achievement of the objectives of this study. Through this activity, students' perspectives on mathematics changed, thereby sparking their interest in delving deeper into mathematics. This can be seen from the responses of students who initially considered mathematics learning confined to the classroom only. After the activity, they were excited to continue implementing vector concepts in daily life. This proves that the specific objective of the study regarding changes in students' attitudes has been successfully achieved. Creative teaching plans and active teaching methods can engage students in the learning process while enhancing their understanding (Rozali & Abd Halim, 2019).

Overall, this study successfully achieved its set objectives. The My Vector activity could be implemented well and effectively in helping students master vector concepts and correctly understand and solve arithmetic operations. Through this action research, I was able to identify that visual learning can accelerate the rate of student understanding, and intervention activities greatly assisted students in the researcher's efforts to reinforce student understanding.

The impact of the study on the organization, especially KML, can be seen through the improvement in the grades of all study participants in the final examination of semester two, with a minimum grade of B+ (one person), while 7 individuals achieved an A- grade and 3 individuals achieved an A grade. Additionally, this study also supports the first shift in the Malaysian Education Development Plan (PPPM) 2013-2025, which aims to improve the quality of STEM education while instilling Malaysian citizens with values such as curiosity and cooperation nurtured throughout the My Vector activity. It is hoped that this activity can provide new ideas and insights into more effective vector teaching and learning strategies.

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Author Contributions
Azlinda, T.: The author conceived and designed the study, collected and analysed the data, interpreted the results, and drafted the manuscript.

Conflicts Of Interest
The author declares no conflicts of interest regarding the publication of this research.

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