



Perception of Integrating Real Case Study in Vector Calculus Course Among Engineering Mathematics Students

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ABSTRACT

BACKGROUND & CONTEXT

Vector calculus is a cornerstone of engineering mathematics, yet its abstract nature often makes it challenging for students to grasp and apply. Studies show mathematical curricula are not fully aligned with industry demands, with lecturers often relying on traditional approaches with minimal real-world examples. Project-based learning (PBL) offers an innovative alternative by immersing students in hands-on projects, such as designing water slides, connecting abstract vector calculus concepts to tangible engineering applications.

PURPOSE OR GOAL

This study examines engineering mathematics students' perceptions of the water slide project-based learning activity in the Vector Calculus course, to determine whether contextualized teaching improves conceptual clarity, confidence, and engagement.

APPROACH OR METHODOLOGY

A quantitative, descriptive design was employed using a structured five-point Likert-scale questionnaire distributed via Google Forms. A total of 294 undergraduate engineering students who had completed the course participated, drawn from diverse academic backgrounds and departments.

OUTCOMES

Students rated the project positively across all dimensions, including enjoyment (4.03), relevance (4.07), and analytic skill development (4.12). Most understood the objectives clearly (4.10) and were satisfied with feedback (4.12), though student-lecturer discussion received the lowest rating (3.84).

CONCLUSIONS

The findings indicate that project-based learning through the water slide project enhances students' engagement, relevance perception, and analytic skills in vector calculus, supporting the value of contextualized, real-world learning in bridging theory and practice.

KEYWORDS

Vector Calculus; Engineering Mathematics; Engineering Education; Water Slide Project.

Introduction

In engineering education, mathematics serves as the foundational language through which complex phenomena are modeled, analyzed, and solved (Nedaei et al., 2022). Among its various branches, vector calculus holds particular importance due to its applications in diverse fields such as fluid dynamics, electromagnetism, structural mechanics, and robotics (Gainsburg, 2015). Despite its significance, the abstract and theoretical nature of vector calculus often presents a barrier to student comprehension, limiting their ability to connect mathematical concepts with practical engineering scenarios (Pepin et al., 2021).

Studies shows that the mathematical curriculum taught in institution is not fully aligned with the demand in industries (p value < 0.05) (Jehopio & Wesonga, 2017). This implies that the mathematical content taught to engineering students does not match the practical demands of the industries in terms of depth, rigor and applicability. On the other hand, there was a growing concern about the teaching method used in the education system especially in delivering mathematics theories. The author highlight that many lecturers rely on traditional pedagogical approaches with minimal use of real-world examples or interactive tools, resulting in limited student engagement (Vimbelo & Bayaga, 2023).

As engineering challenges become more interdisciplinary and data-driven, it is important to focus not only specific mathematical topics but to develop broader competencies such as such as logical reasoning, problem-solving, and modelling (Giménez et al., 2022). A well-designed mathematics curriculum may equip future engineers with the tools to apply mathematical knowledge and thinking in real-world scenario.

Traditional approaches to teaching vector calculus frequently rely on rote learning and isolated problem-solving, which can fail to engage students or equip them with the skills necessary for real-world applications. As engineering disciplines increasingly emphasize interdisciplinary problem-solving and innovation, there is a growing need to align mathematical education with practical contexts. This alignment not only enhances understanding but also prepares students to tackle the complex challenges they will face in their careers.

Project-based learning (PBL) offers an innovative approach to teaching vector calculus by immersing students in hands-on, real-world projects that connect abstract concepts to tangible applications. Instead of learning in isolation, students collaborate on projects that require the application of vector calculus principles, such as designing water slides, modeling fluid dynamics, or optimizing robotic navigation. These projects not only reinforce mathematical concepts but also develop critical problem-solving, teamwork, and communication skills. By integrating PBL into the teaching of vector calculus, educators can foster a deeper understanding of the subject, enhance student motivation, and better prepare learners for the practical challenges they will encounter in their academic and professional careers.

This study seeks to deepen understanding of student perceptions for specific engineering mathematics subject which is the vector calculus course. The finding provides empirical guidance for next curriculum revision to foster deeper engagement and skill mastery through pedagogical innovation. By examining the effects of contextualized teaching methods, this research highlights the transformative potential of bridging theory with practice in engineering mathematics education.

Methodology

Students must create a thrilling slide that uses vector calculus principles to ensure a smooth and controlled stop at the end. They are required to apply vector functions to represent curves in 3D space, calculate tangent vectors, normal vectors, and curvature and to understand the relationship between parameterization and speed. Students are also required to use calculus to analyse and control the motion of an object along a curve and incorporate concepts of work, energy, and friction.

This study employed a quotate, descriptive research design to explore and analyse the perception of undergraduate engineering students toward project-based learning in Engineering Mathematics I (Vector Calculus) course. The design aimed to capture measurable attitudes across various through a survey instrument.

Sampling

The population for this study comprised undergraduate students enrolled in Engineering Mathematics I (Vector Calculus) course which in their first semester. A total of 294 students participated in the survey, where all of them had recently completed the course. In addition, the students came from diverse academic backgrounds such as matriculation, STPM, foundations and international equivalent qualifications.

Instrumentation

The research instrument was a structured questionnaire designed using google forms. Responses to perception items were measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) (Aburbeian et al., 2022). The questionnaire was divided into four key section which are demographic, educational background in mathematics, perception of project-based learning and open-ended feedback.

Results & Discussion

The students' age of this course is ranged from 18 to 22 years old where male is 67.7% and female is 32.3% as shown in Figure 1.

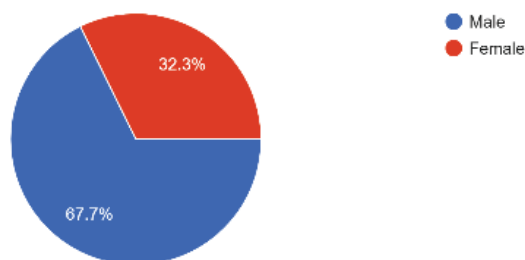


Figure 1: Distribution of gender

The students are mainly from the Department of Electrical, Electronic and System Engineering (JKEES) with 44.9%, followed by Department of Mechanical and Manufacturing Engineering (JKMP) with 25.9%, Department of Civil Engineering with 15.3% and finally Department of Chemical and Process Engineering (JKKP) with 13.9% as in Figure 2.

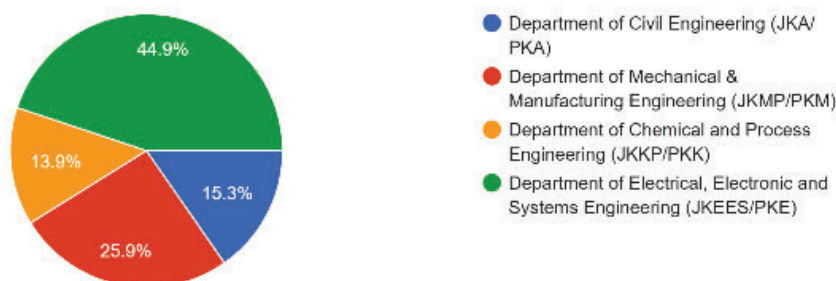


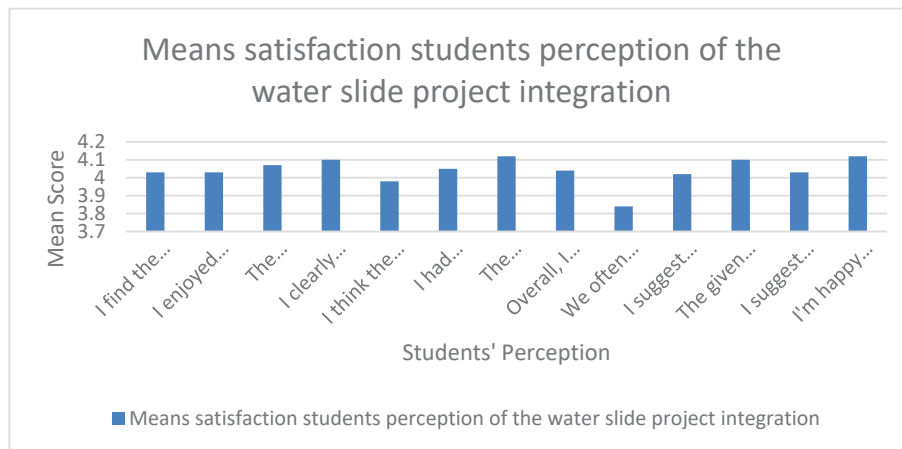
Figure 2: Distribution of departments

The mean score of student perceptions of the water slide project integration is as shown in Table 1.

Table 1: Means satisfaction students perception of the water slide project integration

Students' perception	Mean score.
I find the problem in Water Slide Project interesting	4.03
I enjoyed doing the project	4.03
The project made the course seem more relevant to my interests	4.07
I clearly understand the objective of the project	4.10
I think the project should be implemented in this course	3.98
I had enough time to complete my project	4.05
The project sharpened my analytic skills	4.12
Overall, I was satisfied with the quality of this project	4.04
We often discussed the project with our lecturers/tutors	3.84
I suggest the project should be continued in the future	4.02
The given period was very adequate for the project	4.10
I suggest this project could be applied in other Engineering courses	4.03
I'm happy with the amount and type of feedback from facilitators regarding the learning outcomes	4.12

Both male and female students show about same mean performance of their mathematical cumulative grade point average (CGPA) prior to UKM. The mean CGPA of male is slightly higher which 3.26 while the female has 3.31. This indicate that the gender does not a strong determinant of performance within this sample.

**Figure 3: Means satisfaction students perception of the water slide project integration**

The integration of the water slide project into mathematics curriculum was positively received by the students (see Figure 3). The student reported that they had experienced enhanced engagement, relevance and skill development through the project-based learning activity. Students rated the water slide project highly in terms of enjoyment (mean 4.03), relevance to course content (4.07), and its ability to develop analytic and problem-solving skills (4.12). Most students felt clear about the objectives (4.10) and satisfied with facilitator feedback (4.12). Although scores were generally high, the student-lecturer/tutor discussion received the lowest rating (3.84). This suggests limited engagement between students and instructors during the project. Students would likely feel more supported if there were regular check-ins or casual discussions with their lecturers throughout the project. Hence, the project's structure seems

adequate in duration and well-received. In addition, the student recommends its inclusion in other engineering courses (4.03).

Recommendation

Future research should incorporate larger and more diverse samples to examine the sustained impact of project-based learning on academic progression. This is important to further elucidate the long-term benefits and practice for curriculum design in mathematics engineering.

Conclusion

This study shows positive response on the project-based learning in the Engineering Mathematics I (Vector Calculus) among the students. The response on the mathematics confidence, group learning, and project satisfaction validates the current pedagogical model approach.

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