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A Comparison Study of Students Performance for Vector Calculus Subject

N. B. Masnoor[1], N. Razali[1,*], A. Jedi[2], F. M. Hamzah[1], M. H. Osman[1], H. Othman[1]

[1]Department of Engineering Education, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia
[2]Department of Mechanical Engineering and Process, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor, Malaysia

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Abstract The research objective was to compare the performance of Engineering students in a pretest and post-test of Vector Calculus subject between programmes during their first year of study at the Faculty of Engineering and Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM). This paper also aims to investigate the student's knowledge in Vector Calculus, particularly in main topics including partial derivatives, vector functions, line integrals, double integrals, triple integrals, Green's Theorem, Stokes' theorem, Gauss' theorem, and basic differentiation and integration of complex functions. Each topic is included in Course learning outcomes to analyze either the students show a good or bad performance for Vector calculus subject. 412 first year engineering students from different programmes JKAS, JKMB, JKKP and JKEES were needed to seat for pretest and post-test (Test 1, 2 and 3). The pretest was performed in early of the semester, while the post-test was held afterwards. The analysis results revealed that the performance of students in the post-test was outstanding to their pretest performance. Data analysis of student performance indicated that most students did not seem to understand the basic ideas in each chapter prior to the beginning of the semester.

Keywords Student's Performance, Pretest, Post-Test, Vector Calculus

1. Introduction

The academic performance of university students has recently been a top focus not only for administrators and educators, but also for employers seeking for employees. Academic performance of students is among the most important aspects that employers consider when employing new employees, particularly fresh graduates [1]. As a result, to get excellent results and match the expectations of employers, students need devote their complete attention to their studies.

Expanding the quality and quantity of Science, Technology, Engineering, and Mathematics (STEM) students is crucial in order to advance students' career. This is essential to assess more practical and hands-on tasks, as well as to teach introduction of mathematics, science, and qualitative introductory engineering basics courses. Mathematic courses are required for all undergraduate students at FKAB. UKM evaluates and qualifies students based on the admission requirements that have been implemented. An excellent mathematics grade during the pre-university study is one of the requirements [2].

It has recently been observed that students' basic mathematics skills and level of preparedness at the time of enrollment into higher education has drastically decreased. For students at all levels of academic, the capacity to learn mathematical skills is a significant predictor of potential

[3]. Over the last ten years, Sutherland et al. [4] revealed that engineering Institutions in London have been experiencing problems of accepting degree students graduate programs with relatively low mathematics skills. Undergraduate engineers had a hard time grasping the importance of studying mathematics. Among the most significant knowledge for engineers is mathematical knowledge. Mathematics must be viewed like a medium for describing physical, chemical, and engineering laws by engineering students [5].

The research objectives are to compare the performance of first year Engineering students towards Vector Calculus at FKAB, UKM and evaluate their knowledge in that subject by comparing their pretest and post-test marks. Ismail et al. [6] concluded from a prior study that the pretest can be a good measure of student performance in Mathematics Engineering courses at FKAB, UKM. Shivaraju et al. [7] indicated that using a pretest to shape group-specific education programmes was shown to be a valuable approach.

When learning mathematics, students frequently struggle with equations and grasping the ideas and approaches involved. As stated by [8], psychological incidents such as worry and in need of self-assurance, the mathematics curriculum, which lacks application in practical uses, and how educators encourage students to study mathematics are all aspects causing difficulties in mastering mathematics. A strong mathematical background is seen to be necessary for grasping engineering concepts, specifically for engineering students. The inability to solve a variety of subjects that need mathematics might be caused by a lack of understanding of basic mathematical principles [9]. Furthermore, because mathematics has long been seen as a difficult and challenging topic [10], it is required to engage preconceptions in order to comprehend and solve mathematical problems [11]. Mathematical difficulties are frequently caused by a lack of mathematical skills, therefore knowing the information, talents, and role of educators is critical to success in mathematics [12]. It is acceptable for some students to fail an examination while others succeed, but academic members of the institution should share responsibility for assisting students, particularly underachievers, in improving their academic performance [3]. The students' performance in mathematics may have been influenced by their preconceived notion that mathematics is difficult. It has been acknowledged at an international level that math anxiety poses a negative impact over entire life spans [13], perhaps these negative outcomes have had a negative impact on the students' academic performance.

Academic performance refers to how students approach their studies and execute the tasks that their teacher provides. Grades are widely used to assess the ability to study and memorize stuff, while also the ability to spread knowledge learned verbally or in writing. One of the university's main objectives is to improve academic performance as measured by exam results [14]. Partial derivatives, vector functions and line integrals are some topics of wide components in mathematics. These are basic and fundamental topics for Engineering students who will apply them to other disciplines.

2. Methodology

This study focused on engineering students in the first semester of the 2020/2021 session. The pretest, which included the respondents, was delivered in the early semester, and the post-test was provided to the same students later in the semester. Following that, the pretest results were compared to the student's post-test results.

2.1. Participants

Population sample consisted of 412 first year Engineering students at FKAB, 86 students are from Department of Civil Engineering (JKAS), 118 from Department of Mechanical and Materials Engineering (JKMB), followed by 76 students from Department of Chemical and Process Engineering (JKKP) and 132 students from Department of Electrical, Electronic and Systems Engineering (JKEES).

2.2. Instrument

Pretest includes 30 multiple-choice questions relevant to Vector Calculus subject. For the pretest, 9 questions focused on basic of surfaces in space and partial derivatives (CO1) while 14 questions focused on vector function, vector field, scalar field, gradient, divergence, and curl (CO2), 6 questions focused on line integral, double integral and triple integral (CO3) while another 1 question concentrated on the topics of Green’s Theorem, Stokes’ Theorem and Gauss’ Theorem (CO4).

Course Learning Outcome (CO) for Vector Calculus is shown in Table 1. A learning outcome is a statement of what a student should gain after a certain time period and guided learning [15]. According to Adam [16], a learning outcome is a written description about what a good student should be capable to perform at the completion of a course. It is more concerned with the students' achievements than with the educator's goals. It can also be used to indicate important learning that students have accomplished and ability to prove somewhere at end of the learning process or semester.

Table 1. Course Learning Outcome

CO1	Understand the fundamental of surfaces in space and able to solve the basic ideas of partial derivatives
CO2	Understand and able to solve the ideas of vector function, vector field, scalar field, gradient, divergence, and curl.
CO3	Able to solve engineering problems using the concepts of line integral, double integral, and triple integral.
CO4	Able to solve engineering problem using the ideas of Green's Theorem, Stocks' Theorem and Gauss' Theorem

Tests 1, 2 and 3 are classified as the post-test. Test 1 covers CO1 and CO2, it consisted of 11 questions, 6 questions focused on the CO1 while another 5 questions focused on CO2. Moreover, test 2 only covers the CO3, it has 14 questions which focused on Line integrals, double integrals, and triple integrals topics. As well as Test 3, it only covers CO4, it contains 12 questions which focused on Green's theorem, Stokes' theorem and Gauss' theorem

Table 1 exhibits the contents description in the Vector Calculus pretest (Question 1-30). There are 23% questions on CO1, 48% questions on CO2, 25% questions on CO3 and only 4% on CO4.

Table 2. Pretest Vector Calculus content description (Questions 1-30)

Content	Question No	Item No	Weightage
CO1	4,16,17,18,19,20,21,22,23	9	23
CO2	1,2,5,6,7,8,9,10,11,12,13,14,15,28	14	48
CO3	24,25,26,27,29,30	6	25
CO4	3	1	4

The Data Analysis in Microsoft Office (Ms Excel) was used to examine the students' performance based on the pretest and post-test results towards Course Learning Outcome for Vector Calculus. Figure 1 shows the process flow.

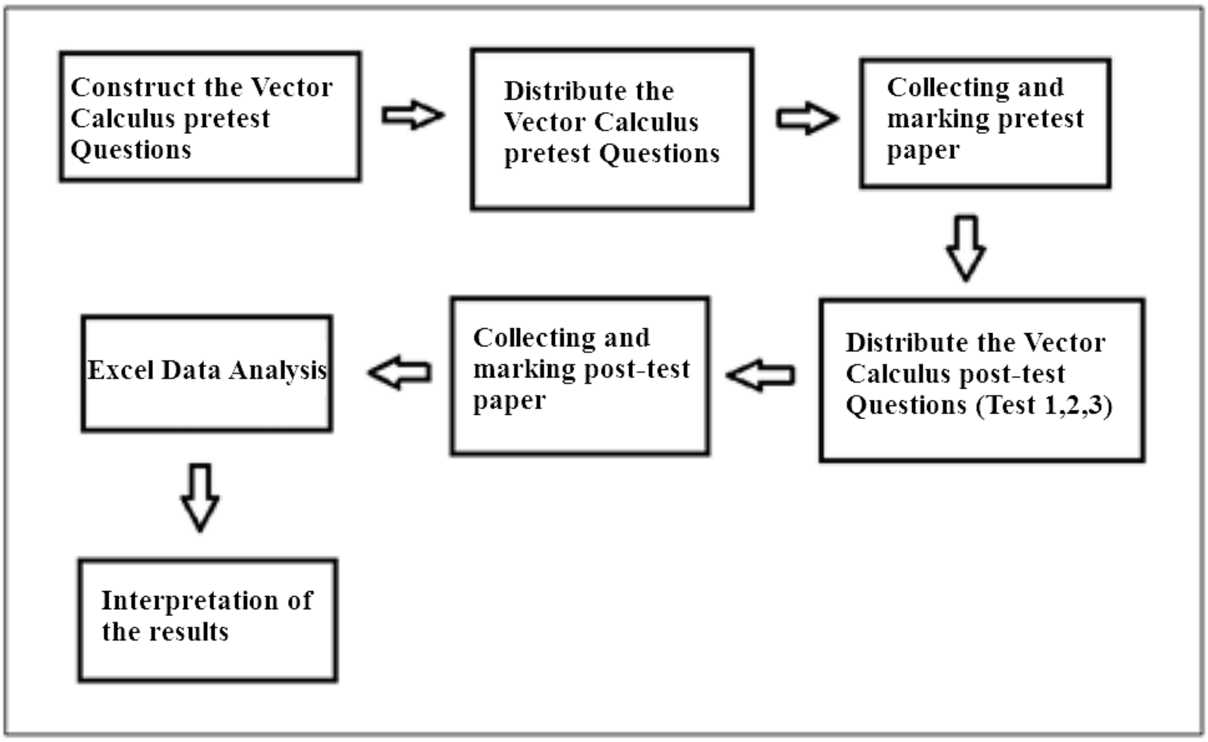

Figure 1. Process flow

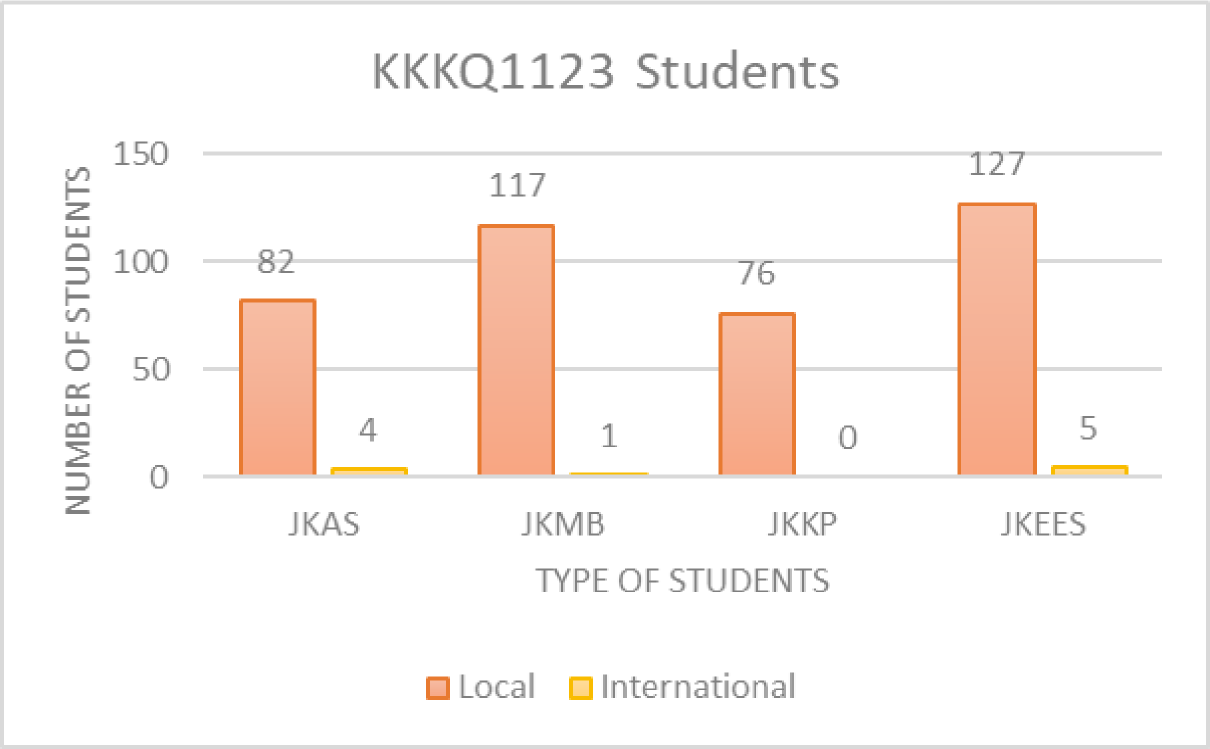

Figure 2. Summary of students of demographics

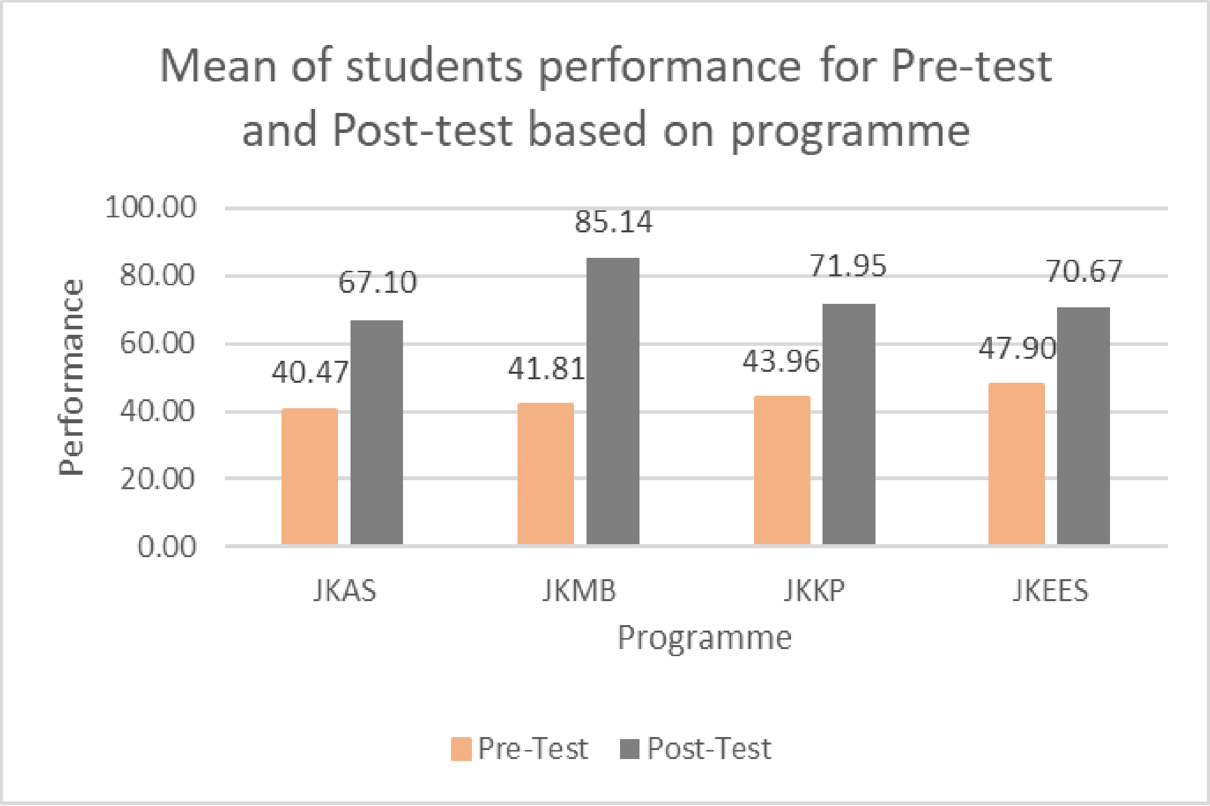

Figure 3. Performance of students in the pretest and post-test by Programme

3. Data Analysis

3.1. Profile Respondents

Figure 2 summarizes the students demographics. 402 students are local while another 10 students are international students. 86 students were from JKAS, 118 students were from JKMB, 76 students were from JKKP, 132 students were from JKEES.

3.2. Pretest and Post-test Results' Analysis

3.2.1. Qualitative Analysis

Figure 3 shows a comparison of students' pretest and post-test performance based on programme. Result shows that there was a significant improvement between the pretest and post-test. Students from all programmes indicate that they can only score less than 50% on the pretest, whereby for post-test they can understand and answer the questions more accurately than their pretest since the graph indicates the increment of their performance.

Based on the Figure 4 until Figure 7, the graph represents the difference in the student performance between the pretest and post-test in engineering programmes. The data analysis was conducted to determine the students' performance between course learning outcome (CO1, CO2, CO3 and CO4) in their programme. For CO1, JKAS shows 21.02% increment in students' performance which is 80.03% compared to 59.01% on their pretest. The performance of students in JKMB increased from 61.91%to 91.48%, while in JKKP, the performance of students increased from 64.13% to 72.65%, and in JKEES, the performance of students increased from 64.84% to 74.78%. In conclusion, they lacked knowledge and understanding in the topics of partial derivatives before the start of the semester considering student's performance was low compared to their post-test and showed more understanding in the fundamental of surfaces in space and were able to solve the basic ideas of partial derivatives.

For CO2, JKAS showed a 19.15% increase in students' performance to 54.6%, compared to 35.45% on the pretest. The performance of JKMB students increased from 36.18% to 78.48%, while the performance of JKKP students increased from 37.82% to 66.8%, and the performance of JKEES students increased from 43.53% to 63.64%. In general, students' post-test performance was greater than their pretest performance, indicating that they have a better understanding and ability to apply the concepts of vector function, vector field, scalar field, gradient, divergence, and curl.

For CO3, JKAS shows 31.79% increment in students' performance which is 67.2% compared to pretest they only got 35.41%. For JKMB, the performance of student increases from 38.36% to 85.46% while for JKKP programme, the performance of student increases from 41.47% to 80.46%, meanwhile for JKEES, the students' performance also showing increment from 44.95% to 73.72%. In conclusion, as indicated by a rise in their post-test results when compared to their pretest scores, students demonstrate a higher understanding and an ability to apply the concepts of line integral, double integral, and triple integral in addressing engineering problems.

For CO4, JKAS indicated a 40.98% rise in students' performance to 66.59%, compared to 25.61% on the pretest. JKMB students' performance improved from 15.38% to 85.16%, while JKKP students' performance improved from 17.11% to 67.9%, and JKEES students' performance improved from 21.26% to 70.52%. It can be concluded that students can apply Green's Theorem, Stokes' Theorem, and Gauss' Theorem in addressing engineering problems because their post-test results were higher than their pretest scores.

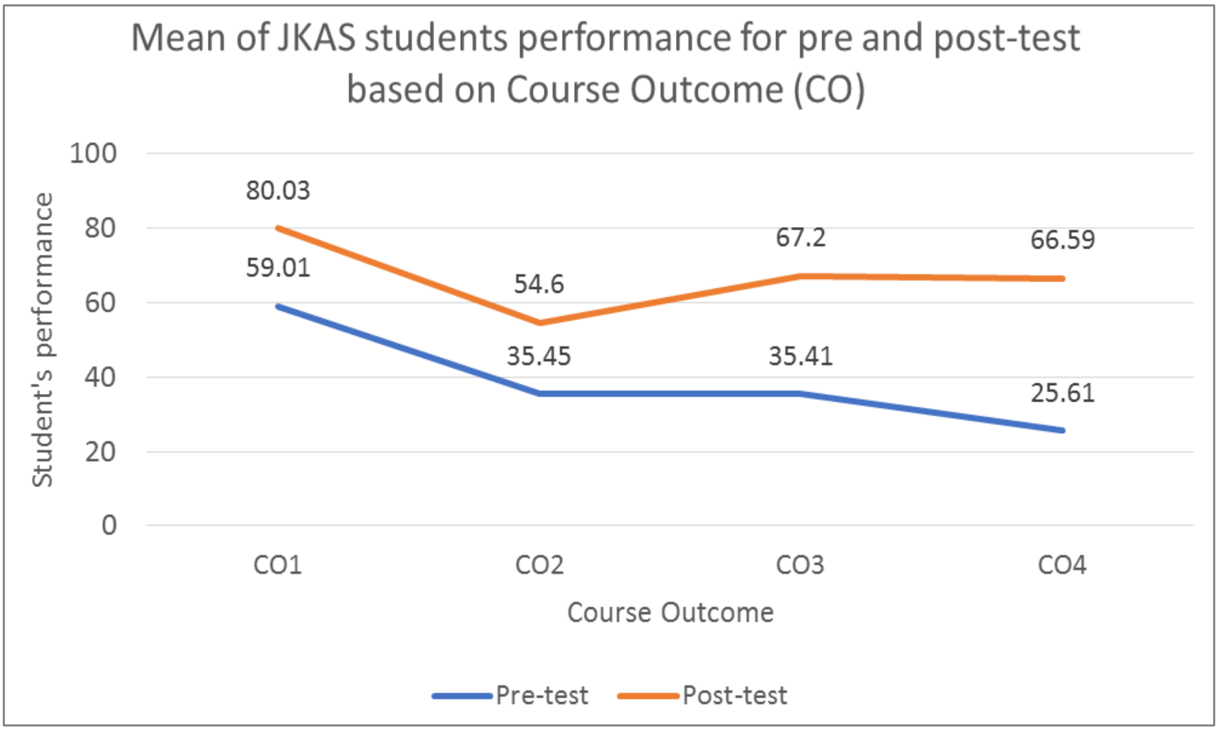

Figure 4. Graph of students performance based on CO for JKAS

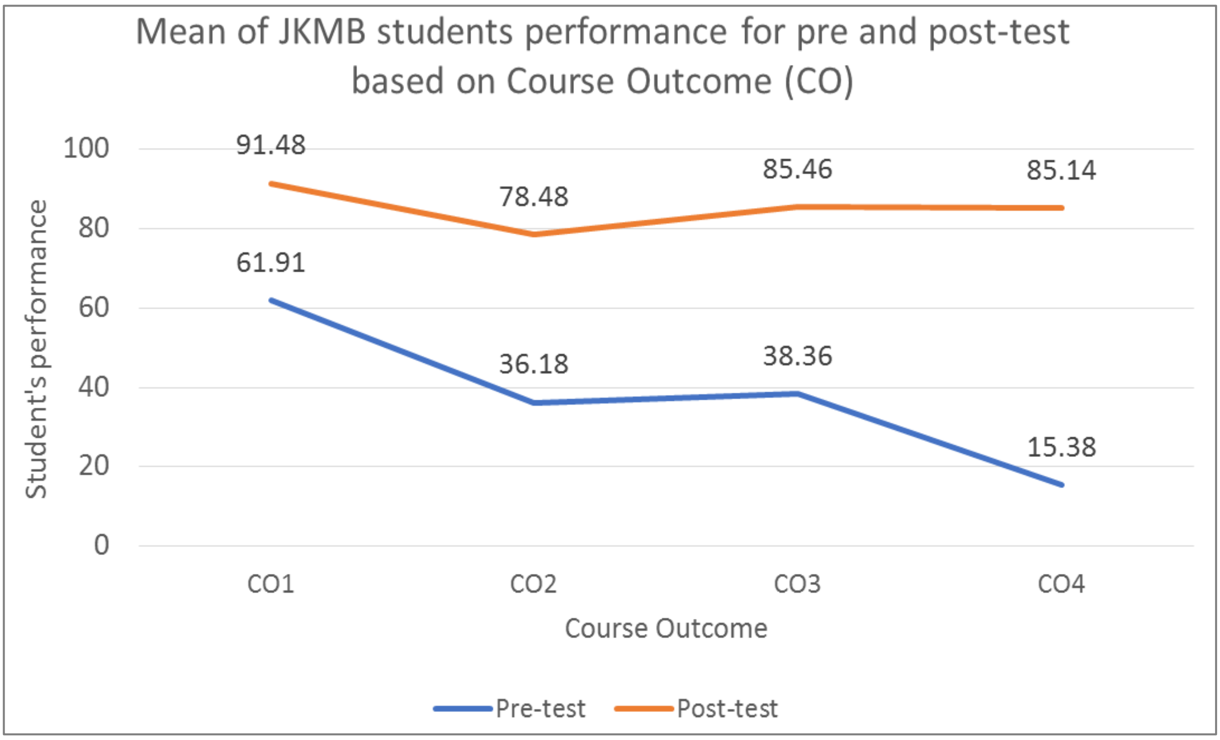

Figure 5. Graph of students performance based on CO for JKMB

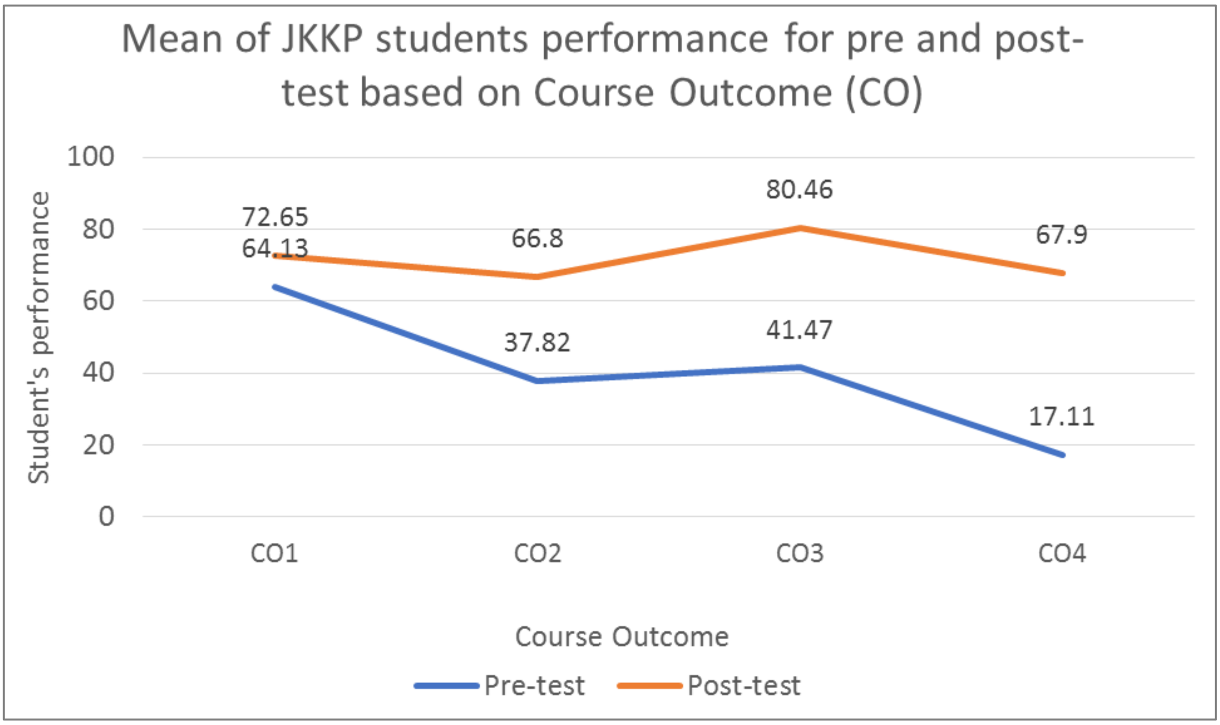

Figure 6. Graph of students performance based on CO for JKKP

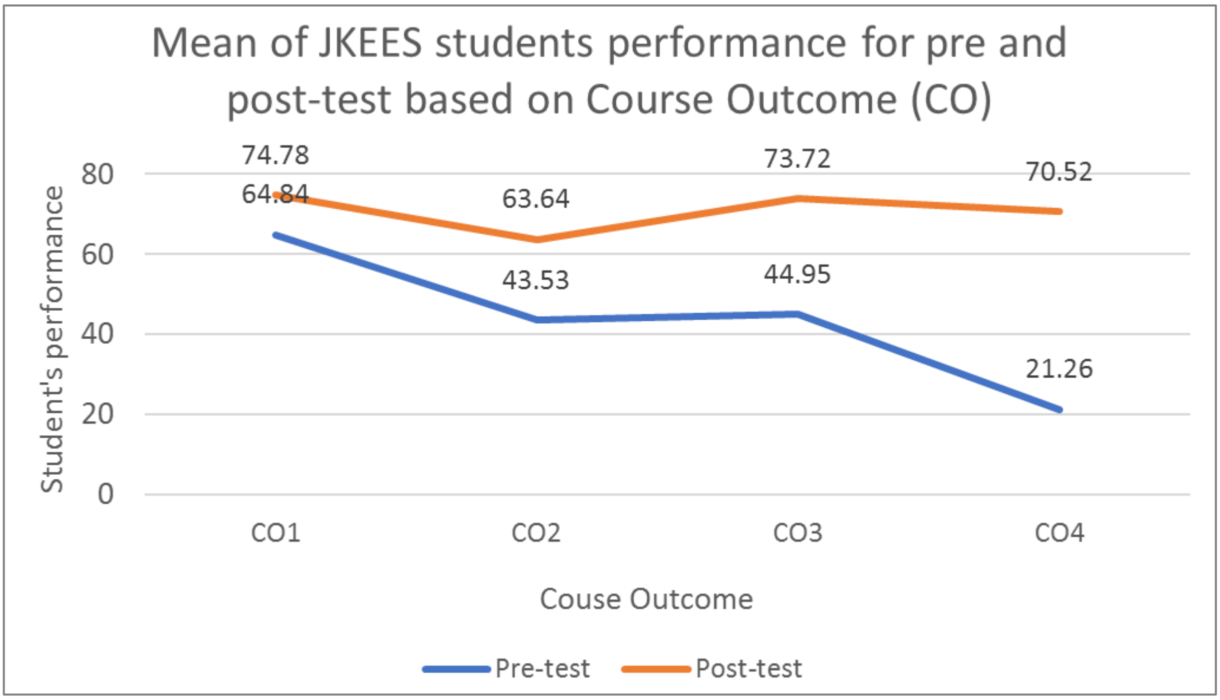

Figure 7. Graph of students performance based on CO for JKEES

3.3. Quantitative Analysis

3.3.1. Paired Sample t-test

The test is performed to test the following hypothesis:

H null: The mean difference between students' pretest and post-test performance is 0.

H alternative: The mean difference between students' pretest and post-test performance is not 0.

3.3.2. Pearson Correlation

A moderate positive linear relationship is indicated by values between 0.3 and 0.7 [17]

Table 3. Paired Sample Statistics: Means JKKP

	Mean	Samples number	SD
Pretest	43.956	76	19.344
Post-Test	71.950	76	19.305

Table 4. Paired Sample Statistics: Correlation JKKP

	r	Significant Value
Pretest	0.490	0.000

According to the results in Tables 3 and 4, there is a significant mean difference in students' performance on the pretest and post-test for JKKP, with a significant value of $0.000 < \alpha = 0.05$. The mean for post-test was nearly 71.95 gretaer than pretest, whereas the Pearson correlation represents a moderate and positive correlation with $r = 0.49$. This suggests that after studying the Vector Calculus course in FKAB, JKKP students performed better.

Table 5. Paired Sample Statistics: Means JKMB

	Mean	Samples number	SD
Pretest	41.81043	117	16.352
Post-Test	85.13917	117	15.317

Table 6. Paired Sample Statistics: Correlation JKMB

	r	Significant Value
Pretest	0.300	0.000

According to the results in Tables 5 and 6, there is a significant mean difference in students' pretest and post-test performance for JKMB, with a significant value of $0.000 < \alpha = 0.05$, the mean for post-test was 85.14 larger compared to pretest, whereas the Pearson correlation reveals moderate and positive correlation with $r = 0.300$. This means that after taking the Vector Calculus course at FKAB, the JKMB students performed better.

Table 7. Paired Sample Statistics: Means JKAS

	Mean	Samples number	SD
Pretest	40.467	82	18.321
Post-Test	67.101	82	19.082

Table 8. Paired Samples Statistics: Correlation JKAS

	r	Significant Value
Pretest	0.458	0.000

According to the results in Tables 7 and 8, there are a significant mean difference in students' pretest and post-test performance for JKAS, with a significant value $0.000 < \alpha = 0.05$. The mean for post-test score was 67.10 greater than pretest, while the Pearson correlation indicates a moderate and positive correlation with $r = 0.458$. This means that after taking the Vector Calculus course, JKAS students performed better.

Table 9. Paired Sample Statistics: Means JKEES

	Mean	Samples number	SD
Pretest	47.896	127	18.214
Post-Test	70.665	127	14.398

Table 10. Paired Sample Statistics: Correlation JKEES

	r	Significant Value
Pretest	0.474	0.000

According to the results in Tables 9 and 10, there is a significant mean difference in students' pretest and post-test performance for JKEES, with a significant value of $0.000 < \alpha = 0.05$. The mean for post-test score was 70.67 larger than pretest, while the Pearson correlation reveals moderate and positive correlation with $r = 0.474$. This means that after completing the Vector Calculus course, the JKEES students performed better.

3.3.3. Analysis of Variance, ANOVA

ANOVA is being used to evaluate the following hypothesis.

H null: There is no significant difference between the performance of students between programme.

H alternative: There is significant difference between the performance of students between programme.

Table 11 represents the p-value = 0.000 smaller than 0.05. Thus, alternative hypothesis is accepted, in conclusion there was strong enough evidence to conclude that the four-population means are not equal so the performance of students between programme is significantly different.

Table 11. ANOVA Test Statistics: Groups

Source of variance	SS	df	MS	F	P-Value
Between programme	28547.87	3	9515.958	27.71438	0.0000
Within programme	136656.5	398	343.3581		
Total	165204.4	401			

4. Discussion and Conclusion

The research objective was to find out the relative relationship in student's performance in Vector Calculus subject between pretest and post-test. The findings showed there was significant difference between pretest and post-test when compared to programmes based on ANOVA test.

For Vector Calculus component, knowledge on partial derivatives, vector function, vector field, scalar field, gradient, divergence, curl, line integral, double integral, triple integral, Green's Theorem, Stokes' Theorem and

Gauss' Theorem are crucial in resolving a problem. Based on the results from Qualitative Analysis, majority of students could not understand the given question classify by Course learning outcomes for the pretest. By the end of the chapter, however, students had a better conceptual knowledge of mathematics. This also demonstrates that students' skills and talents in solving Mathematics problems are developing since it shows a drastic increment for the post-test.

As for Green's Theorem, Stokes' Theorem and Gauss' Theorem questions, the results showed the students' pretest score are the lowest depends on other chapters. The pretest questions must properly represent the actual nature of the mathematical skills that should be developed [18]. The score was only 25% and below for every programme, even though the post-test result was greater to put it another way, there must be two basic explanations how something like this could happened. To begin with, the students totally misunderstood the topics. Second, students did not frequently apply Green's Theorem, Stokes' Theorem, or Gauss' Theorem in their everyday lives. As a result, as evidenced by the findings, a lack of practice could have resulted in poor abilities or performance. We can only reconstruct courses according to the relevancy of their fields as educators and academics of the faculty and present the material in the best way possible [19].

In behavioral research, pretest and post-test designs are often utilized. The measuring of change is a tool for evaluating the effectiveness of treatments [20]. We may conclude that the pretest is an effective predictor of student success in FKAB, UKM Mathematics Engineering courses. This conclusion is in line with the findings of the Ismail et al. investigation [21].

The self-test has been found to be an effective technique for identifying students' weaknesses in specific areas of engineering mathematics. This study provides insight into how to improve learning possibilities in classrooms. This involves educating students prior they begin the semester so that they are confident and competent, as well as reducing the institutional structuring of subject through pedagogical approaches such as conversation and group work that encourage students to communicate and affect their own understanding.

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REFERENCES

[1] Surjeet. K. Y, Brijesh. B, Saurabh. P. "Data Mining Applications: A comparative study For Predicting Student's Performance," International Journal of Innovative Technology & Creative Engineering.Vol.1 2011, No.12, 2011

[2] "Panduan Prasiswazah. Fakulti Kejuruteraan. Universiti Kebangsaan Malaysia," 2007.

[3] Tang, H. E., Voon, L. L. & Julaihi, N. H., "A case study of 'high-failure rate' mathematics courses and its' contributing factors on UiTM Sarawak diploma students," Paper presented at the Conference on Scientific & Social Research, 2009.

[4] Sutherland, R. & Pozzi, S., "The changing mathematical background of undergraduate engineers: A review of the issues," Report prepared for The Engineering Council, 1995.

[5] Sazhin S. S, "Teaching mathematics to engineering students," International Journal of Engineering Education, 14, 145-152., 1998.

[6] Ismail, N. A., Nopiah, Z. M., Asshaari, I., Othman, H., Tawil, N. M., & Zaharim, A., "Mathematical Performance of Engineering Students in Universiti Kebangsaan Malaysia (UKM)," Procedia-Social and Behavioral Sciences, 60, 206–211., 2012.

[7] Shivaraju PT, Manu G, Vinaya M, Savkar MK. "Evaluating the effectiveness of pre- and post-test model of learning in a medical school," Natl J Physiol Pharm Pharmacol 2017;7(9):947-951., 2017.

[8] Nordin, "Prosiding Simposium Kebangsaan Sains dan Matematik ke V," Universiti Teknologi Malaysia, 20-22., 1992.

[9] M. Bursal and L. "Paznokas, School Science and Mathematics," 106(4), 173-180., 2006.

[10] M. H. Ashcraft and K. S. Ridley, "Am. Psychol. Soc," 181-185., 2002.

[11] Khashi'ie, Najiyah & Mohd Said, Rahaini & Zainal, Nurul & Miswan, Nor., "A Comparison Study of Students' Performance in Pre and Post Result of A Mathematics," 2017. /Competency Test. MATEC Web of Conferences. 87. 04001. 10.1051/matecconf/20178704001

[12] S. F. Mokhtar, Z. M. Yusof and M. Misiran, "Journal of Applied Sciences Research," 8(8), 4133-4137., 2012.

[13] Luttenberger, S., Wimmer, S., & Paechter, M, "Spotlight on math anxiety. Psychology Research and Behavior Management," Volume 11, 311–322, 2018. https://doi.org/10.2147/prbm.s141421

[14] B. L. Dinglasan and A. D. C. Patena, "Alberta School Of Business," Research Paper No. 2013-1308., 2013.

[15] Harvey, L., "Analytic Quality Glossary. Quality Research International," 2004

[16] Adam, S., "Using learning outcomes," Report for United Kingdom Bologna Seminar 1-2 July 2004, Herriot-Watt University Edinburgh., Scotland, 2004

[17] Ratner, B, "The correlation coefficient: Its values range between +1/−1, or do they?" Journal of Targeting, Measurement and Analysis for Marketing, 17(2), 139–142.,

2009, https://doi.org/10.1057/jt.2009.5

[18] Nopiah, Z. M., Fuaad, N. F. A., Rosli, N. S., Arzilah, N., & Othman, H., “Predicting the Performance of the Diploma Engineering Students Using the Pretest Method,” Procedia - Social and Behavioral Sciences, 102, 153–157., 2013, https://doi.org/10.1016/j.sbspro.2013.10.727

[19] Asshaari, I., Tawil, N. M., Othman, H., Ismail, N. A., Nopiah, Z. M., & Zaharim, A., “The Importance of Mathematical Pre-University in First Year Engineering Students,” Procedia - Social and Behavioral Sciences, 60, 372–377.,2012, https://doi.org/10.1016/j.sbspro.2012.09.393

[20] Dimitrov DM, Rumrill PD Jr. “Pretest-posttest designs and measurement of change,” Work. 2003;20(2):159-65.

[21] Ismail, N. A. B., Ariff, F. H. M., Asshaari, I., Othman, H., & Nopiah, Z. M., “Pretesting on the First Semester Engineering Students in UKM: Does It Make Difference?,” Procedia - Social and Behavioral Sciences, 18, 81–86., 2011, https://doi.org/10.1016/j.sbspro.2011.05.012