Available online at
https://jcrinn.com/
https://crinn.conferencehunter.com/

Journal of Computing Research and Innovation 10(1) 2025

Journal of Computing Research and Innovation

Students Achievement in Mathematics: The Relationship between Performance in Calculus I and Calculus II

Maisurah Shamsuddin[1*], Siti Balqis Mahlan[2], Norazah Umar[3]

[1,2,3]*Universiti Teknologi MARA Penang Branch, Permatang Pauh Campus, 13500 Permatang Pauh, Penang, Malaysia*

ARTICLE INFO

Article history:
Received 25 June 2024
Revised 12 September 2024
Accepted 26 February 2024
Online first
Published 1 March 2025

Keywords:
Basic Calculus
Advanced Calculus
Pearson Correlation
Relationship
Descriptive

DOI:
10.24191/jcrinn.v9i2

ABSTRACT

Calculus is among the most important branches of mathematics that is widely used in various fields of science and engineering. It explores changes using basic ideas, including integration, differentiation, and limitation. The goal of advanced calculus is to take the basic ideas of calculus to a deeper and more complex level. Basic and advanced calculus have a supportive relationship where learning increasingly difficult problems in advanced calculus requires a solid understanding of basic calculus concepts. Therefore, this study attempts to determine whether the assessment results of Engineering students for the Calculus I (basic) and Calculus II (advanced) have a significant relationship with each other. In addition, student performance in these two subjects was descriptively evaluated. The research sample used was a total of 67 Engineering students who took Calculus I (Semester March - August 2023) and Calculus II (Semester October 2023 - February 2024). Students' final assessment scores were taken and analysed using Statistical Package for Social Sciences **(**SPSS**)** version 20.0 software through descriptive statistics and Pearson correlation analysis. Results showed that the performance of students who obtained an A grade in Calculus II had increased by 10% from Calculus I. Based on the Pearson correlation analysis, there was a strong positive linear relationship between Calculus I and II with a value of $r = 0.561$ (p-value < 0.05). Although this relationship was significant, only 32.6% of the variation in Calculus II can be explained in this model. It suggests that a wide range of other factors, including learning and teaching strategies used by lecturers or by students themselves, can have an impact on students' performance. Since understanding engineering mathematics necessitates a solid calculus foundation, it is hoped that this study will encourage students to work hard at improving their grasp of the fundamentals of the subject.

1. INTRODUCTION

Calculus is a fundamental branch of mathematics that provides essential tools for understanding change and motion. It forms the foundation for advanced studies in various scientific and engineering disciplines, making a solid grasp of its concepts crucial for students pursuing these fields. A good understanding of the importance of calculus in a wide range of careers and engineering education is important for students as

[1*] Corresponding author. *E-mail address*: maisurah025@uitm.edu.my
https://doi.org/10.24191/jcrinn.v10i1.458

they make decisions about how much mathematics to take at university (Huang, 2011). Many students perceive calculus as a challenging subject to master. A strong foundation in algebra, geometry and trigonometry is essential, which may leave students who lack proficiency in these areas to struggle. Calculus also demands higher-order thinking and multi-step problem-solving skills, which can be intimidating. Additionally, many concepts require the ability to visualise curves, slopes and areas under curves, posing a challenge for some learners. Nevertheless, a study conducted in Northern Province, Zambia, by Chama et al. (2023) showed that students have a positive perception and attitude towards calculus. Learning motivation, learning anxiety, mathematical connection ability, problem-solving ability and students' perceptions of teacher competence significantly affect mathematics learning achievement and are highly correlated (Retnawati, 2022).

Calculus 1, often the first course in a calculus sequence, introduces students to the fundamental concepts of limits, derivatives, and the basics of integration. Meanwhile, Calculus 2 builds on this foundation, exploring deeper into techniques of integration, series and sequences, polar coordinates and parametric equations. The progression from Calculus 1 to Calculus 2 requires a thorough understanding of the initial concepts to successfully grasp more complex topics. This transition is not merely a step up in difficulty but a continuation of conceptual understanding. Basic Calculus becomes difficult owing to a lack of knowledge and a poor foundation in Basic Mathematics (Domondon et al., 2022). The principles learned in Calculus 1 are integral to tackling the more advanced topics in Calculus 2. Therefore, a strong foundation in Calculus 1 is often predictive of a student's success in subsequent calculus courses. Performance in first-term calculus consistently impacts success in second-term calculus for students in science, mathematics, and engineering (Sahmbi, 2020). Positive experiences and success in previous mathematics courses can boost confidence and create a more favourable perception of calculus.

This paper aims to investigate the relationship between students' performance in Calculus 1 and their subsequent success in Calculus 2. Specifically, it seeks to answer the following questions: How does proficiency in Calculus 1 affect students' ability to understand and apply concepts in Calculus 2? Understanding these relationships can provide insights into how to better prepare students for advanced mathematical studies.

2. LITERATURE REVIEW

Today, many studies have examined basic mathematics achievement. Basic mathematics is important in learning mathematics and calculus to the next level. Many recent studies (Ormonoy, 2022) have shown the importance of solving math problems in elementary school. In the end, problem-solving plays an important role in the process of mastering one or another theoretical material studied in the primary grades, develops students' thinking skills and concerns the difficulties facing students when learning mathematics.

One of the reasons for the low overall achievement in mathematics is a lack of mathematical problem-solving skills. These elements are influenced by student, teacher, curriculum, school, and family considerations (Algani & Eshan, 2019). In terms of problem-solving, most students struggle with creative thinking abilities, particularly fluency, adaptability and novelty (Yayuk et al., 2020). Furthermore, the structure and content of textbooks can impede the development of problem-solving skills as they frequently provide limited possibilities for learning through problem-solving (Masina & Mosvold, 2023).

According to Tiwari (2023), a variety of factors influence student achievement in mathematics, including student-related factors such as thinking, attitude, knowledge, and participation. Equally important are teacher-related factors, such as knowledge, activities, quality, and beliefs, which have a direct impact on student outcomes. Furthermore, systemic factors such as the curriculum, evaluation system, and authorities' mindsets all contribute significantly to low achievement levels. Furthermore, environmental and societal factors, which include both the school's internal and external environments as well as societal attitudes towards education, have an impact on student achievement in mathematics.

https://doi.org/10.24191/jcrinn.v10i1.458

Research by Wang et al. (2023) on factors predicting success in mathematics has identified several key predictors and several factors that influence math achievement worldwide. Two factors shown to positively influence outcomes are the student's grade level and their family's socioeconomic status (SES). In contrast, five factors were associated with lower math achievement: student absenteeism or tardiness, repeating grades or dropping out, student misbehaviour, teacher and staff shortages, and the use of student-centered instruction. Another research by Maamin et al. (2020) discovered that the predominant teacher factor with a significant relationship to students' maths achievement is the teacher's qualities as measured by the teacher quality dimension. To increase students' achievement in mathematics, stakeholders must place special emphasis on the teacher characteristics dimension of teacher quality. Stakeholders should prioritize improving teacher characteristics such as qualifications, experience, and content knowledge to enhance student mathematics achievement.

While a solid mathematical foundation is important, self-efficacy is also a key motivational predictor of success in calculus. Self-efficacy refers to a student's belief in their ability to succeed in specific tasks or subjects. Students with high self-efficacy are more likely to engage with challenging material, seek help when needed, and persist through difficulties. According to Nuruddin et al. (2020), a high level of self-efficacy alone does not guarantee high performance. However, students must also improve their understanding and knowledge of mathematical techniques to enhance their performance in integral calculus.

Additionally, other psychological factors play a role in mathematical achievement. Ugwuanyi et al. (2020) found that emotional intelligence, self-efficacy, and self-esteem are positively related to students' achievement in mathematics, suggesting that these factors significantly predict academic success in the subject. Zakariya (2021) further supports this, stating that high scores on prior mathematics knowledge tests and strong self-efficacy significantly enhance students' ability to solve first-year calculus tasks.

Calculus performance is significantly predicted by several factors, including the senior high school strand, calculus enhancement programs, and admission scores in mathematics and abstract reasoning (Agua et al., 2023). Non-cognitive elements like achievement objectives and mathematics resilience also influence students' performance in mathematics. Particularly, university students' performance in mathematics is significantly correlated with their values and mastery-approach goals (Vergara, 2021). These findings highlight the importance of both cognitive and non-cognitive factors in predicting and improving calculus performance at the university level. However, there is a growing disconnect between high school pre-calculus grades and university calculus performance, suggesting a need for improved alignment and communication between high school and university educators (Barr et al., 2022).

The transition from introductory to advanced mathematics and the factors influencing student performance in calculus courses have been the subject of recent studies. Numerous factors, such as major, instructor, gender, and timing of the course, have been found to be predictive of Calculus I success (Hurdle et al., 2022). According to Peters & Ogilvie (2020), a significant number of students have demonstrated success in applying their mathematical knowledge to real-world situations during the transfer from Calculus I to engineering courses. A new model based on the Four Component Instructional Design has been developed to support the calculus secondary-tertiary transition. It emphasises reasoning, meaningful problem-solving, and concept-procedure connections (Wade et al., 2023). Although these investigations concentrate on calculus, related studies in computer science (CS) have discovered that CS1 grades can serve as predictors of CS2 performance, with most students either maintaining or marginally declining their grades during the transition (Layman et al., 2020).

Research consistently shows that a solid foundation in precalculus is essential for success in calculus courses. Students must have a solid foundation in pre-calculus concepts before continuing to Calculus 1 and beyond. The need to align knowledge states and critical learning pathways can help identify areas for additional enrichment and remediation to improve students' understanding of basic calculus concepts. Knowledge Space Theory analysis has provided evidence supporting the importance of a solid precalculus background for calculus success (Chahine & Grinshpon, 2020).

https://doi.org/10.24191/jcrinn.v10i1.458

Research supports the importance of a solid mathematical foundation. For instance, students who have taken precalculus tend to have significantly lower fail rates in Calculus I compared to those who have only completed college algebra or trigonometry. This may be due to their stronger motivation and clearer pathway toward science-related degrees (Hurdle & Mogilski, 2022). Similarly, Sencindiver (2020) found that students who actively manage and reinforce their precalculus knowledge achieve higher performance in Calculus I compared to those who do not. Moreover, mastering the concepts taught from precalculus through Calculus II provides the foundational knowledge necessary for advanced studies in science, technology, engineering, and mathematics (Voigt et al., 2020).

McNicholl et al. (2021) implemented Pathways, a research-based precalculus curriculum, in a large-lecture format supplemented by recitations, clickers, and online homework, and discovered that this implementation resulted in improved student success in precalculus, improved student retention in calculus, and significant shifts in student understanding of precalculus ideas that are fundamental to learning calculus. According to the study, increases in precalculus student achievement resulted in higher calculus retention rates and marked changes in students' comprehension of precalculus concepts, which are essential to learning calculus.

Additionally, the study by Schraeder et al. (2019) revealed that, while students viewed prior calculus exposure in high school as beneficial, it was not deemed essential for success in college calculus; however, some students believed that a poor high school calculus class could negatively impact their college performance, with the placement method, whether through testing or taking prerequisites, emerging as a more significant factor in student success than prior calculus experience. However, Watson et al. (2023) demonstrated that the Precalculus Concept Assessment Inventory was used to assess students' precalculus proficiency. The researchers discovered that students who were exposed to the Modelling Practices on Calculus (MPC) model were more likely to succeed in their calculus course, even if they had limited precalculus knowledge at the start. The MPC active learning model not only enhanced calculus success for students, even those with low precalculus proficiency, but also led to significant improvements in their precalculus skills throughout the semester.

Active learning approaches in calculus instruction have shown promising results in enhancing student engagement and performance. Active learning techniques have been shown to improve student engagement, comprehension, and retention in Science, Technology, Engineering, and Mathematics (STEM) courses, especially mathematics and calculus. Research has shown that implementing active learning strategies can improve students' perceptions of mathematics, increase classroom engagement, and facilitate discussion (Kurepa et al., 2019). Another study suggests that lecturers can respond to student learning needs by emphasising sensitivity to student participation and introducing advanced mathematical thinking (Petropoulou et al., 2020). Students' perspectives on learning in calculus courses reveal two major approaches: coping intention, in which students seek assistance to reduce uncertainty, and learning intention, in which students take responsibility for their learning (Hauk & Hsu, 2022). These findings suggest that tailoring teaching methods to student needs can enhance the learning experience in undergraduate mathematics courses.

3. METHODOLOGY

This study was conducted on a sample of 67 Engineering students from diploma programs in Electrical, Mechanical, and Civil Engineering who took Calculus I during the March-August 2023 semester and Calculus II during the October 2023-February 2024 semester. The population consisted of 82 students enrolled in Calculus I, but purposive (judgmental) sampling was used to select only those who passed Calculus I for further analysis. Data for the study included the final assessment scores for both Calculus I and Calculus II that are from a paired sample. Analysis was carried out using descriptive and inferential statistics with the Statistical Package for Social Sciences (SPSS) version 20.0 to explore the relationship between students' performance in both courses.

https://doi.org/10.24191/jcrinn.v10i1.458

A descriptive study of the student's grades was initially conducted to examine the percentage frequency of students achieving grades A, B and C in both subjects. Therefore, the grades were slightly consolidated to focus solely on grades A, B and C, as shown in Table 1.

Table 1. Combination of student score grade

Marks	Grade	Grade Combination
100 - 75	A+, A, A-	A
74 - 60	B+, B, B-	B
59 - 50	C+, C	C

This study proceeded with regression and correlation analysis to examine the relationship between Calculus I and Calculus II. The analysis requires the assumption that the data used must be normally distributed and the homogeneity of variance. To verify that these assumptions are true, a few residual diagnostic plots, including scatter plots, normal probability plots, and histograms, will be employed. Pearson correlation coefficient, r, was used to measure the strength and direction of the linear relationship between the independent variable (Calculus I) and the dependent variable (Calculus II). The scale for interpreting the strength of the correlation ranged from -1 to 1. A correlation value close to 1 or -1 indicates a perfect relationship, either positive or negative, while a value of 0 indicates no significant linear relationship between the variables. Table 2 displays the correlation scale based on the r value (Jamil, 2020).

Table 2. Correlation value and relationship

Correlation coefficient, r	Strength/Relationship
1.00	Perfect
0.7 - 0.99	Very Strong
0.5 -0.69	Strong
0.3 - 0.49	Moderate
0.1 - 0.29	Weak
0.01 - 0.19	Very Weak

Meanwhile, a linear regression analysis was performed to explain the tendency of Calculus II score changes based on changes in Calculus I scores. A simple linear regression model was employed in this study. First, the coefficient of determination (R^2) value was examined to indicate the percentage of variation in the Calculus II score that can be explained by the Calculus I score. Subsequently, the t-test and p-value were assessed to determine if the regression coefficient is statistically significant, with a p-value of less than 0.05 being considered significant. In contrast, the F-value was used to examine the fit of the model that resulted significantly from the relationship between these two variables.

As with all surveys, some limitations are present in this study. First, the results are specific to students from Engineering courses and may not be representative of all students from other disciplines. A larger and more diverse sample could provide more generalizable results. Second, the study uses only the final assessment scores for both Calculus I and Calculus II. This approach does not consider other factors that may influence student performance, such as continuous assessment, attendance, participation, or different teaching methods, which could provide a more comprehensive understanding of the students' learning outcomes. Future research could consider addressing these gaps to provide a more comprehensive analysis.

https://doi.org/10.24191/jcrinn.v10i1.458

4. RESULT AND DISCUSSION

Figure 1 shows the descriptive results, which are the percentage bar charts for grades in Calculus I and Calculus II. The results indicated that the majority of students obtained a grade B in both subjects, with 48% in Calculus I and 45% in Calculus II. This is followed by grade C with 34% and grade A with 18% in Calculus I. In Calculus II, the second highest percentage was grade A at 28%, followed by grade C at 27%. There was also a noted increase in the percentage of grade A students from Calculus I to Calculus II, with a rise of 10%, while grades B and C saw a decrease of 5% and 7%, respectively. The positive increase in grade A suggested that 18% of students were able to master the basics in Calculus I and maintain excellence in Calculus II (28%). However, the percentage of grade C remained relatively high, implying that while student performance in Calculus was satisfactory, they mainly grasped basic concepts and might struggle with more complex problems or advanced applications. Students also need support from lecturers and peers to improve their basic understanding for more comprehensive achievement (Brookhart, 2017).

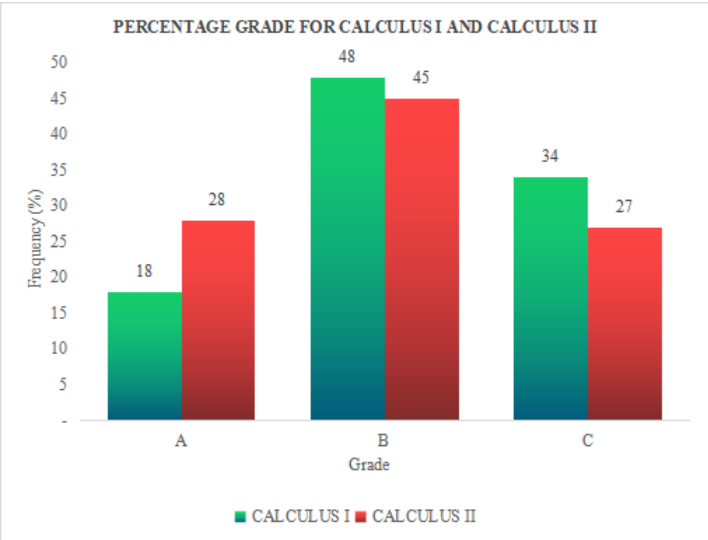

Fig 1. Bar chart for percentage grades of Calculus I and Calculus II

Figure 2 and Figure 3 are the results of assumptions for independence of observation, normality, linearity, and homoscedasticity. It is found that the data obtained from the histogram is evenly distributed according to the bell shape, and from the P-P plot, the points are all around the line and in the diagonal direction, although there are only a few that deviate slightly from the straight line as shown in Figure 2. This shows that the assumption of normality is not violated.

https://doi.org/10.24191/jcrinn.v10i1.458

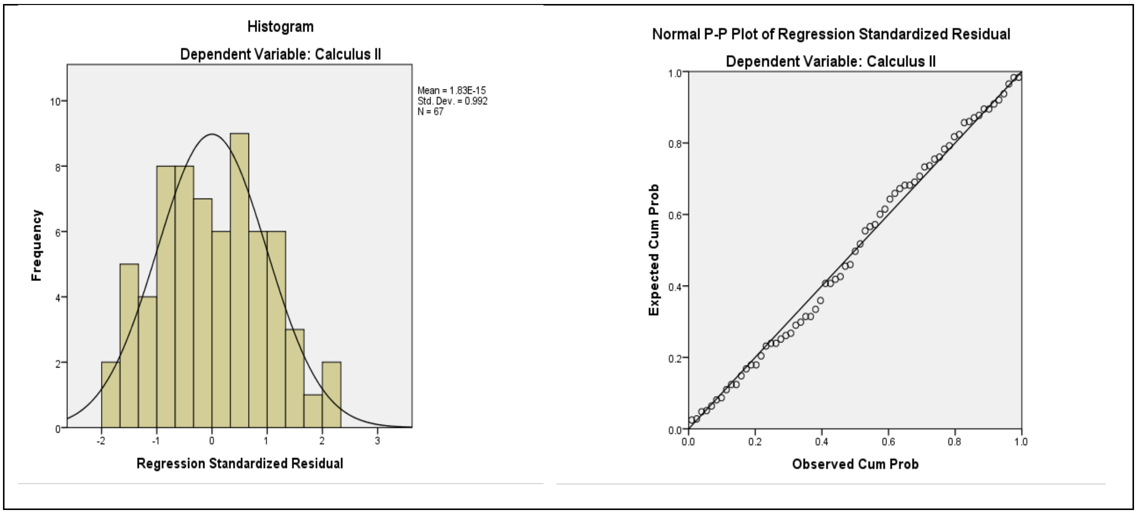

Fig.2**.** Diagnostics on the normality assumptions

In Figure 3, the plots of the regression standardized residuals and the regression standardized predicted values are randomly distributed, which indicates that the assumption of homoscedasticity is not violated. These residuals also have constant variance. It was also found that the assumption of linearity was met through simple linear patterns, as shown in the regression plots of standardized residuals and dependent variables (Calculus II).

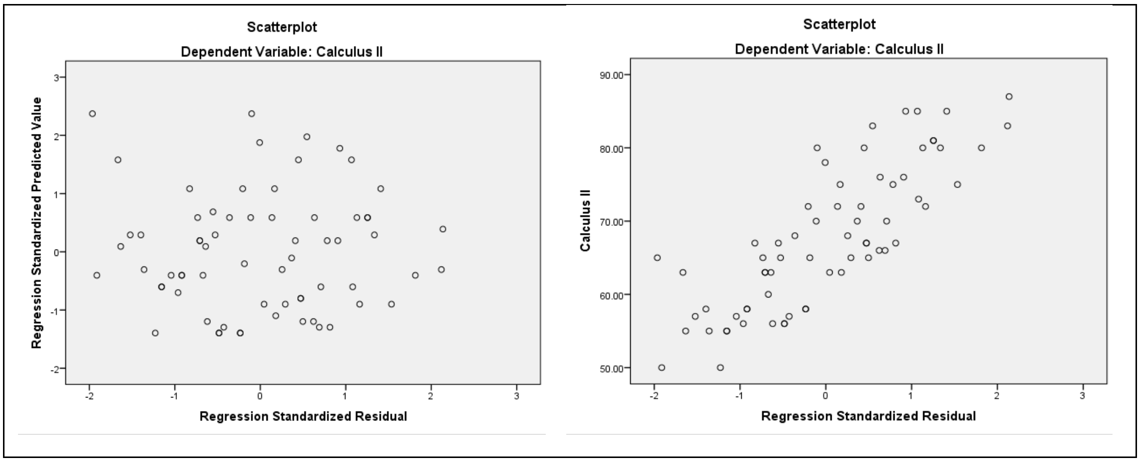

Fig.3. Diagnostics on the homoscedasticity and linearity assumptions

The Pearson correlation analysis, as shown in Table 3, was conducted to determine the strength and direction of the linear relationship between the performance in Calculus I and Calculus II. The results indicated a significant positive correlation, with a correlation coefficient of $r = 0.571$ and a p-value of 0.00 (< 0.05), suggesting a strong relationship between the two variables. Statistically, this means that students who perform well in Calculus I are likely to achieve higher grades in Calculus II. In other words, there is a tendency for students with higher scores in Calculus I to also score higher in Calculus II, which reflects a strong positive linear association between the two courses. This finding is supported by previous studies.

https://doi.org/10.24191/jcrinn.v10i1.458

Mittag & Collins (2000) found that Calculus I grades were the best predictor of Calculus II performance, with students who underwent reform in Calculus I more likely to earn higher grades in Calculus II. Similarly, Bullock et al. (2016), in a natural experiment comparing reformed and non-reformed Calculus I cohorts, found no disadvantage in Calculus II performance for students in the reformed Calculus I group. These studies corroborate the idea that strong performance in Calculus I is generally associated with better outcomes in Calculus II, further validating the results of the current study.

Table 3. Correlation between Calculus I and Calculus II

		Calculus II
Calculus I	**Pearson Correlation**	0.571
	Sig. (1-tailed)	0.00
	N	67

Table 4 shows the results of R^2 of the regression analysis conducted in this study. It was revealed that $R^2 = 0.326$, indicating that 32.6% of the variation in Calculus II scores can be explained by the Calculus I scores. Although this percentage was relatively low, it suggested that Calculus I scores still influenced Calculus II scores. The remaining 67.4% was influenced by other factors not accounted for by this model. Possible factors include the students' individual approaches to learning and their level of mastery of basic Calculus I concepts, which was satisfactory based on the grades obtained in Calculus I.

Table 4. Summary for R square

Model	R	R Square
1	.571	0.326

Predictors: (Constant), Calulus I

Table 5. Summary of simple linear regression analysis

	Regression Coefficients	t	Sig.
(Constant)	32.364	5.079	0.00
Calculus I	0.551	5.603	0.00

F = 31.397, p = 0.00

a.Dependent Variable: Calculus II,

b.Predictors: (Constant), Calculus I

Table 5 shows the summary of simple linear regression analysis. From the result, the regression model obtained are as follows:

$$\text{Calculus II Score} = 32.364 + 0.551(\text{Calculus I Score}) \quad (1)$$

The regression model (Eq.1) explains how Calculus I scores influence Calculus II performance. The coefficient of 0.551 for Calculus I indicates that for each additional mark a student scores in Calculus I, their Calculus II score is expected to increase by approximately 0.551. This reflects a positive linear relationship between the two courses, which is statistically significant as demonstrated by the t-value of 5.603 and p-value of 0.00 (<0.05). The large t-value confirms that this coefficient is significantly different

https://doi.org/10.24191/jcrinn.v10i1.458

from zero, meaning the relationship between Calculus I and II scores is not due to chance. The constant of 32.364 in the regression model represents the hypothetical score in Calculus II if a student scored zero in Calculus I. While this constant is required for the regression equation, it is more of a technical artifact and doesn't carry practical meaning in this context, as no student would realistically score zero in Calculus I.

The F-value of 31.397 with a p-value of 0.00 (<0.05) shows that the overall regression model is statistically significant (Table 5). This means that the combination of the constant and the coefficient for Calculus I explains a significant portion of the variance in Calculus II scores. The R-squared (R^2) value of 0.326 further supports this, indicating that 32.6% of the variability in Calculus II scores is explained by Calculus I scores (Table 4).

Thus, this model demonstrates that Calculus I performance is a strong predictor of Calculus II performance, as supported by the significant t-test for the coefficient and the F-test for the overall model. The analysis affirms that students who perform better in Calculus I are likely to achieve higher scores in Calculus II. This result aligns with past research, such as the findings of Mittag & Collins (2000) and Bullock et al. (2016), which support the predictive power of Calculus I scores on subsequent Calculus II performance.

5. CONCLUSION

The results of this study highlighted the critical role of a strong foundation in Calculus I for succeeding in Calculus II. Even though other factors could also contribute to the outcome, the significant increase in the number of students achieving grade A in Calculus II suggested that mastering the basics in Calculus I can lead to higher achievement in more advanced calculus concepts. However, the persistently high percentage of grade C students indicated that many students only achieve a satisfactory level of understanding. These suggest the necessity for additional support. Providing targeted support for students struggling with fundamental concepts in Calculus I can help improve their performance in Calculus II. This support can include tutoring, peer study groups, as well as additional resources such as online tutorials and practice problems.

Future studies should investigate other factors that influence Calculus II performance, such as students' study habits, classroom environment and instructor effectiveness, to develop a more comprehensive understanding regarding the determinants of success in calculus courses.

In conclusion, the study demonstrated that a solid grasp of Calculus I concepts is crucial for success in Calculus II. Enhancing foundational knowledge and providing robust support systems can significantly improve students' performance and confidence in tackling advanced mathematical problems. In addition, skipping this step can significantly affect a student's understanding and performance in their subsequent mathematical studies.

6. ACKNOWLEDGEMENTS

We would like to acknowledge the support of Department of Computers and Mathematics Sciences, Universiti Teknologi Mara (UiTM), Pulau Pinang Branch for the facilities and generous support on this research.

7. CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare that are relevant to the content of this article.

https://doi.org/10.24191/jcrinn.v10i1.458

8. AUTHORS' CONTRIBUTIONS

Norazah Umar: conceptualization, methodology, formal analysis, investigation, and writing-original draft; **Siti Balqis Mahlan**: conceptualization, literature review, formal analysis, and supervision; **Maisurah Shamsuddin**: conceptualization, investigation, data analysis, and interpretation of the result; supervision, writing-review, and editing. All authors read and approved the final manuscript.

9. REFERENCES

Algani, Y. M., & Eshan, J. (2019). Reasons and suggested solutions for low-level academic achievement in mathematics. *International e-Journal of Educational Studies*, *3*(6), 181-190. https://doi.org/10.31458/IEJES.604884

Agua, B. M. G., Lingo, M., & Lingo, J. (2023). A multiple linear regression model of students' performance in calculus in the new normal. *Journal of Research, Policy & Practice of Teachers and Teacher Education*, *13*(1), 103-117. https://doi.org/10.37134/jrpptte.vol13.1.8.2023

Barr, D., Clifton, R., Renaud, R., & Wang, X. (2022). An analysis of the relationship between high-school pre-calculus and university calculus grades. *International Journal of Mathematical Education in Science and Technology*, *54*(7), 1229-1256. https://doi.org/10.1080/0020739X.2022.2117656

Brookhart, S. M. (2017). *How to use grading to improve learning*. ASCD.

Bullock, D., Johnson, K. E., & Callahan, J. (2016, June). Longitudinal success of Calculus I reform. In *ASEE Annual Conference & Exposition*. https://doi.org/10.18260/p.25580

Chahine, I. C., & Grinshpon, M. (2020). Using knowledge space theory to delineate critical learning paths in Calculus. *International Journal of Learning, Teaching and Educational Research*, *19*(3), 123-148. https://doi.org/10.26803/ijlter.19.3.8

Chama, C., Sampa, R. L., Mutambo, D., Musonda, A., & Musonda, F. F. (2023). Learners' perceptions and attitudes towards learning of calculus in secondary schools: The case of three selected secondary schools in a district of the Northern Province of Zambia. *Journal of Advanced Research in Education, 2*(3), 68-75. https://www.pioneerpublisher.com/jare/article/view/315

Domondon, C. S., Pardo, C. G., & Rin, E. T. (2022). Analysis of difficulties of students in learning calculus. *Sci.Int. (Lahore), 34*(6), 1-4.

Hauk, S., & Hsu, P. S. (2022). Undergraduate and instructor perspectives on learning in first-year Mathematics courses in the United States: A Case Study in Calculus. *La Matematica*, *1*(3), 583-617. https://doi.org/10.1007/s44007-022-00022-1

Huang, C. H. (2011). Investigating the attitudes toward calculus of engineering students in Taiwan. *World Transactions on Engineering and Technology Education, 9*(2), 80-85.

Hurdle, Z. B., Akbuga, E., & Schrader, P. (2022). Exploring Calculus I students' performance between varying course times among other predictive variables. *International Electronic Journal of Mathematics Education, 17*(4), em0700. https://doi.org/10.29333/iejme/12234

Hurdle, Z. B., & Mogilski, W. (2022). The impact of prerequisites for undergraduate calculus I performance. *International Electronic Journal of Mathematics Education, 17*(3), em0696. https://doi.org/10.29333/iejme/12146

Jamil, K.H. (2020). Metodologi penyelidikan dalam pendidikan: Amalan dan analisis kajian. By Ghazali

https://doi.org/10.24191/jcrinn.v10i1.458

Darusalam & Sufean Hussin. Kuala Lumpur. Penerbit Universiti Malaya, 2019, pp. 630. *Intellectual Discourse,* 28.

Kurepa, A., Roop, J. P., & Edoh, K. (2019). Changing students' perception of mathematics through active learning. *International Journal of Education*, *11*(1), 29-39. https://doi.org/10.5296/ije.v11i1.13983

Layman, L., Song, Y., & Guinn, C. (2020, April). Toward predicting success and failure in cs2: A mixed-method analysis. In *Proceedings of the 2020 ACM Southeast Conference* (pp. 218-225).

Maamin, M., Maat, S. M., & Ikhsan, Z. (2020). A systematic review of teacher factors and mathematics achievement. *Universal Journal of Educational Research*, *8*(3), 998-1006.

Mittag, K. C., & Collins, L. B. (2000). Relating calculus-I reform experience to performance in traditional calculus-II. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 10*(1), 82-94.

Nuruddin, M., Noor, C. N., & Abidin, A. Z. (2020, March). Exploring the relationship between self-efficacy and mathematics performance in integral calculus among applied science university students. *Journal of Physics: Conference Series*, *1496*(1), 012018.

Masina, F., & Mosvold, R. (2023). Impediments to learning problem-solving in Malawian lower secondary mathematics textbooks. *African Journal of Teacher Education and Development, 2*(1), 9 pages. doi:https://doi.org/10.4102/ajoted.v2i1.23

McNicholl, T. H., Frank, K., Hogenson, K., Roat, J., & Carlson, M. P. (2021). Improving student success and supporting student meaning-making in large-lecture precalculus classes. *PRIMUS*, *31*(7), 792-810.

Ormonoy, T. (2022). The importance of solving math problems in elementary school: *Pentingnya memecahkan masalah matematika di sekolah dasar*. *Indonesian Journal of Education Methods Development*, *17*(4). https://doi.org/10.21070/ijemd.v20i.628

Peters, T., & Ogilvie, C. (2020). A quantitative analysis of the near transfer of learning from calculus to subsequent engineering courses. *International Journal of Mathematical Education in Science and Technology, 51*(7), 1088-1097. https://doi.org/10.1080/0020739X.2019.1656825

Petropoulou, G., Jaworski, B., Potari, D., & Zachariades, T. (2020). Undergraduate mathematics teaching in first year lectures: Can it be responsive to student learning needs?. *International journal of research in undergraduate mathematics education*, *6*, 347-374.

Retnawati, H. (2022). Empirical study of factors affecting the students' mathematics learning achievement. *International Journal of Instruction, 15*(2), 417-434.

Sahmbi, G. (2020). *A Tale of Two Universities: Investigating Factors Affecting the Secondary to Tertiary Transition into Calculus for Students in STEM Disciplines*. University of Toronto (Canada).

Schraeder, M. R., Pyzdrowski, L. J., & Miller, D. A. (2019). The impact of prior exposure to calculus. *American Journal of Educational Research, 7*(3), 237-243. https://doi.org/10.12691/education-7-3-8

Sencindiver, B. D. (2020). *Success in Calculus I: Implications of students' precalculus content knowledge and their awareness of that knowledge* [Doctoral dissertation, Colorado State University].

Tiwari, D. D. (2023). Factors affecting the achievement of students in mathematics. *Mathematics Education Forum Chitwan, 8* (1), 11-23. https://doi.org/10.3126/mefc.v8i1.60473

Ugwuanyi, C. S., Okeke, C. I., & Asomugha, C. G. (2020). Prediction of learners' Mathematics performance by their emotional intelligence, self-esteem and self-Efficacy. *Cypriot Journal of*

Educational Sciences, *15*(3), 492-501.

Vergara, C. R. (2021). Mathematics resilience and achievement goals: Exploring the role of non-cognitive factors to mathematics performance of university students amidst of pandemic. *Open Access Library Journal*, *8*(12), 1-10.

Voigt, M., Apkarian, N., Rasmussen, C., & Progress through Calculus Team. (2020). Undergraduate course variations in precalculus through Calculus 2. *International Journal of Mathematical Education in Science and Technology, 51*(6), 858-875. https://doi.org/10.1080/0020739X.2019.1636148

Wang, X. S., Perry, L. B., Malpique, A., & Ide, T. (2023). Factors predicting mathematics achievement in PISA: A systematic review. *Large-Scale Assessments in Education*, *11*(1), 24. https://doi.org/10.1186/s40536-023-00174-8

Wade, C. H., Sonnert, G., & Sadler, P. (2023). Presenting a new model to support the secondary-tertiary transition to college calculus: The secondary precalculus and calculus four component instructional design (SPC 4C/ID) model. *Journal of Mathematics Education at Teachers College, 14*(1), 1-9.

Watson, C. N., Duran, P., Castillo, A., Fuller, E., Potvin, G., & Kramer, L. (2023). The supportive role of active learning in a calculus course on low precalculus proficiency students. *International Journal of Mathematical Education in Science and Technology*, 1-22. https://doi.org/10.1080/0020739X.2023.2255189

Yayuk, E., Purwanto, As'ari, A. R., & Subanji. (2020). Primary school students' creative thinking skills in mathematics problem solving. *European Journal of Educational Research, 9*(3), 1281-1295. https://doi.org/10.12973/eu-jer.9.3.1281

Zakariya, Y. F. (2021). Self-efficacy between previous and current mathematics performance of undergraduate students: an instrumental variable approach to exposing a causal relationship. *Frontiers in Psychology*, *11*, 556607.

https://doi.org/10.24191/jcrinn.v10i1.458