Perception and Academic Performance of STEM Students in Learning Calculus

Bonifacio L. Giangan Jr.*, Melanie G. Gurat
For affiliations and correspondence, see the last page.

Abstract

This study aimed to determine the relationship between academic performance and students' perceptions in learning Calculus during distance learning modality. Learning Calculus is part of developing students' Mathematics skills and abilities towards enhancing STEM education in Senior High School. Thirty-five (35) STEM students were purposively sampled at a public school in Davao Region, Philippines. These students took up Pre-Calculus and Basic Calculus during pandemic. This study used a quantitative research design, particularly the descriptive-correctional method, to analyze the collected data. Based on the result, the level of students' perceptions was positive, while the level of academic performance was very satisfactory. Moreover, no significant correlation exists between students' perceptions and academic performance in learning calculus on distance learning. This implies that students can perform well regardless of their perceptions in learning Calculus, in both Pre- Calculus and Basic Calculus. However, further assessment needs to be done in their Mathematics subjects at the Tertiary level since the modality used was not face-to-face. Appropriate action may be considered based on the assessment result, such as bridging courses or tutorial sessions.

Keywords: Attitudes, Basic Calculus, Modular Approach, Pre-Calculus, Distance Learning

Introduction

Learning Calculus is part of developing students' Mathematics skills and abilities towards enhancing Science, Technology, Engineering, and Mathematics (STEM) education in Senior High School. Ayebo et al. (2016) stated that College calculus has a great deal of potential to increase the proportion of students majoring in STEM professions. It is a prerequisite for all STEM disciplines and, if taken effectively, should give students a successful first year of college and a springboard into more challenging coursework. Calculus subject is beneficial to both STEM and non-STEM students for developing critical thinking and problem-solving skills, the twin goals of mathematics education (Hagman, 2019).

College calculus has received attention in recent years, which has led to more emphasis on problem-solving in practical contexts, increased attention to helping students develop conceptual understanding rather than just procedural fluency, and frequently more active learning strategies used in the classroom, such as student-centered instruction and increased technology use (Rasmussen et al., 2014). One of the greatest challenges facing students in learning calculus is the ability to persevere in the face of failure (Crawford et al., 2018) because Calculus subject is known to be a "difficult" subject. High school students struggle to understand the mathematical content of calculus courses. This is also the case for most undergraduate students who find calculus to be a challenging topic, and they frequently misunderstand the notion of

function (Tarmizi, 2010). In addition, students also found difficulty in function graphs and trigonometric manipulations, domain and range, values of a limit function, the maximum and minimum values in the story matter, using integral rules, using substitution and partial integral techniques, and in the completion of the volume of rotary objects (Fatimah & Yerizon, 2019).

Ellis et al. (2016) found that students' top justifications for quitting the calculus program were changing their majors and no longer needing to complete it, lacking the time and effort necessary to succeed in calculus, and having a bad experience with differential calculus. The difficulty was identified as frequently attributed to the student's lack of confidence in their mathematical competence. This was supported by Liang (2009), who said that perceptions of learning calculus would affect students' performance in learning calculus. Understanding how students perceive their mathematics learning abilities is essential because it relates to mathematics achievement (Lee & Kung, 2018).

Moreover, a greater challenge was faced by both students and teachers with the COVID-19 pandemic. Through the Department of Education (DepEd) Order no. 12 series of 2020, students' learning and teaching process throughout the country shifted from face-to-face to distance learning. Learning modalities were being used, such as online, TV/Radio, blended, and modular modalities. Marber National High School, a public school in Davao Region in the Philippines, used modular modality to ensure the continuity of the

students' learning, providing the quality distribution of modules across disciplines. Susilawati et al. (2020) stressed that learning Calculus in distance learning is ineffective, particularly in online learning. Tsvigu (2007) established that the learning environment could affect students' learning, both favorably and unfavorably, with the learning support system being the key contributing component in a distance education system. Students also faced technological, personal, domestic, assessment, pedagogical, consultation, and test anxiety challenges during COVID-19 (Bringula et al., 2021). Hence, this study explored the relationship between the students' perceptions and academic performance in learning Calculus on a distance learning modality.

Research Questions

The primary purpose of this study is to determine the relationship between the student's perception and academic performance in Calculus. Specifically, this study sought to answer the following questions:

1. What is the level of perception of learning Calculus of STEM students?
2. What is the level of academic performance of STEM Students in learning Calculus?
3. Is there a significant correlation between STEM students' perception and academic performance in learning Calculus?

Literature Review

Students' perception

Students in various situations and statuses have different perceptions of the foundation of the prerequisite knowledge in learning calculus. However, this brought a further study that may relate to how the students or learners reveal their perception in learning Calculus.

According to García-Santillán et al. (2016), the study of mathematics could be analyzed from various angles. This means considering the viewpoint of the subject matter of mathematics, student's perceptions and attitude, assessing their needs, attitudes, beliefs, and feelings to confront them, from the point of view of the teachers, from the educational system, their curricula, and the teaching-learning models involved. Meanwhile, Ellis, Kelton, and Rasmussen (2014) stated that when considering factors like course enrollment and other background variables, the studies reveal that students are more likely to identify as

Switchers than Persisters if they believe their instructor holds whole-class discussions infrequently.

Susilawati, Darmawan, and Desiasni (2020) highlighted that the students' difficulty levels stayed constant. Tang, Nor, and Voon (2013) revealed that Calculus learning, as perceived by the students and ideas made by the lecturers to improve it and lessons in calculus, ought to be structured to relate concepts and theories to practical applications. On the other hand, Krishnan (2016) highlighted that when learning mathematics, students prefer the online approach, but when it comes to assessment, they prefer the traditional mode.

Academic Performance

Based on the 2018 Program for International Students Assessment (PISA) results, the Philippines performed poorly under challenging courses like calculus and came in second last overall in mathematics. Padernal and Diego (2020) revealed that regardless of the student's place of origin or entrance exam results, senior high school students generally performed at an average intellectual level in Pre-Calculus.

Further, Ayebo et al. (2016) emphasized that college calculus has a great deal of potential to increase the proportion of students majoring in STEM professions. It is a prerequisite for all STEM disciplines and, if taken effectively, should give students a successful first year of college and a springboard into more challenging coursework. Meanwhile, Nasir et al. (2018) stressed that since students frequently memorize information rather than comprehend it, their performance is average.

Tarmizi (2010) conducted a study on visualizing students' difficulties in learning Calculus. He found that students do not perform well in Calculus and that they need further attention, such as conducting tutorial sessions to check their misconceptions of the students. Similarly, Tsvigu (2007) also conducted a study on calculus, but the experiences, and learning styles were considered. Furthermore, the modality in the study was distance learning. Also, Fatimah and Yerizon (2019) analyzed the student learning difficulties with calculus subjects.

Methodology

This study used a quantitative approach, particularly the descriptive-correlational design. It is descriptive because it aimed to describe the level of perception

and academic performance of STEM Students in learning Calculus. These two variables were also correlated; hence this study was also correlational.

Participants

The participants of the study were senior high school students in Marber National High School under the Science, Technology, Engineering, and Mathematics strand. The purposive sampling method was used in selecting the participants in this study. There were 35 STEM students suited to required characteristics or criteria inclusion, such as participants are STEM students and took up Pre-Calculus and Basic Calculus.

Sources of the Data

There were two sources of data used in this study. The Likert scale questionnaire in determining the perception of the STEM students in learning calculus and the record of the teachers.

The research instrument was adapted from Tang et al. (2013) in determining the STEM students' perceptions, particularly in Pre-Calculus and Basic Calculus. The questionnaire consists of 20 items. There are 9 negative statements (Items 6, 8,9,10, 11,12,14,16,17) and 11 positive statements in the questionnaire. It is a 5-point Likert scale questionnaire. The lowest scale is 1, strongly disagree, and the highest is 5, strongly agree. The questionnaire was reliable with an alpha value of 0.874.

Data Gathering Procedure and Data Analysis

The researcher secured a permit letter from the principal's office to conduct the study. Once approved, the survey questionnaire was distributed via google form, and the responses were recorded. Moreover, the participants would be free to withdraw from being a respondent. The data were analyzed and interpreted.

The ratings in the negative items of the questionnaire were reversed. The mean was computed to determine the level of students' perceptions and the level of academic performance in learning calculus. Moreover, the standard deviation was also computed. Tables 1 and 2 show the verbal interpretation of the mean. The correlation between the level of academic performance and students' perceptions was explored through Pearson-r.

Ethical Considerations

Generally, the study aimed to determine the

relationship between the students' perception and academic performance in Calculus. Thereby, there is no conflict of interest in the present study. Rest assured that the privacy of the participants was respected, and all the data collected was treated with the utmost confidentiality. With these, the researcher can only retrieve all the accomplished data, and identification codes were used to replace the respondents' names. Also, the data were only used to conduct this research.

Results

Level of Perception on Learning Calculus of Science, Technology, Engineering and Mathematics (STEM) Students.

Table 1 shows the mean and qualitative description of STEM students' perception of learning calculus.

Table 1. *Perception of STEM Students in Learning Calculus*

Statement	Mean	SD	Int.
1. I would like to continue my Calculus learning in an advanced course.	3.97	1.071	Agree
2. I feel that Calculus will be useful to me in my future profession.	4.11	.963	Agree
3. The thought of being enrolled in a Calculus course makes me nervous.	4.14	.943	Agree
4. Calculus seems very mysterious to me.	4.06	1.056	Agree
5. Most people would benefit from taking a Calculus course.	3.97	.891	Agree
6. I have difficulty seeing how Calculus is related to my field of study.	3.54	1.197	Agree
7. I see being enrolled in a Calculus course as a very pleasant experience.	3.97	1.014	Agree
8. Calculus is not really useful because it tells me what I already know anyway	1.97	1.224	Disagree
9. I wish that I could avoid taking my Calculus course.	2.69	1.132	Neutral
10. Calculus is too Calculus-oriented to be of much use to me in the future.	3.40	.946	Neutral
11. I get upset at the thought of enrolling in another Calculus course.	2.57	1.037	Neutral
12. I feel frightened when I have to deal with mathematical formulas.	3.40	1.168	Neutral
13. I am excited at the prospect of actually using Calculus in my future job.	3.49	1.173	Neutral
14. Studying Calculus is a waste of time.	1.89	1.301	Disagree
15. Calculus thinking can play a useful role in everyday life.	3.71	1.017	Agree
16. Dealing with numbers makes me uneasy.	2.86	1.115	Neutral
17. Calculus is too complicated for me to use effectively.	3.14	.975	Neutral
18. Calculus thinking will one day be as necessary for efficient citizenship as the ability to read and write.	3.49	.659	Neutral
19. Calculus will be useful to me in comparing the relative merits of different objects, methods, programs, etc.	3.83	.923	Agree
20. Calculus training is relevant to my performance in my field of study.	3.69	.832	Agree
Overall	3.55	.476	Positive

As shown in Table 1, most of the positive items were rated within 3.50-4.49. The overall weighted mean is 3.55, which means the grade 11 and 12 students of Marber National High School had a positive attitude

Giangan & Gurat

towards learning Calculus even though they were taught using a modular approach. It was also observed that the students agreed that they find it difficult to relate Calculus in the field of their study. However, they disagreed that Calculus is not useful and that studying it is a waste of time. For other positive and negative statements, the students were undecided whether they agreed or disagreed with the statements.

Level of Academic Performance of STEM Students in Learning Calculus

Table 2 shows the students' level of performance in the calculus subjects.

Table 2. *Academic Performance of the Senior High School Students*

Subject	Weighted Mean	Verbal Interpretation
Pre-Calculus	89	Very Satisfactory
Basic Calculus	89	Very Satisfactory
Overall	89	Very Satisfactory

As gleaned in Table 2, the level of the academic performance of 35 STEM students was 89 in their Pre-calculus and Basic Calculus subjects. The overall grade in Calculus was 89. This is qualitatively described as very satisfactory. This implies that students performed well in their calculus subject even during modular distance learning.

Correlation between perception and academic performance of STEM students in learning Calculus

Table 3 shows the correlation between STEM students' perception and academic performance in learning Calculus.

Table 3. *Correlation between the level of students' perception and the level of academic performance of STEM students in learning Calculus*

		Pre-calculus	Basic Calculus Grade	Mean
Perception	Pearson Correlation	.126	.133	.132
	Sig. (2-tailed)	.469	.446	.448
	N	35	35	35

As shown in Table 3, the perception of the STEM students in learning Calculus through a modular approach was not positively correlated with their grades in Pre-Calculus ($r=.126$), Basic Calculus ($r=.133$), and their mean grade in Calculus ($r=.132$). However, the result also revealed a weak and not significant correlation in Pre-calculus ($p=.469$), Basic Calculus ($p=.446$), and the mean grade ($p=.448$). This implies that there was no significant correlation between the perception of the STEM students in learning Calculus and their grades.

Discussion

The students' perceptions of learning Calculus were positive. This contradicts the result of Ellis et al. (2016) that students had a lack of confidence in learning Calculus. Despite the positive result in learning Calculus using a modular approach, according to Krishnan (2016), face-to-face training helps the students learn and understand mathematical ideas more effectively since they feel more at ease communicating with their peers and the teacher in this setting. Ayebo et al. (2016) added that students also retain information better when they can relate it to actual problems.

The senior high school students under the STEM strand had a very satisfactory performance in Calculus in learning through modular modality. This shows that the senior high school students under the STEM strand had very satisfactory performance in applying concepts and solving problems involving conic sections, systems of nonlinear equations, series and mathematical induction, circular and trigonometric functions, trigonometric identities, and polar coordinate systems. The result in the study of Padernal and Diego (2020) was only an average intellectual level in Pre-Calculus. The possible reason was the lessons were only memorized but not comprehended (Nasir et al., 2018).

Moreover, Tarmizi (2010) found the students have difficulty understanding functions. Moreover, they also had very satisfactory performance in determining the limit of a function, differentiating, and integrating algebraic, exponential, logarithmic, and trigonometric functions in one variable, and formulating and solving problems involving continuity, extreme values, related rates, population models, and areas of plane regions. This contradicts Fatimah and Yerizon (2019) who found that students' difficulty in function graphs and trigonometric manipulations, domain and range, values of a limit function, the maximum and minimum values in the story matter, using integral rules, using substitution and partial integral techniques, and in the

completion of the volume of rotary objects. Since Tsvigu (2007) said that the distance education system could affect students' learning favorably and unfavorably. In this study, the result reveals that the distance learning education system favorably affects the students' performance in Calculus. In addition, even if the STEM students faced technological, personal, domestic, assessment, pedagogical, consultation, and test anxiety challenges during COVID-19 (Bringula et al., 2021), they could perform well in their Calculus subjects. Also, this disconfirmed the statement of Susilawati et al. (2020) that learning Calculus in distance learning is not effective.

On the other hand, even if there was a favorable result on the students' performance and their perception of learning Calculus in the modular approach, issues such as the scenario in the modular approach need to be considered. The students were given summative assessments but had all the resources in their homes. Hence, the result differed from Tarmizi (2010), who even suggested tutorial sessions to correct the students' misconceptions in learning some concepts in Calculus.

Furthermore, the data result showed no significant correlation between students' perceptions and academic performance in learning Calculus through modular learning. This suggests that their perceptions did not affect their academic performance in learning Calculus. This contradicts the study of Liang (2009), who said that perceptions of learning calculus would affect students' performance in learning calculus.

Conclusion

Despite the students' positive perception of modular learning in Calculus and their very satisfactory performance, teachers must still consider ways to let their students appreciate Calculus subjects and let them understand the application of the subject. This pertains not only as a requirement in Tertiary courses but also the application of this in real life. Tutorials must also be considered, especially since the modality during the pandemic was not face-to-face.

Moreover, even if the result revealed no significant correlation between students' perceptions and academic performance in learning Calculus on a distance learning modality, the perception and performance of the students must still be given attention. Other factors may also be considered to improve the perception and performance of the students in learning Calculus. Knowledge of the

students may be measured again as a diagnostic assessment in Mathematics at the Tertiary level to determine what lessons needs to be given emphasis. Possible interventions can also be done, such as offering bridging courses for those who cannot get a passing score on the diagnostic test.

References

Ayebo, A., Ukkelberg, S., & Assuah, C. (2016). Success in Introductory Calculus: The Role of High School and Pre-calculus Preparation. *International Journal of Research in Education and Science, 3*(25311), 11–19.

Bringula, R., Reguyal, J. J., Tan, D. D., & Ulfa, S. (2021). Mathematics self-concept and challenges of learners in an online learning environment during COVID-19 pandemic. *Smart Learning Environments*, 8(1).

Crawford, P., Moseley., Nancarrow, M. & Ward, E. (2018) Calculus Challenges: An Active Learning Approach. *PRIMUS, 28*(6), 616-625, DOI:10.1080/10511970.2017.1387630

Ellis J, Fosdick BK, Rasmussen C. (2016). Women are 1.5 times more likely to leave STEM pipeline after calculus compared to men: Lack of mathematical confidence a potential culprit. *PLoS One, 11*(7):e0157447

Ellis, J., Kelton, M. L., & Rasmussen, C. (2014). Student perceptions of pedagogy and associated persistence in calculus. *ZDM, 46*(4), 661–673.

Eng, T. H., Li, V. L., & Julaihi, N. H. (2010). The Relationships Between Students' Underachievement in Mathematics Courses and Influencing Factors. *Procedia - Social and Behavioral Sciences, 8*, 134–141.

Fatimah, S., & Yerizon. (2019). Analysis of difficulty learning calculus subject for mathematical education students. *International Journal of Scientific and Technology Research, 8*(3), 80–84.

García-Santillán, A., Escalera-Chávez, M. E., Moreno-García, E., & Santana-Villegas, J. D. C. (2016). Factors that Explains Student Anxiety toward Mathematics. *EURASIA Journal of Mathematics, Science and Technology Education, 12*(2).

Hagman, J. (2019). Towards a Forward-Thinking College Calculus Program. In (Ed.), Theorizing STEM Education in the 21st Century. IntechOpen. https://doi.org/10.5772/intechopen.87940

Krishnan, S. (2016). Students' Perceptions Of Learning Mode In Mathematics. *The Malaysian Online Journal of Educational Sciences*, 4(2).

Lee, C.-Y., & Kung, H.-Y. (2018). Math self-concept and mathematics achievement: Examining gender variation and reciprocal relations among junior high school students in Taiwan. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(4), 1239–1252.

Liang, S. (2009). Validating the Instrument: Students' Perceptions on Learning Calculus. NERA Conference Proceedings 2009. Paper 21.

Nasir, A. M., Omar, N. A. B., Sarudin, E. S. B., Masrom, S., &

Ahmad, N. H. (2018). Teaching and learning of pre-calculus: an insights of educators. *Journal of Fundamental and Applied Sciences, 9*(6S), 452.

Padernal, R. E., & Diego, C. V. (2020). Academic Performance of Senior High School Students in Pre-Calculus. *Philippine Social Science Journal, 3*(2), 69–70.

Rasmussen C, Marrongelle K, & Borba MC (2014). Research on calculus: What do we know and where do we need to go? *ZDM, 46*(4):507-515

Republic of the Philippines. Official Gazette, *Proclamation 929*. Declaring a State of Calamity Throughout the Philippines Due to Corona Virus Disease 2019.

Susilawati, T., Darmawan, I., & Desiasni, R. (2020). The effectiveness of online calculus 2 learning during the Covid-19 pandemic. *Journal of Physics: Conference Series* , *1657*(1), 012089.

Tang, H. E., Julaihi, N. H., & Voon, L. L. (2013). Attitudes and perceptions of university students towards calculus. *Social and*

Management Research Journal, 10(1), 1.

Tarmizi, R. A. (2010). Visualizing students' difficulties in learning calculus. *Procedia - Social and Behavioral Sciences*, *8*, 377–383.

Tsvigu, C. (2007). *Students ' Experiences , Learning Styles and Understanding of Certain Calculus Concepts□: a Case of Distance Learning At the Zimbabwe.*

Affiliations and Corresponding Information

Bonifacio Giangan Jr.
Saint Mary's University
Nueva Vizcaya, Philippines

Melanie Gurat, PhD
Saint Mary's University
Nueva Vizcaya, Philippines