Perception and Academic Performance of STEM Students in Learning Calculus

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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. Ayeb 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. Tsuvigu (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, Tsuvigu (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

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean</th>
<th>SD</th>
<th>Int.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I would like to continue my Calculus learning in an advanced course</td>
<td>3.97</td>
<td>1.074</td>
<td>Agree</td>
</tr>
<tr>
<td>2. I feel that Calculus will be useful to me in my future profession</td>
<td>4.11</td>
<td>.963</td>
<td>Agree</td>
</tr>
<tr>
<td>3. The thought of being enrolled in a Calculus course makes me nervous</td>
<td>4.14</td>
<td>.943</td>
<td>Agree</td>
</tr>
<tr>
<td>4. Calculus seems very mysterious to me</td>
<td>4.06</td>
<td>1.050</td>
<td>Agree</td>
</tr>
<tr>
<td>5. Most people would benefit from taking a Calculus course</td>
<td>3.97</td>
<td>.941</td>
<td>Agree</td>
</tr>
<tr>
<td>6. I have difficulty seeing how Calculus is related to my field of study</td>
<td>3.54</td>
<td>1.197</td>
<td>Agree</td>
</tr>
<tr>
<td>7. I see being enrolled in a Calculus course as a very pleasant experience</td>
<td>3.97</td>
<td>1.014</td>
<td>Agree</td>
</tr>
<tr>
<td>8. Calculus is not really useful because it tells me what I already know</td>
<td>1.97</td>
<td>2.224</td>
<td>Disagree</td>
</tr>
<tr>
<td>9. I wish that I could avoid taking my Calculus course</td>
<td>2.69</td>
<td>1.832</td>
<td>Neutral</td>
</tr>
<tr>
<td>10. Calculus is too Calculus-oriented to be much use to me in the future</td>
<td>3.30</td>
<td>.946</td>
<td>Neutral</td>
</tr>
<tr>
<td>11. I get upset at the thought of enrolling in another Calculus course</td>
<td>2.57</td>
<td>1.037</td>
<td>Neutral</td>
</tr>
<tr>
<td>12. I felt enlightened when I have to deal with mathematical formulas</td>
<td>3.40</td>
<td>1.168</td>
<td>Neutral</td>
</tr>
<tr>
<td>13. I am excited at the prospect of actually using Calculus in my future job</td>
<td>3.49</td>
<td>1.173</td>
<td>Neutral</td>
</tr>
<tr>
<td>14. Studying Calculus is a waste of time</td>
<td>1.89</td>
<td>3.130</td>
<td>Disagree</td>
</tr>
<tr>
<td>15. Calculus thinking can play a useful role in everyday life</td>
<td>3.71</td>
<td>1.017</td>
<td>Agree</td>
</tr>
<tr>
<td>16. Dealing with numbers makes me uneasy</td>
<td>2.86</td>
<td>1.185</td>
<td>Neutral</td>
</tr>
<tr>
<td>17. Calculus is too complicated for me to use effectively</td>
<td>3.14</td>
<td>.975</td>
<td>Neutral</td>
</tr>
<tr>
<td>18. Calculus thinking will one day be as necessary for efficient citizenship as the ability to read and write</td>
<td>3.40</td>
<td>.959</td>
<td>Neutral</td>
</tr>
<tr>
<td>19. Calculus will be useful to me in comparing the relative merits of different objects, methods, programs, etc.</td>
<td>3.83</td>
<td>.923</td>
<td>Agree</td>
</tr>
<tr>
<td>20. Calculus training is relevant to my performance in my field of study</td>
<td>3.69</td>
<td>.832</td>
<td>Agree</td>
</tr>
</tbody>
</table>

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...
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>
<thead>
<tr>
<th>Subject</th>
<th>Weighted Mean</th>
<th>Verbal Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Calculus</td>
<td>89</td>
<td>Very Satisfactory</td>
</tr>
<tr>
<td>Basic Calculus</td>
<td>89</td>
<td>Very Satisfactory</td>
</tr>
<tr>
<td>Overall</td>
<td>89</td>
<td>Very Satisfactory</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Perce</th>
<th>Pre-calculus</th>
<th>Basic Calculus Grade</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>.126</td>
<td>.133</td>
<td>.132</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.469</td>
<td>.446</td>
<td>.448</td>
</tr>
<tr>
<td>N</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>

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. Ayobo 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 Tsvigui (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**


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


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