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Students' Mathematical Readiness and Challenges Encountered in Calculus: Basis for Developing School-Based Intervention Program

Jewelle Evanna C. Irigayen
Cagayan State University-Aparri Campus
jewelleevanna@gmail.com

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ABSTRACT

This study evaluated the mathematical readiness and challenges encountered in Calculus among Grade 12 students from four public senior high schools in Camalaniugan and Lal-lo, Cagayan, with an ultimate aim to develop a school-based intervention program. The participants were dominantly 17-year-old males from low-income families earning ₱10,000 and below, with maintained average GWA of 91.12 and Calculus grade of 88.57. The findings revealed that students were at *Approaching Proficiency* level in conceptual understanding and problem solving but significantly struggling in applying Calculus to engineering scenarios with a *Partial Credit* level. Conversely, their confidence, motivation, and attitude were rated *high.* Despite of it, students *often* encountered challenges. Statistical analysis using one-way ANOVA and Pearson-r revealed that mathematical readiness significantly varied based on age and academic grades in General Mathematics, Pre-Calculus, and Calculus, whereas sex and socio-economic status showed no significant impact. Remarkably, no significant correlations were found between student profiles and the challenges encountered, suggesting that difficulties in Calculus are a universal experience regardless of demographic background. While academic performance positively correlated with conceptual understanding and affective readiness, they failed to correlate with problem-solving and application skills, emphasizing a critical gap between theoretical knowledge and real word scenarios. To address this gap, intervention program was developed, project BRIDGE STEM (Bridging Readiness through Integrated Drills and Guided Engineering). This aim to bridge the gap between students' high affective readiness and their limited ability to apply Calculus concepts to engineering contexts, ultimately supporting the K-12 goal of preparing STEM students for tertiary engineering education.

Keywords: *Mathematical readiness, challenges encountered, Calculus, STEM students, school-based intervention program*

INTRODUCTION

In the modern STEM workforce, mathematical skill is the foundation. High-level reasoning is not just a classroom requirement but a critical professional skill in the 21st century (World Economic Forum, 2020). Calculus is the primary gateway to the field of engineering. However, success in Calculus demands a deep conceptual grasp of algebra, functions, and limits, foundations that must be solidified in high school (Ceci & Williams, 2020).

The K–12 Basic Education Program (Republic Act No. 10533) was designed to meet these standards by creating a specialized STEM strand (DepEd, 2016) in the Philippines. Despite of this reform, a readiness gap continuous. Many students can perform repetitive calculations but struggle to apply mathematical rules to real-world engineering problems (Luna & Morales, 2018; PNU, 2022). This gap becomes wider where students lack the instructional resources and support systems available (Villanueva et al., 2021; Cordova, 2020). While the national recognizes these challenges, there is a lack of evidence for the municipalities of Camalaniugan and Lallo, Cagayan. These communities face barriers such as limited access to advanced materials and specific socio-demographic hurdles. Without local data, the standard deviations are not properly evaluated if it actually works with the students.

To address this gap through the ARAL PROGRAM ACT, schools must build support systems based on the documented needs of their students. With that this study evaluated the mathematical readiness and identify challenges encountered in Calculus of Grade 12 STEM students of Camalaniugan and Lal-lo. By analyzing how the students' socio-demographic and academic profile correlate, this provided evidence to create a localized school-based intervention program that help students succeed in engineering.

Conceptual/Theoretical Framework

Mathematical readiness is a developmental state arising from students' socio-demographic and academic profile and challenges encountered. This study is anchored in two complementary theories that explain the emotional and mental dimensions of learning. First, Albert Bandura's Social Cognitive Theory suggests that readiness is shaped by self-efficacy where a student's belief in their own ability to succeed. This confidence is built through past performance; students who excelled in Pre-Calculus carry higher motivation into Calculus, while those with a history of low achievement often experience a decline in the persistence needed for complex problem-solving. Complementing this is John Sweller's Cognitive Load Theory, which addresses the mental side of readiness. Sweller argues that when a student's foundational knowledge of limits, derivatives, or integration is shallow, their brain faces an "intrinsic overload" when encountering multi-step Calculus problems. This mental exhaustion blocks analytical reasoning and leads to errors, regardless of the student's general intelligence. Together, these theories suggest that readiness deficits are caused by specific knowledge gaps and a lack of academic confidence, rather than a lack of general ability.

Building on these foundations, the research paradigm evaluates how a student's Independent Variables including their age, sex, socioeconomic status, and grades in prerequisite math subjects influence their overall Mathematical Readiness. This readiness is measured across four key areas: conceptual understanding, analytical problem-solving, the ability to apply math to engineering scenarios, and the student's level of motivation. By treating Calculus challenges as a co-dependent factor, the framework determines if a student's profile predicts not only their performance but also the specific nature of their struggles.

Finally, this framework aligns with the legislative mandates of Republic Act No. 10533, which requires a smooth, learner-centered transition from high school to college. By identifying specific readiness gaps, this study provides the evidence-based foundation required by the ARAL Program Act (RA 12028). This law requires schools to establish functional support systems and intervention programs, ensuring that aspiring engineers in rural communities have a clear path to academic recovery and success.

The study used the IV-DV model to illustrate this association. This is a conceptual diagram that Figure 1 shows.

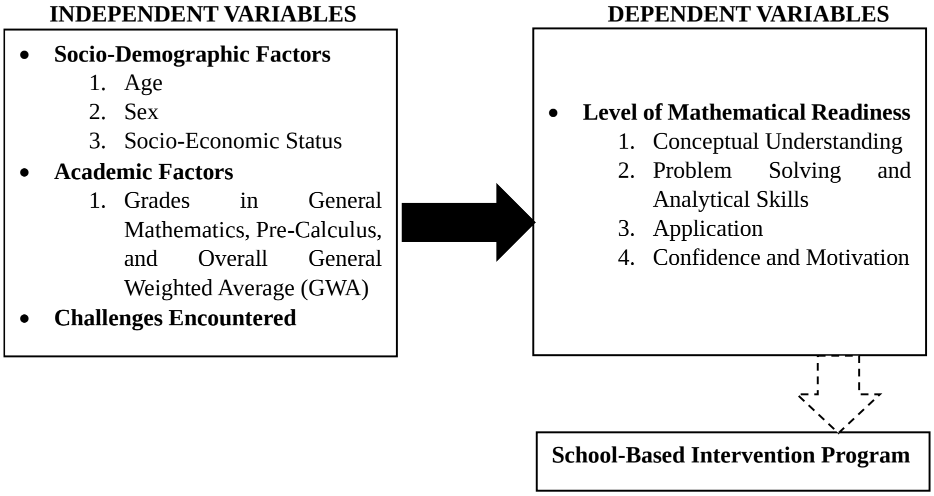

Figure 1. Paradigm of the study

Statement of the Problem

This study aimed to determine the level of mathematical readiness and the challenges encountered in Calculus of Grade 12 STEM students from selected senior high schools. Specifically, it sought to answer the following questions:

1. What is the profile of the respondents in terms of the following variables?
    a. Socio-demographic Profile
        a.1. Age
        a.2. Sex
        a.3. Socio-economic status
    b. Academic Profile
        b.1. Grades in General Mathematics, Pre-Calculus, and Calculus
        b.2. Overall academic performance (GWA)
2. What is the level of mathematical readiness of respondents in terms of:
    a. Conceptual understanding of Calculus concepts
    b. Problem-solving and analytical skills in Calculus
    c. Application of calculus to introductory engineering scenarios
    d. Confidence, motivation and attitude toward learning Calculus
3. What are the challenges and strategies do Grade 12 SHS STEM students encounter in learning Calculus?
4. Is there a significant difference between the mathematical readiness of the STEM learners when grouped according to profile?
5. Is there a significant relationship between the profile of the SHS STEM learners and their Challenges encountered in Calculus?
6. What intervention program can be developed based in the identified weaknesses in mathematical readiness particularly in Calculus and the challenges encountered by the respondents?

Literature Review

Mathematical Readiness Levels

In the Philippines, Grade 12 STEM non-health students express desire to pursue engineering but there is a gap between their aspirations and actual readiness for the field. Research shows many students struggle in Calculus because they have not mastered foundational Algebra (Barroso, 2020; Moreno et al., 2025). This lack of conceptual understanding, paired with poor analytical reasoning, makes it difficult for them to solve abstract problems or choose the right mathematical procedure (Barroso, 2020).

Mathematical readiness particularly in Calculus includes dimensions- conceptual understanding, problem solving and analytical skills, application of Calculus in engineering and confidence, motivation and attitude towards learning- important to the educational approach needed for success in engineering practice.

a. Conceptual Understanding

Conceptual understanding is one of the fundamental dimensions for readiness which includes grasping of basic concepts such as functions, algebra, and calculus is necessary, yet often lacking among first-year engineering students (DOST, 2021). Despite general knowledge of foundational mathematics, students often struggle with certain concepts in Calculus. Specifically, many students have a very hard time conceptualizing ideas of limits and continuity and its theoretical basis, which means they often think of limits as simply a matter of algebraic manipulation (Luna & Morales, 2018). It is also the same with using definite and indefinite integration to determine area or volume, or applying differentiation rules under challenging, multi-step challenges (PNU, 2022; Santos, 2020). This indicates a need for assessment that goes beyond procedural fluency.

b. Problem Solving and Analytical Skills

The mathematical readiness gap of Grade 12 STEM students often starts in relying on memorized formulas rather than analytical thinking. While students may excel in structured classrooms, they often struggle with Calculus problems that require logical leaps or multi-step modeling (Barroso, 2020). It is linked as shallow learning the pre-requisites like Geometry and Trigonometry. Without a deep understanding of these basics, students find it nearly impossible to visualize core Calculus concepts like rates of change (Moreno et al., 2025).

c. *Application of Calculus to Engineering*

Engineering requires the ability to turn real world physical constraints into math. Many students lack this skill because they haven't been exposed to enough context-based learning (Nolasco, 2025). As the problems get harder, this technical gap makes students become overwhelmed and often leads to a drop in confidence. This mental exhaustion creates a performance ceiling that can ultimately discourage them from pursuing engineering altogether (Moreno et al., 2025).

d. Confidence, Motivation, and Attitude towards Learning

Factors such as confidence, motivation and attitudes strongly linked to learning achievement, such positive attitudes toward mathematics significantly affect learning outcomes. Low confidence and math anxiety inhibit students' attitude towards work and persistence (Garcia and Dela Cruz, 2022).

The reviewed literature indicates that mathematical readiness among SHS STEM students is not merely a matter of prior content exposure but a more complex interaction of conceptual understanding, cognitive skills and affective factors. Although students often enter engineering programs with foundational mathematical knowledge, persistent difficulties in limits, continuity, differentiation, and integration suggest gaps in deep conceptual comprehension rather than procedural ability alone. Weak algebraic skills remain a critical barrier, reinforcing the cumulative nature of mathematical learning. There must be a deeper foundation of learning the basics in mathematics to have a good analytical skill. Overall, the literature suggests that improving mathematical readiness requires a holistic approach that strengthens conceptual foundations, addresses equity gaps, and supports students' cognitive and affective development.

Challenges Encountered in Calculus

Calculus transition is blocked by a procedural-conceptual gap. STEM students frequently treat derivatives and limits as mental rules to be memorized rather than tools to measure change (Barroso, 2020; De Lara & Santos, 2024). This makes it difficult for them to grasp the logic behind the Fundamental Theorem of Calculus or tell the difference between continuity and differentiability (Bautista & Reyes, 2026). Simple algebraic and arithmetic errors learning loss made the theoretical gaps worse. These basic mistakes disrupt more complex tasks like the chain, product, or quotient rules (Corpuz, 2023). Eventually, even when students understand the steps for integration or differentiation, a weak foundation in basic math remains the primary reason they get the wrong answer (Barroso, 2020).

For aspiring engineers, the biggest challenge is translating word problems into Calculus equations. While students are often good at solving equations, they struggle with optimization and related rates because they cannot connect abstract variables to physical reality (Nolasco, 2025). Researchers have noted that students find it difficult to interpret what a mathematical result actually means (De Lara & Santos, 2024). This gap shows that students learning calculus usually not thinking as they are engineers. They struggle to choose the right technique when faced with unfamiliar, complex scenarios (Villanueva, 2024; Bautista & Reyes, 2026).

The major challenge to student determination is emotional barriers. High math anxiety and low confidence are common among Grade 12 students, often made worse by the fast-paced STEM curriculum (Moreno et al., 2025). Instructional problems and limited resources make many students find teacher explanations hard to follow and feel they don't get enough feedback to fix their mistakes (Nolasco, 2025). Other factors also play a role such as limited study time, distractions, and poor self-study materials keep students from reaching the level needed for college engineering (Corpuz, 2023). In the end, this gap is a primary source of demotivation. Students struggle to find the relevance in complex operations, making it harder to stay engaged (Villanueva, 2024).

Socio-Demographic and Academic Factors of Mathematical Readiness

Educational mathematics readiness in engineering can be influence by socio-demographic characteristics including age, gender, socio-economic status, and academic history. Research found that students from higher social economic status backgrounds are better prepared for math due to better tutoring and resources (Villanueva et al., 2021). In contrast, this gap in learning was worsened among rural and low-SES students due to deficient infrastructures and support systems (Cordova, 2020).

Gender and academic history also play key roles. Male students report higher math confidence and achievement but this gap disappears in the right educational environment (Santos et al., 2022). High academic performance in Pre-Calculus and Calculus generally predict success in engineering (Garcia, 2021) however, grades alone do not tell the whole story. They often fail to measure a student's true conceptual understanding or problem-solving depth (Luna & Morales, 2018).

Overall, socio-demographic and academic variables highlight the essential for interventions made to students from different backgrounds in engineering education.

Effect of the K–12 STEM Curriculum on College Calculus Preparedness

The introduction of the K–12 Basic Education Curriculum was a major shift extending basic education to 12 years and introducing a specialized STEM track to strengthen math foundations (DepEd, 2016). The new curriculum has generally improved basic algebra and pre-calculus skills compared to the old system. However, these gains lack of conceptual depth and application skills required for college-level engineering.

Students who complete the STEM strand are consistently better prepared for engineering than their non-STEM peers (Dela Cruz and Santos, 2022). Reyes et al. (2020) curriculum mapping shows that the transition from senior high to university is improving however significant conceptual gaps remain.

Despite these reforms, the system still struggles with inconsistent teaching quality and a lack of resources (Mendoza, 2021). Findings from the Philippine Normal University (2022) reveal that many STEM graduates still cannot apply mathematical concepts to engineering problems, suggesting a need for better teaching methods. Many students still report low motivation and math anxiety (Garcia & Dela Cruz, 2022. This confirms that a student's emotional attitude toward math is just as important as the syllabus (Dominguez and Tolentino, 2019).

Conclusively, the K-12 reform must be supported by better teaching, stronger student motivation, and more consistent resources to be truly effective.

School Based Intervention for Mathematics Readiness

Traditional teaching strategy fails to bridge the learning gaps in advanced math like Calculus. To address this gap, schools are turning to Differentiated Instruction (DI). It makes learning more meaningful and caters to different student needs by using open questions, parallel tasks, and technology. This approach helps students connect what they already know to new, real-life situations, turning a "too complex" subject into something engaging (Insorio, 2024b).

Another powerful tool is collaborative learning. Math anxiety drops and students' confidence grows when they are solving problems together (Siller & Ahmad, 2024). Working in pairs or groups allows students to clarify tough solutions and exchange ideas in ways that solo study cannot (Barroso, 2020).

Digital interventions have also become vital. Internet based platforms like Facebook Messenger to deliver video lessons helped students cope when they couldn't talk to a teacher face-to-face during the distance learning (Insorio & Insorio, 2023).

However, any intervention success depends on the student's approach. Math anxiety fueled by the idea that math is difficult remains as a major barrier. To keep students from not giving up, support systems must use scaffolding and self-regulation techniques.

METHODS

Research Design

This study employed a quantitative descriptive-comparative-correlational research design to examine the mathematical readiness of Grade 12 STEM students. The descriptive component was used to present respondents' socio-demographic and academic characteristics and to assess their level of readiness in terms of conceptual understanding, problem-solving and analytical skills, application of Calculus in engineering contexts, and confidence, motivation, and attitudes toward learning Calculus. It also described the challenges encountered by students. The comparative component determined whether significant differences existed in mathematical readiness when respondents were grouped according to their socio-demographic and academic profiles. Meanwhile, the correlational component examined the degree and direction of the relationship between students' profiles and the challenges they encountered in learning Calculus, allowing the identification of significant associations among variables.

Locale of the Study

The study was conducted in four public secondary schools in Cagayan: Camalaniugan National High School (CNHS) in Dugo, Camalaniugan; Lal-lo National High School (LNHS) in Centro, Lal-lo; Magapit National High School (MNHS) in Magapit, Lal-lo; and Logac National High School (LoNHS) in Logac, Lal-lo. These institutions offer Senior High School programs, including the STEM strand with a focus on Engineering, and are committed to developing well-rounded, values-oriented learners aligned with national educational goals. These schools were selected as the locale of the study due to their substantial enrollment of STEM students and the expressed interest of their administrators and faculty in addressing issues related to students' readiness for college-level learning. Their inclusion provided an appropriate setting for examining pre-collegiate preparation among Grade 12 STEM learners.

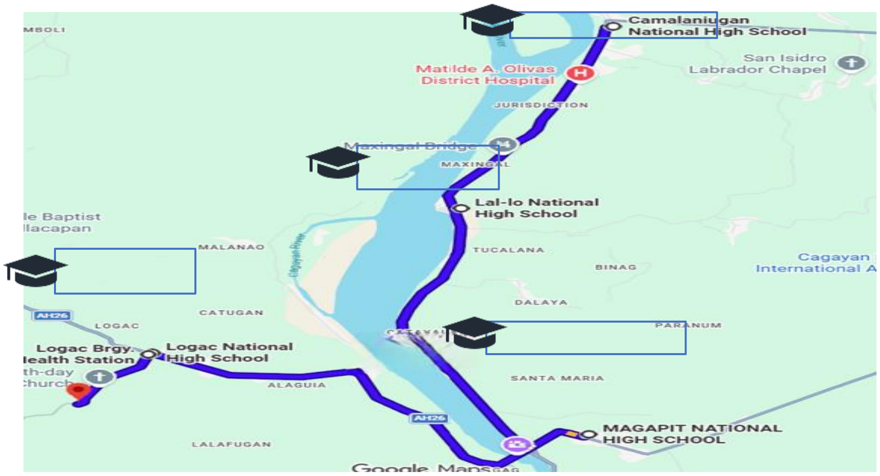

Figure 2. *Location Map*

Respondents and Sampling Technique

The respondents of the study were Grade 12 STEM students from the four selected public secondary schools who were officially enrolled for the School Year 2025–2026 and intended to pursue an engineering program at the tertiary level. This group was chosen as it represents students for whom mathematical readiness in Calculus is critical in preparation for college engineering education. Purposive sampling was employed to select participants who met specific criteria relevant to the study's objectives (Etikan et al., 2016). The inclusion criteria required that respondents: (1) be officially enrolled as Grade 12 STEM students in the identified schools; (2) have taken or be currently enrolled in Calculus; and (3) intend to pursue an engineering course. Students who did not meet these criteria, such as those from other strands, transferees, repeaters, or those with incomplete academic records, were excluded. This targeted selection ensured that the participants were directly aligned with the study's purpose, thereby enhancing the relevance and reliability of the data gathered for developing the proposed intervention program.

School	Population	Sample Size
CNHS	74	9
LNHS	177	35
MNHS	24	8
LoNHS	26	8

The researcher notes that the sample sizes for CNHS, LoNHS, and MNHS are relatively small due to the limited population of qualifying Grade 12 STEM students in those schools. All qualifying students in these smaller schools were included to maximize the usable data. For LNHS, where the population was substantially larger, the sample was drawn proportionally using systematic sampling within the purposively identified pool of eligible respondents.

Research Instruments

The study utilized a researcher-made instrument composed of four integrated parts, developed through content specification, item construction, expert validation, pilot testing, and reliability analysis (Fraenkel et al., 2019). Part I gathered respondents' socio-demographic and academic profile, including age, sex, family income, mathematics grades, general weighted average, and intention to pursue engineering. Part II was a Calculus Achievement Test measuring mathematical readiness in conceptual understanding, problem-solving, and application to engineering contexts. It consisted of 30 multiple-choice items covering Limits, Differentiation, and Integration, and 5 open-ended problems assessed using an analytic rubric adapted from NCTM (2014). Part III was a Mathematical Readiness Affective Scale with 30 items measuring confidence, motivation, and attitude toward Calculus using a five-point Likert scale. Reverse-coded items were included to control response bias (Paulhus, 1991). Part IV was a Calculus Challenges Checklist with 25 items across five domains: conceptual, procedural, application, affective/environmental, and instructional/resource challenges, rated on a four-point frequency scale. The instrument underwent expert validation and pilot testing, and reliability was established using Cronbach's alpha, with a target coefficient of at least 0.80 to ensure internal consistency.

Data Gathering Procedure

A systematic and ethical procedure was followed in the data collection process. The researcher first secured official permission from the administrations of CNHS, LNHS, MNHS, and LoNHS. Upon approval, an orientation was conducted to inform respondents about the study's purpose, voluntary participation, confidentiality, and their right to withdraw at any time. Informed consent was obtained prior to participation. The instrument was administered personally during regular class hours with the approval of subject teachers. The Calculus Achievement Test (Part II) was completed within 60 minutes, while Parts I, III, and IV were administered in a separate 30-minute session. All responses were collected on the same day, checked for completeness, and clarified immediately when necessary. The data were then organized, coded, and encoded for analysis, ensuring accuracy and reliability of the dataset.

Data Analysis

Once data has been collected, descriptive and inferential statistical methods were used to analyze them in accordance with the research questions and hypotheses of the study. For Research Question 1, which about on profiling the respondents, frequencies and percentages were used for categorical variables, while means and standard deviations were computed for continuous data. For Part II (Calculus Achievement Test), the level of mathematical readiness of respondents was determined using mean scores and score range classifications for each content dimension. The mean score per item was computed by dividing the total points earned by all respondents on a given item by the total number of respondents (N = 60). For subscale-level analysis, respondents were grouped into score ranges, and frequency distributions were generated. The descriptive levels and their corresponding score ranges for each dimension were established as follows:

Table A. *Score Range Interpretation for Section A: Conceptual Understanding of Calculus Concepts (Max = 10 points)*

Score Range	Descriptive Level	Interpretation
9 – 10	Excellent	The respondent demonstrates a thorough and accurate understanding of limits, continuity, and related theorems.
7 – 8	Proficient	The respondent demonstrates a solid understanding of most concepts with only minor gaps.
5 – 6	Approaching Proficiency	The respondent demonstrates partial understanding of Calculus concepts but with notable gaps.

3 – 4	Basic	The respondent demonstrates limited understanding and requires substantial remediation.
0 – 2	Below Basic	The respondent demonstrates little to no understanding of foundational Calculus concepts.

Table B. *Score Range Interpretation for Section B: Problem-Solving and Analytical Skills in Calculus (Max = 20 points)*

Score Range	Descriptive Level	Interpretation
18 – 20	Excellent	The respondent demonstrates mastery of differentiation and integration techniques and analytical reasoning.
14 – 17	Proficient	The respondent demonstrates competence in most problem-solving procedures with minor errors.
10 – 13	Approaching Proficiency	The respondent demonstrates partial competence with consistent procedural or conceptual errors.
5 – 9	Basic	The respondent demonstrates limited problem-solving ability and requires targeted intervention.
0 – 4	Below Basic	The respondent demonstrates serious deficiencies in analytical and procedural skills.

The level of mathematical readiness in terms of application of Calculus to introductory engineering scenarios (Part II, Section D, Items 31–35) was determined using the weighted mean and standard deviation of the rubric scores assigned to each problem-solving item. Each item was scored using a five-level analytic rubric with score values of 0, 1, 2, 3, and 4 for four-point items (Items 31–33) and 0, 1, 2, and 3 for three-point items (Items 34–35), corresponding to No Credit, Minimal Credit, Partial Credit (Major Error), Partial Credit (Minor Error), and Full Credit, respectively. The weighted mean per item was computed as: $WM = \Sigma(f \cdot x) / N$ where WM is the weighted mean rubric score, f is the frequency of respondents who received each rubric score, x is the rubric score value (0–4 or 0–3), and N = 60. The standard deviation (SD) was computed to measure the dispersion of rubric scores around the mean, using the formula: $SD = \sqrt{[\Sigma f(x - WM)^2 / N]}$.

The descriptive level of each item was determined by computing the proportion of the weighted mean to the item's maximum rubric score (WM ÷ max), and interpreting this proportion against the rubric-based scale presented in Table C. This approach ensures that items with different maximum scores (3 or 4 points) are interpreted on a comparable proportional basis, consistent with the recommendations of Nitko and Brookhart (2011) for rubric-based performance assessment.

Table C. *Rubric Score Interpretation Scale for Section D: Application of Calculus to Introductory Engineering Scenarios*

WM Proportion (WM ÷ Max Score)	Descriptive Level	Rubric Score Label	Interpretation
0.81 – 1.00	Full Credit	4 / 3	Correct setup, complete solution, correct final answer, and accurate engineering interpretation.
0.61 – 0.80	Partial Credit (Minor)	3 / 2	Correct approach with minor computational error, or correct answer without sufficient working.
0.41 – 0.60	Partial Credit (Major)	2 / 1	Some correct steps but significant conceptual or procedural error; final answer incorrect.
0.11 – 0.40	Minimal Credit	1	Relevant formula or concept identified but incorrectly applied; minimal work shown.

0.00 – 0.10	No Credit	0	No work shown, completely incorrect, or item left blank.

The level of mathematical readiness of the respondents in terms of confidence, motivation, and attitude toward learning Calculus (SOP Q2d) was determined using the weighted mean of each item and subscale in Part III. The following scale was used to interpret the computed weighted means, adapted from the five-point Likert scale interpretation framework recommended by Likert (1932) as operationalized in educational research:

Table D. *Weighted Mean Interpretation Scale for the Mathematical Readiness Affective Scale (Part III)*

Mean Range	Descriptive Value	Interpretation
4.21 – 5.00	Very High	The respondents consistently and strongly agree with the statement, indicating a very high level of confidence, motivation, or positive attitude toward Calculus.
3.41 – 4.20	High	The respondents generally agree with the statement, indicating a high level of affective readiness for learning Calculus.
2.61 – 3.40	Moderate	The respondents are neither clearly agreeable nor disagreeable, indicating a moderate or uncertain level of affective readiness.
1.81 – 2.60	Low	The respondents generally disagree with the statement, indicating a low level of confidence, motivation, or positive attitude.
1.00 – 1.80	Very Low	The respondents strongly and consistently disagree with the statement, indicating a very low level of affective readiness for Calculus.

The overall affective readiness score, computed as the sum of all thirty (30) item scores after reverse-scoring applicable items, was interpreted using the following total score ranges: 127–150 = Very High; 103–126 = High; 79–102 = Moderate; 55–78 = Low; 30–54 = Very Low.

The frequency and nature of challenges encountered by the respondents in learning Calculus were determined using the weighted mean of each item and subscale in Part IV. The following scale was used to interpret the computed weighted means based on the four-point frequency scale employed in the checklist:

Table E. *Weighted Mean Interpretation Scale for the Calculus Challenges Checklist (Part IV)*

Mean Range	Descriptive Value	Interpretation
3.26 – 4.00	Always	The respondents consistently experience the described challenge in learning Calculus, indicating a pervasive and critical difficulty that requires immediate attention.
2.51 – 3.25	Often	The respondents frequently experience the described challenge, indicating a recurring difficulty that significantly affects their Calculus learning.
1.76 –2.50	Sometimes	The respondents occasionally experience the described challenge, indicating a moderate difficulty that may intermittently affect their performance.
1.00 – 1.75	Never	The respondents rarely or never experience the described challenge, indicating that this area does not significantly impede their learning of Calculus.

To determine the significant relationship between the respondents' profile variables and their level of mathematical readiness and challenges in Calculus, the following inferential statistical tools were used. Pearson's product-moment correlation coefficient (r) was used to determine the relationship between continuous profile variables and the achievement test scores and affective scale scores, where data satisfied the assumptions of normality and linearity. Spearman's rank-order correlation coefficient (ρ) was used as a non-parametric alternative when the data did not meet the assumptions required for Pearson's r. The one-way Analysis of Variance (ANOVA) was employed to test for significant differences in the level of mathematical readiness across groups defined by categorical profile variables (e.g., sex, socio-economic status, intended engineering course). Post-hoc comparisons using Tukey's Honestly Significant Difference (HSD) test were conducted when the ANOVA yielded a significant F-ratio. All inferential tests were evaluated at a 0.05 level of significance. All statistical computations were performed using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS).

Ethical Consideration

Ethical principles were followed throughout the conduct of the study. All participants were informed of the study's objectives, procedures, and their rights as research subjects. Participation was completely voluntary, and respondents had the right to refuse or withdraw from the study without consequence. An informed consent form was provided, ensuring participants are aware of how their data will be handled and used solely for academic purposes.

For confidentiality and anonymity, it was ensured that identifying information will not be included in both data records and research outputs. All collected data were stored securely and accessible only to the researcher and authorized faculty supervisors. Research data will be retained for a period of three (3) years following the completion of the study. After the retention period, all physical data will be shredded and disposed of securely. Digital data will be permanently deleted from all storage devices using secure deletion methods that overwrite the data to prevent recovery. Prior to the start of data collection, the study sought and obtained ethical clearance from the university's Institutional Research Ethics Committee.

RESULTS AND DISCUSSION

Student's Profile Variables

Table 1. *Frequency and Percentage Distribution of the students in terms of profile variables*

Profile Variables		Frequency (n=60)	Percentage
I. Socio-Demographic Profile			
Age	20	1	1.67
	18	23	38.33
	17	36	60
Mean = 17.43	*SD = 0.59*		
Sex	Male	39	65
	Female	21	35
Socio-Economic Status	40,001 and above	11	18.33
	30,001-40,000	1	1.67
	20,001-30,000	7	11.67
	10,001-20,000	14	23.33
	10,000 and below	27	45
Mean = 27, 900	*SD = 40, 442. 76*		
II. Academic Profile			
Grades in General Mathematics	96-99	6	10
	92-95	17	28.33
	88-91	15	25
	84-87	18	30
	Below 84	4	6.67
Mean = 89.62	*SD = 4.57*		
Grades in Pre-Calculus	96-99	4	6.67

	92-95	13	21.67
	88-91	16	26.67
	84-87	19	31.67
	Below 84	8	13.32
Mean = 88.45 *SD = 4.7*			
Grades in Calculus	96-99	4	6.67
	92-95	16	26.67
	88-91	13	21.67
	84-87	17	28.32
	Below 84	10	16.67
Mean = 88.57 *SD = 4.75*			
Overall General Weighted Average (GWA)	96-99	7	11.67
	92-95	22	36.67
	88-91	20	33.33
	84-87	9	15
	Below 84	2	3.33
Mean = 91.12 *SD = 3.71*			

The data in Table 1 shows the socio-demographic and academic profile. The socio-demographic profile reveals that the highest proportion of respondents were 17 years old (60 percent), while the lowest was 20 years old (1.67 percent), with a mean age of 17.43 (SD = 0.59). The low standard deviation indicates that the ages are closely clustered around the mean. In terms of sex, male students (65 percent) represent the highest proportion, while female students (35 percent) comprise the lowest. Although no mean is computed for this variable, the disparity indicates an imbalance in STEM participation. A more pronounced disparity is observed in socio-economic status, where the highest proportion of students belong to the ₱10,000 and below income group (45 percent), while the lowest is ₱30,001–40,000 (1.67 percent). The reported mean income of ₱27,900 with a very large SD of 40,442.76 indicates high variability and possible skewness in the data.

The academic profile shows that the highest proportion of students falls within the 84–87 range (30 percent), while the lowest is below 84 (6.67 percent), with a mean of 89.62 (SD = 4.57). The relatively small standard deviation indicates that most students' grades are clustered near the mean, reflecting generally consistent performance in General Mathematics. This pattern shifts in Pre-Calculus, where the highest group remains at 84–87 (31.67 percent), but the lowest category (below 84) increases to 13.32 percent, with a slightly lower mean of 88.45 (SD = 4.70). There is a slight decrease of mean but with similar spread of scores. The trend becomes more evident in Calculus, where the highest proportion slightly decreases to 28.32 percent (84–87), while the lowest (below 84) further increases to 16.67 percent. The mean grade of 88.57 (SD = 4.75) remains close to that of Pre-Calculus, but with increasing proportion of low-performing students. Interestingly, when examining the overall General Weighted Average (GWA), the highest proportion of students falls within 92–95 (36.67 percent), while only 3.33 percent are below 84, with a relatively high mean of 91.12 (SD = 3.71). The lower standard deviation suggests that students' overall academic performance is consistently high. However, this contrasts with the increasing number of low-performing students in calculus.

Student's Level of Mathematical Readiness

a. Conceptual Understanding of Calculus

Table 2a. *Students' Level of Mathematical Readiness in terms of Conceptual Understanding of Calculus*

Conceptual Understanding of Calculus	Frequency (n=60)	Percentage
9 – 10 (Excellent)	8	13.33
7 – 8 (Proficient)	18	30.00
5 – 6 (Approaching Proficiency)	22	36.67
3 – 4 (Basic)	9	15.00
0 – 2 (Below Basic)	3	5.00
Weighted mean	*6.11*	*Approaching*
S.D.	2.14	*Proficiency*

The data presented in Table 2a show that the respondents obtained an overall weighted mean of 6.11 out of 10 points with a standard deviation of 2.14, placing the group at the Approaching Proficiency level in terms of conceptual understanding of Calculus concepts.

As shown, the Approaching Proficiency level (scores 5–6) recorded the highest frequency, with 22 students or 36.67 percent of the respondents falling within this band. This suggests that the students can handle familiar and straightforward problems. Meanwhile, the *Below Basic* level (scores 0–2) recorded the lowest frequency, with only 3 students or 5.00% of the respondents falling within this range. These students demonstrated near-total unfamiliarity with the foundational concepts.

Research reveals that students' difficulties in Calculus STEM from factors such as the abstract nature of the subject, inadequate foundational knowledge in prerequisite topics such as functions and algebra, and ineffective instructional strategies that do not engage students in meaningful learning experiences (Auxtero & Callaman, 2020, as cited in Nuñez et al., 2023). Furthermore, Perante (2022) found that most K-12 graduates were not mathematically college-ready, with only 43% of incoming first-year college engineering students demonstrating sufficient mathematical preparation for higher mathematics in college. Hence, the students in the *Below Basic* category in this study represent a particularly vulnerable subgroup who, without immediate and targeted intervention, face a high risk of failure in college-level engineering Calculus.

b. Problem-Solving and Analytical Skills in Calculus

Table 2b. *Students' Level of Mathematical Readiness in terms of Problem-Solving and Analytical Skills in Calculus*

Problem-Solving and Analytical Skills in Calculus	Frequency (n=60)	Percentage
18 – 20 (Excellent)	5	8.33
14 – 17 (Proficient)	14	23.33
10 – 13 (Approaching Proficiency)	25	41.67
5 – 9 (Basic)	13	21.67
0 – 4 (Below Basic)	3	5.00
Weighted mean	*11.61*	*Approaching*
S.D.	*4.16*	*Proficiency*

The data presented in Table 2b reveal that the respondents obtained an overall weighted mean of 11.61 out of points with a standard deviation of 4.16, placing the group at the Approaching Proficiency level in terms of problem-solving and analytical skills in Calculus. As shown, the Approaching Proficiency level (scores 10–13) recorded the highest frequency, with 25 students or 41.67 percent of respondents, the largest concentration across all score ranges. This suggests that most Grade 12 STEM students in the selected schools could perform routine differentiation and integration procedures on familiar problem types but encountered persistent difficulty when items required higher-order analytical reasoning. Meanwhile, the *Below Basic* level (scores 0–4) recorded the lowest frequency, with only 3 students or 5.00 percent of respondents. Despite being the smallest group numerically, these students demonstrated critically deficient problem-solving skills. The large SD of 4.16 confirms that these students are statistical outliers whose performance departs dramatically from the group mean, representing a subgroup whose mathematical readiness for college-level engineering Calculus is severely compromised.

Generally, the concentration of 41.67 percent of respondents at the Approaching Proficiency level, combined with the wide SD of 4.16 and the 5.00 percent Below Basic cluster, reveals a class whose problem-solving readiness is fragile and highly variable. Sulistyaningsih et al. (2025) found that students with higher prior mathematical knowledge were significantly better able to formulate mathematical models and complete the problem-solving process in differential Calculus, while students with weaker foundations consistently failed at the problem identification and formulation stages.

c. Application of Calculus to Introductory Engineering Scenarios

Table 2c. *Students' Level of Mathematical Readiness in terms of Application of Calculus to Introductory Engineering Scenarios*

Application of Calculus to Introductory Engineering Scenarios	Frequency (n=60)	Percentage
Optimization — Rectangular water tank: minimize surface area S; state the engineering significance.		
Full Credit	8	13.33
Partial (Minor)	17	28.33
Partial (Major)	22	36.67
Minimal Credit	12	20
No Credit	4	6.67
Mean	*2.17*	*Partial Credit (Major)*
S.D.	*1.10*	
Differentiation — Temperature of metal rod $T(x) = 5x^2 - 3x + 2$: rate of change at $x = 2$, minimum position, and engineering interpretation.		
Full Credit	10	16.67
Partial (Minor)	16	26.67
Partial (Major)	20	33.33
Minimal Credit	10	16.67
No Credit	4	6.67
Mean	*2.30*	*Partial Credit (Major)*
S.D.	*1.13*	
Integration — Pipeline arc length $y = x^3$: set up integral, estimate using Trapezoidal Rule ($n = 4$), explain engineering relevance.		
Full Credit	5	8.333
Partial (Minor)	10	16.67
Partial (Major)	22	36.67
Minimal Credit	16	26.67
No Credit	7	11.67
Mean	*1.83*	*Partial Credit (Major)*
S.D.	*1.10*	
Integration — Velocity $v(t) = 6t^2 - 4t$: displacement and total distance traveled from $t = 1$ to $t = 3$; engineering distinction.		
Full Credit	0	0
Partial (Minor)	9	15
Partial (Major)	18	30
Minimal Credit	24	40
No Credit	9	15

Mean	*1.45*	*Partial Credit (Major)*
S.D.	*0.92*	
Integration — Drainage canal $A(x) = 4 - x^2$: total cross-sectional area, volumetric flow rate, engineering significance.		
Full Credit	0	0
Partial (Minor)	11	18.33
Partial (Major)	20	33.33
Minimal Credit	22	36.67
No Credit	7	11.67
Mean	*1.58*	*Partial Credit (Major)*
S.D.	*0.92*	
Overall Weighted mean	*1.87*	*Partial Credit (Major)*
S.D.	*1.03*	

The data presented in Table 2c reveal that the respondents obtained an overall weighted mean of 1.87 out of a maximum rubric score with a standard deviation of 1.03, placing the group at the Partial Credit (Major) level across all five problem-solving items. Among the five problem-solving items, the differentiation problem involving the temperature of a metal rod $T(x) = 5x^2 - 3x + 2$ — obtained the highest mean score of 2.30 with an SD of 1.13, placing it at the Partial Credit (Major) level. Notably, 10 students or 16.67 earned *Full Credit* on this item, and 16 students or 26.67 earned *Partial Credit (Minor)*, together representing 43.34 who demonstrated at least a reasonably competent approach to the problem. This relatively stronger performance on this compared to the other items may be attributed to the fact that it builds directly on standard differentiation procedures specifically finding the derivative and setting it equal to zero which are among the most frequently practiced skills in Senior High School Applied Calculus. At the opposite end, the item on the integration problem requiring respondents to find the displacement and total distance traveled given the velocity function $v(t) = 6t^2 - 4t$, and to articulate the engineering distinction between the two recorded the lowest mean score of 1.45 with an SD of 0.92, placing it solidly at the Partial Credit (Major) level. Critically, not a single respondent among the 60 earned Full Credit on this item (0.00 percent), and only 9 students or 15.00 earned Partial Credit (Minor). The majority, 24 students or 40.00 earned only Minimal Credit, indicating that they could identify a relevant formula or concept but could not apply it correctly. An additional 9 students or 15.00 received No Credit. Similarly, the item involving the cross-sectional area of a drainage canal and volumetric flow rate recorded the second lowest mean of 1.58 (SD = 0.92), with no student earning *Full Credit* (0.00) and the majority (36.67) earning only *Minimal Credit*. These results collectively underscore the severe difficulty that Grade 12 STEM students in the selected schools experience when required to apply integration concepts to engineering contexts involving physical meaning and professional interpretation.

The overall weighted mean of 1.87 across all five items, combined with the complete absence of *Full Credit* responses in Items 4 and 5 and only 13.33 and 16.67 *Full Credit* rates in Items 41 and 42 respectively, reveals a critical gap between what students can do procedurally in Calculus and what they are expected to do analytically in engineering-contextualized problems. Kartinah et al. (2021), as cited in Nuñez et al. (2023), found that while students can apply lessons they already know to familiar situations, they consistently lack the knowledge necessary to solve unfamiliar or applied problems — a cognitive obstacle that is particularly acute in engineering-contextualized Calculus tasks. Furthermore, Malusay et al. (2024) found that strengthening teachers' Technological Pedagogical Content Knowledge (TPACK) in selected Calculus topics through professional development programs significantly improved instructional quality in Senior High School STEM Calculus in the Philippines, suggesting that teacher competency in delivering contextualized engineering applications is a critical lever for improving student outcomes in this domain.

d. Confidence, Motivation, and Attitude toward Learning Calculus

Table 2d. *Students' Level of Mathematical Readiness in terms of Confidence, Motivation, and Attitude toward Learning Calculus*

Statements	Weighted Mean	Descriptive Value
A. Confidence in Calculus		
1. I am confident that I can solve basic Calculus problems independently.	3.48	High
2. I believe my mathematics background is sufficient for Calculus.	3.35	Moderate
3. I persist and do not give up when I face a difficult Calculus problem.	3.60	High
4. I feel prepared to take Calculus-based subjects in college.	3.27	Moderate
5. I trust that I can understand new Calculus topics with sufficient practice.	3.75	High
6. When I struggle in Calculus, I believe I can improve with more effort.	3.98	High
7. I can explain a Calculus concept clearly to a classmate.	3.08	Moderate
8. I do not believe I have the ability to pass a Calculus course in college. *(R)	3.50	High
9. I feel overwhelmed and helpless when I encounter unfamiliar Calculus problems. *(R)	3.30	Moderate
10. I am confident in applying Calculus concepts to solve real engineering problems.	3.37	Moderate
Category Mean	*3.47*	*High*
B. Motivation toward Learning Calculus		
11. I study Calculus because I see its direct value in engineering.	3.80	High
12. I go beyond required lessons to deepen my understanding of Calculus.	3.15	Moderate
13. I enjoy discovering how Calculus applies to real engineering problems.	3.43	High
14. I set personal goals to improve my Calculus performance.	3.60	High
15. Solving a challenging Calculus problem makes me feel accomplished.	3.72	High
16. I seek additional resources (videos, books, tutors) when I struggle.	3.33	Moderate
17. I look forward to learning more advanced Calculus topics in college.	3.43	High
18. I find no reason to study Calculus beyond what is required in class. *(R)	3.62	High
19. I give up easily when a Calculus topic becomes difficult to understand. *(R)	3.58	High
20. I am willing to spend extra time practicing Calculus to improve my performance.	3.65	High
Category Mean	*3.53*	*High*
C. Attitude toward Learning Calculus		
21. I believe Calculus is an important subject for engineering students.	4.13	High
22. I think studying Calculus is worth the effort it demands.	3.92	High
23. I approach difficult Calculus topics with a positive attitude.	3.52	High
24. I value the logical reasoning that studying Calculus develops in me.	3.87	High

25. My Calculus performance reflects my effort, not just my natural ability.	3.72	High
26. My teachers have adequately prepared me for the demands of Calculus.	3.47	High
27. I do not feel anxious about encountering Calculus in college. *(R)	3.27	Moderate
28. I think Calculus is unnecessarily difficult and not useful in real life. *(R)	3.68	High
29. I believe I can develop a strong understanding of Calculus if I study consistently.	3.85	High
30. I feel that learning Calculus contributes positively to my overall intellectual growth.	3.75	High
Category Mean	*3.72*	*High*
Overall Weighted Mean	3.57	High

The data presented in Table 2d reveal that the respondents obtained an overall weighted mean of 3.57, placing the group at the High level of affective readiness in terms of confidence, motivation, and attitude toward learning Calculus. Across the entire instrument, item 21 — "I believe Calculus is an important subject for engineering students" under Attitude toward Learning Calculus, obtained the highest weighted mean at 4.13, interpreted as High and approaching Very High. This near-ceiling response reflects a near-universal recognition among the respondents that Calculus is not merely an academic requirement but a foundational tool for their intended engineering profession. On the other end, the item "I go beyond required lessons to deepen my understanding of Calculus" recorded the lowest weighted mean in this subscale at 3.15, interpreted as only Moderate. The moderate rating reflects a common pattern among students in public senior high schools in the Philippines, where limited time, scarce learning resources, unstable internet access, and competing academic and household responsibilities constrain the capacity for self-directed study. Macaso and Dagohoy (2022) confirmed that positive attitudes, confidence, enjoyment, and valuing mathematics are strong predictors of achievement among Filipino senior high school students but these affective factors must be supported by accessible learning resources and enabling instructional environments to produce meaningful performance outcomes.

The overall weighted mean of 3.57 (High) across all three subscales is an encouraging finding that signals a strong affective foundation for Calculus learning among the respondents. However, the divergence between this high affective readiness and the Approaching Proficiency or Partial Credit cognitive performance documented in Tables 2a, 2b, and 2c underscores a critical insight: positive attitudes, strong motivation, and growth mindset beliefs are necessary but not sufficient conditions for Calculus achievement. Domondon et al. (2022) identified the causes of difficulty in Basic Calculus as limited conceptual understanding, confusion with formulas and processes, and a lack of time and confidence suggesting that even students who express high motivation and positive attitudes may remain academically at risk if the instructional support they receive does not adequately address their conceptual gaps.

Students’ Challenges Encountered in Calculus

Table 3. *Students’ Challenges Encountered in Calculus*

Statements	Weighted Mean	Descriptive Value
A. Conceptual Challenges		
1. I struggle to understand the formal definition of a limit.	2.53	Often
2. I confuse continuity with differentiability.	2.67	Often
3. I cannot visualize what a derivative represents geometrically.	2.77	Often
4. I find it hard to connect integration to area and accumulation.	2.65	Often

5. I do not fully understand why the Fundamental Theorem of Calculus works.	2.78	Often
Category Mean	*2.68*	*Often*
B. Procedural Challenges		
6. I make frequent errors applying differentiation rules (chain, product, quotient).	2.82	Often
7. I find integration techniques (substitution, integration by parts) difficult.	2.95	Often
8. I struggle to set up and evaluate definite integrals correctly.	2.80	Often
9. Implicit differentiation is confusing to me.	2.88	Often
10. Algebraic or arithmetic errors consistently lead me to incorrect Calculus answers.	2.87	Often
Category Mean	*2.86*	*Often*
C. Application Challenges		
11. I cannot translate word problems into Calculus equations.	2.82	Often
12. Optimization and related rates problems are difficult for me.	2.97	Often
13. I struggle to apply Calculus concepts to engineering or science contexts.	2.92	Often
14. I do not know which Calculus technique to use in an unfamiliar problem.	2.98	Often
15. I have difficulty interpreting the physical or engineering meaning of my Calculus answers.	2.90	Often
Category Mean	*2.92*	*Often*
D. Affective and Environmental Challenges		
16. I feel anxious or nervous during Calculus exams or recitations.	2.95	Often
17. I lack confidence in my ability to succeed in Calculus.	2.77	Often
18. I do not have access to adequate review materials or references for Calculus.	2.53	Often
19. The pace of instruction is too fast for me to understand each Calculus topic fully.	2.85	Often
20. I have limited time to study and practice Calculus outside of class.	3.00	Often
Category Mean	*2.82*	*Often*
E. Instructional and Resource Challenges		
21. My teacher's explanations are difficult to follow or understand.	2.43	Sometimes
22. I do not receive timely or helpful feedback on my Calculus work.	2.60	Often
23. The Calculus learning materials provided are insufficient for self-study.	2.67	Often
24. Distractions in my learning environment make it hard to focus on Calculus.	2.77	Often
25. I struggle to connect what I learn in class to how Calculus is used in engineering.	2.85	Often
Category Mean	*2.66*	*Often*
Overall Weighted Mean	2.79	Often

The data presented in Table 3 reveal that the respondents experienced an overall weighted mean of 2.79, interpreted as *Often*, across all five subscales of the Calculus Challenges Checklist. Along Affective and Environmental Challenges**,** Item 20 — *"I have limited time to study and practice Calculus outside of class"* recorded the highest weighted mean at 3.00, interpreted as *Often* and the highest score in this entire scale. For students in public senior high schools in Camalaniugan and Lallo, Cagayan, limited study time is not merely an academic issue but a socio-economic one, many students commute long distances to school, assist with household responsibilities, and lack the financial resources for tutoring or supplementary instruction. This finding directly contextualizes the moderate self-directed learning behavior observed in

Table 2d, Item 12, where students expressed limited willingness to study beyond required lessons are not necessarily due to lack of motivation but due to structural time constraints. In contrast, Item 21 — *"My teacher's explanations are difficult to follow or understand"* recorded the lowest weighted mean in across the entire instrument at 2.43, the only item falling in the *Sometimes* range. This comparatively favorable rating for teacher clarity suggests that the respondents generally find their Calculus teachers' explanations accessible and comprehensible, even if the pace of instruction (Item 19, WM = 2.85) and the connection to engineering contexts (Item 25) remain challenges. This is an important shade: the problem is not primarily with how teachers explain Calculus, but with how the curriculum and instructional pacing structure the learning experience. Malusay et al. (2024) found that enhancing teachers' TPACK in selected Calculus topics through professional development programs significantly improved instructional quality in Senior High School STEM Calculus in the Philippines, highlighting teacher knowledge development — particularly in connecting Calculus to technological and engineering contexts — as a critical lever for bridging the instructional gap identified in Item 25 of the present study.

The overall weighted mean of 2.79 (*Often*) across all five subscales, with Application Challenges recording the highest category mean (2.92) and Instructional and Resource Challenges recording the lowest (2.66), reveals a clear hierarchy of difficulty among the respondents. The convergence of frequently reported application challenges with the near-zero *Full Credit* rates in Table 2c confirms that the inability to apply Calculus to engineering contexts is both the most frequently experienced challenge and the most consequential performance gap.

Comparison between the mathematical readiness of the STEM students when grouped according to profile

Table 4. *Comparison between the mathematical readiness of the STEM students when grouped according to profile*

Profile Variables	*Mathematical Readiness*		
	f-value	P-value	Statistical Inference
Age	3.468	0.038	Significant*
Sex	1.774	0.189	Not Significant
Socio-economic status	0.512	0.727	Not Significant
Grades in General Mathematics	85.389	< .001	Significant*
Grades in Pre-Calculus	61.275	< .001	Significant*
Grades in Calculus	125.133	< .001	Significant*
Overall General Weighted Average	38.005	< .001	Significant*

The data presented in Table 4 reveal that among the seven profile variables examined, five yielded statistically significant differences in mathematical readiness: age, grades in General Mathematics, Pre-Calculus, Calculus, and overall academic performance or GWA.

As shown, a significant difference in mathematical readiness was found among respondents when grouped according to age (F = 3.468, p = 0.038). Turkey HSD post hoc comparisons reveals that 18-year-old respondents were significantly higher ready over 17-year-old. This gap likely stems from the additional year of cognitive maturation within the K-12 curriculum. Eighteen-year-old STEM students typically process advanced math at a more deliberate pace than younger, accelerated peers. This aligns with the K-12 framework's sequential design and supports findings by *Pursuing STEM Careers (2023)*, which identified age as a consistent differentiator in academic experience among Filipino learners. Consequently, schools should not assume uniform readiness across different age cohorts within the same grade.

More so, a highly significant difference in mathematical readiness was found when respondents were grouped according to their grade in General Mathematics, Pre-Calculus, Calculus and GWA. Turkey HSD post hoc comparisons shows that Pre-Calculus grade proved to be one strongest influencer in mathematical readiness having all 10 pairwise to be statistically significant. This implies that Pre-Calculus plays a critical role in the STEM strand. As Padernal and Diego (2020) and Hurdle and Mogilski (2022) suggest, Pre-Calculus is a direct and measurable predictor of Calculus success. Mastery at this level creates a distinct advantage that persists across all performance tiers. Similarly, the GWA also significantly influences readiness but the Turkey HSD post hoc comparisons shows that 8 out of 10 (lowest) reach significance. This suggests that while high academic engagement across all subjects correlates with math success, a general academic deficit at the lower end creates a uniform lack of readiness. This aligns with Philippine research identifying prior GPA as a reliable forecast of future mathematical retention.

Correlation between the profile of the SHS STEM learners and their Challenges encountered in Calculus and Mathematical Readiness

Table 5a. *Correlation between the profile of the SHS STEM learners and their Challenges encountered in Calculus*

Profile Variables	*Challenges Encountered*		
	r-value	P-value	Statistical Inference
Age	0.041	0.755	Not Significant
Sex	-0.134	0.307	Not Significant
Socio-economic status	0.033	0.804	Not Significant
Grades in General Mathematics	0.012	0.928	Not Significant
Grades in Pre-Calculus	0.061	0.642	Not Significant
Grades in Calculus	0.027	0.836	Not Significant
Overall academic performance in Math	0.023	0.863	Not Significant

*Tested at 0.05 level of significance using Pearson-r.
*N. S -Not Significant; S-Significant; H.S-Highly Significant; S.I-Statistical Inference

Table 5a reveal that none of the seven profile variables including age, sex, socio-economic status, grades in General Mathematics, grades in Pre-Calculus, grades in Calculus, and overall academic performance showed a statistically significant correlation with the challenges encountered by the respondents in learning Calculus. All r-values were negligible in magnitude, and all corresponding p-values exceeded the 0.05 level of significance. The absence of any significant correlation across all profile variables with Calculus challenges strongly suggests that the difficulties encountered in learning Calculus whether conceptual, procedural, application-based, or affective are not confined to any particular subgroup of learners. Rogayan et al. (2021), in a qualitative study of Filipino Senior High School STEM students, found that challenges in STEM learning were experienced broadly across the student population regardless of background, driven primarily by subject complexity, high workload, and teacher expectations rather than by individual demographic characteristics. The present findings extend this conclusion to the domain of Calculus specifically, affirming that the challenges of learning Calculus in the selected schools are a shared and collective experience across all learner profiles.

Table 5b. *Correlation between the profile of the SHS STEM students and their Mathematical Readiness*

Profile Variables	*Conceptual understanding of Calculus concepts*			*Problem-solving and analytical skills in Calculus*			*Application of calculus to introductory engineering scenarios*			*Confidence, motivation and attitude toward learning Calculus*		
	r	**P**	**S.I**	**r**	**P**	**S.I**	**r**	**P**	**S.I**	**r**	**P**	**S.I**
Age	-0.034	0.795	N.S	0.038	0.771	N.S	0.095	0.468	N.S	-0.022	0.870	N.S
Sex	-0.204	0.118	N.S	-0.198	0.129	N.S	-0.127	0.335	N.S	-0.154	0.241	N.S
Socio-economic status	-0.143	0.277	N.S	-0.089	0.500	N.S	-0.165	0.207	N.S	-0.080	0.543	N.S
Grades in General Mathematics	***.307****	***0.017***	***S***	0.156	0.235	N.S	0.15	0.254	N.S	***.391*****	***0.002***	***H.S***
Grades in Pre-Calculus	***.294****	***0.023***	***S***	0.168	0.199	N.S	0.084	0.523	N.S	***.344*****	***0.007***	***H.S***
Grades in Calculus	***.363*****	***0.004***	***H.S***	0.203	0.120	N.S	0.233	0.073	N.S	***.369*****	***0.004***	***H.S***
Overall academic performance in Math	***.365*****	***0.004***	***H.S***	0.240	0.064	N.S	0.233	0.073	N.S	***.433*****	***0.001***	***H.S***

The data presented in Table 5b reveal a differentiated and theoretically coherent pattern of correlations between the respondents' profile variables and their mathematical readiness across four dimensions: conceptual understanding of Calculus concepts, problem-solving and analytical skills, application of Calculus to introductory engineering scenarios, and confidence, motivation, and attitude toward learning Calculus. The socio-demographic variables including age, sex, and socio-economic status yielded uniformly non-significant correlations with all four readiness dimensions. In contrast, the four academic profile variables grade in General Mathematics, Pre-Calculus, Calculus, and GWA produced a specific and meaningful pattern of significant correlations, particularly with conceptual understanding and affective readiness.

The significant correlation between academic grades and conceptual understanding is theoretically expected. Students who built stronger conceptual foundations in these prerequisite subjects are better equipped to construct meaningful understanding of new Calculus concepts rather than relying on memory-based procedures. Abocejo and Cabuquin (2023) found a positive and highly significant correlation between mathematics performance and academic achievement for Filipino high school students, establishing that high performance in mathematics is closely linked to overall academic competence and the ability to engage meaningfully with more advanced mathematical concepts. Similarly, the significant correlation between academic grades and the affective dimension, confidence, motivation, and attitude is equally important and reflects a well-established relationship between academic success and positive mathematical self-concept. Students, who have accumulated positive achievement experiences, reinforce their belief in their ability to succeed, sustain their motivation, and cultivate favorable attitudes toward the subject. Macaso and Dagohoy (2022) confirmed that positive attitudes, confidence, enjoyment, and valuing mathematics are strong predictors of achievement among Filipino senior high school students and the present finding extends this relationship in the reverse direction that prior academic achievement also predicts the affective orientation students bring to Calculus learning. Furthermore, Capinding (2023) noted that learners with self-confidence in mathematics were more likely to succeed academically, and that there is a positive correlation between students' favorable attitudes, confidence levels, and independent mathematical learning — all of which are reinforced by a history of strong academic performance.

Conversely, the non-significant correlations between all academic profile variables and problem-solving and analytical skills and application to engineering scenarios reveal an important limitation of prior grades as predictors of higher-order mathematical competencies. Although students with higher grades tend to understand concepts better and feel more confident, their performance on multi-step problem-solving and real-world engineering application tasks is not significantly predicted by their subject grades alone. This suggests that problem-solving ability and engineering application are competencies that require deliberate, contextualized practice beyond what is typically assessed and rewarded in the graded classroom environment.

Targeted School Based Intervention Program

The study reveals a confidence-competency gap wherein students show significant gap on their mathematical readiness in conceptual understanding and problem solving and analytical skills despite a high level of confidence, motivation and attitude towards learning Calculus. Also, application of calculus to engineering contexts is both the most frequently experienced challenge and the most consequential performance gap. Therefore, the evidences gathered in this study serves as indicator that a school-based intervention program is essential to address the identified mathematical readiness level and challenges encountered. Insorio & Macandog (2022) confirmed that without a structured intervention the transition from SHS to engineering program remains a significant barrier for students. To address this gap, a Project BRIDGE STEM (Bridging Readiness through Integrated Drills and Guided Engineering) is developed.

The project BRIDGE STEM is composed of three approaches. First is the Skill Lab. This approach introduces a bi-weekly drill sessions focusing on repetitive procedural accuracy in algebraic manipulation and calculus rules. This is adapted through the use of peer led, math buddy, system where students with high grades in General Mathematics or Pre-Calculus (96-99) paired to those below 84 brackets to provide supportive tutoring. Combining the foundational skill and buddy system, it aims to improve mathematical skills and create an environment social belonging essential in STEM success. Peer-led guidance effectively scaffolds learning within the "Zone of Proximal Development" without requiring additional teacher hours (Clemente et al., 2024). Sessions are conducted during vacant periods or after school remedial instruction hours as mandated by DepEd Order No. 8 series of 2015. Second approach is called Contextualized Engineering Module. This approach transforms the school a living textbook which helps students learn how Calculus work in real world structures. Students spend less mental energy trying to visualize the problem and more on solving the Calculus behind it when a module uses a familiar schema (Picardal and Sanchez, 2022). The third and last approach is called Calculus Context Lecture. This approach is inviting an alumnus with technical experience through recorded video or in person lecture to have a talk on how they use rate of change or accumulation in engineering field. This connects the classroom learning to real-world engineering. The involvement of alumni with technical experience as guest lecturers or via recorded testimonials is a strategic intervention supported by De Guzman et al. (2021) and Pascual (2021), who emphasize the importance of relatable role models in reinforcing the utility value of STEM subjects.

CONCLUSION

The study concludes that STEM students' mathematical readiness in calculus is within Approaching Proficiency level in conceptual understanding and problem-solving but significantly struggling to apply concepts in engineering. Nevertheless, students show high level of confidence, motivation, and positive attitude towards Calculus which indicates an emotional foundation that supports further learning. However, the students often encounter conceptual, procedural and application challenges that hinders translating theory into practice. Students' mathematical readiness significantly varied based on age and academic grades in General Mathematics, Pre-Calculus, and Calculus, whereas sex and socio-economic status showed no significant impact. Remarkably, no significant correlations were found between student profiles and the challenges encountered, suggesting that difficulties in Calculus are a universal experience regardless of demographic background. While academic performance positively correlated with conceptual understanding and affective readiness, they failed to correlate with problem-solving and application skills, emphasizing a critical gap between theoretical knowledge and real word scenarios. With that, a project BRIDGE STEM is developed.

Recommendations

Based on the findings and conclusion of this study, the following are recommended:

1. The school principals and administrator should review the possible adaptation of the targeted intervention program, project BRIDGE STEM.
2. The SHS Math and Calculus Teachers should provide more procedural problem-solving practices to improve students' procedural mastery.
3. The STEM students should proactively review and master General Mathematics and Pre-Calculus concepts since academic performance significantly influence mathematical readiness.

The future researchers should conduct longitudinal studies to determine if the identified readiness level accurately predict success in higher-level engineering mathematics.

References

Abellera, M., Delos Santos, J., & Reyes, R. (2019). Socio-economic and geographic disparities in access to STEM education in the Philippines. *Philippine Journal of Educational Equity, 14*(2), 45–60. https://philjournalsci.dlsu.edu.ph/

Academic Recovery and Accessible Learning (ARAL) Program Act, Rep. Act No. 12028. (2024). *Official Gazette of the Republic of the Philippines*.

Almaden, R. D. (2023). Attitudes and mathematics performance among STEM students in the Philippines. *Philippine Journal of STEM Education, 17*(1), 33–47. https://philstem.org/pjstem/

Bandura, A. (2012). On the functional properties of perceived self-efficacy revisited. *Journal of Management, 38*(1), 9–44. https://doi.org/10.1177/0149206311410606

Barroso, N. C. (2020). Mathematical models in predicting retention of STEM students in Pre-Calculus. *International Journal of Professional Development, Learners and Learning*.

Bautista, J. M., & Reyes, L. D. (2026). Cognitive predictors of success in engineering mathematics: A longitudinal study of Filipino STEM students. *Philippine Journal of Science and Technology Education*.

Ceci, S. J., & Williams, W. M. (2020). Mathematics and STEM career trajectories. *Educational Research Review, 12*(1), 104–118. https://doi.org/10.1016/j.edurev.2014.12.002

Commission on Higher Education. (2013). *CHED memorandum order no. 20, series of 2013: Policies, standards, and guidelines for engineering education*. https://ched.gov.ph/wp-content/uploads/2017/10/CMO-No.-20-Series-of-2013.pdf

Commission on Higher Education. (2021). *Policies, standards, and guidelines for engineering education*. CHED Philippines. https://ched.gov.ph/policies/

Cordova, M. L. (2020). Socioeconomic factors affecting math proficiency in Philippine rural schools. *Asian Journal of Educational Research, 8*(2), 57–68. http://asianeducres.com/

Corpuz, M. A. (2023). Assessing the mathematical readiness of Senior High School graduates: The impact of the spiral curriculum. *Journal of Southeast Asian Educational Research*.

De Guzman, M., San Pedro, T., & Javier, R. (2021). Impact of alumni mentoring on the career persistence of STEM students in Philippine public schools. *Journal of Vocational Education*, *9*(2), 114–128.

Dela Cruz, J. M., & Garcia, R. P. (2022). Measuring mathematical readiness in engineering freshmen. *Philippine Journal of Education and Development, 15*(2), 45–59. http://www.pjedphil.org

Dela Cruz, J. M., & Santos, M. L. (2022). The impact of senior high school STEM strand on college mathematics preparedness. *Philippine Journal of Science Education, 13*(1), 78–89. https://philsci.edu.ph

De Lara, K. T., & Santos, P. R. (2024). From classroom to construction: Bridging the conceptual gap in Calculus for engineering freshmen. *Manila Educators Review*.

Department of Education. (2015). *DepEd order no. 8, series of 2015: Implementing the K to 12 basic education program*. https://www.deped.gov.ph/wp-content/uploads/2019/01/DO_s2015_08.pdf

Department of Education. (2016). *K–12 basic education curriculum guide – STEM strand*. DepEd Philippines. https://www.deped.gov.ph/k-to-12/curriculum-guides/

Department of Science and Technology. (2021). *Mathematics preparedness of STEM students: National report*. DOST Philippines. https://dost.gov.ph/publications/reports.html

Dominguez, A., & Tolentino, N. (2019). Affective factors influencing mathematics achievement in the K–12 system. *Philippine Journal of Educational Psychology, 14*(2), 55–70. https://www.pjep.org.ph

Domondon, C. S., Pardo, C. G., & Rin, E. T. (2023). Analysis of difficulties of students in learning Calculus. Research in learning Calculus. *ResearchGate*. https://www.researchgate.net/publication/368810478_ANALYSIS_OF_DIFFICULTIES_OF_STUDENTS_IN_LEARNING_CALCULUS

Enhanced Basic Education Act of 2013, Rep. Act No. 10533. (2013). *Official Gazette of the Republic of the Philippines*.

Exploring Filipino STEM students' struggles in mathematics. *International Research Journal of Multidisciplinary Studies*. https://www.irjms.com/wp-content/uploads/2026/01/Manuscript_IRJMS_07643_WS.pdf

Garcia, R. P. (2021). Correlation of senior high school math grades to engineeringmath success. *Philippine STEM Research Journal, 11*(1), 60–75. https://philstemjournals.org/

Garcia, R. P., & Cruz, J. M. (2022). Impact of senior high school academic strand on mathematics achievement. *Philippine Journal of Education, 15*(2), 45–59. http://www.pjedphil.org

Garcia, R. P., & Dela Cruz, J. M. (2022). Motivation and confidence in mathematics: Effects on STEM learning outcomes. *Philippine Journal of Educational Psychology, 17*(1), 25–40. https://www.pjep.org.ph

Guinocor, M., Almerino, P., Mamites, I., Devosora, A., & Messias, J. E. (2020). Mathematics performance of SHS students: A basis for a math enrichment program. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(12), 195–206. https://doi.org/10.3991/ijet.v15i12.13961

Hanushek, E. A., Schwerdt, G., & Woessmann, L. (2018). Economic gains from improved math skills: Evidence from international assessments. *Journal of Economic Growth, 23*(3), 165–182. https://doi.org/10.1007/s10887-018-9151-1

Hiebert, J., & Grouws, D. A. (2017). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404).

Hong, D. S. (2023). Examining opportunities to learn limit in widely used calculus textbooks. International Journal of Science and Mathematics Education, 21, 881–898. https://doi.org/10.1007/s10763-022-10273-7

Insorio, A. O., & Macandog, A. D. (2022). Video-based supplemental learning materials in enhancing students' academic performance in mathematics. *Journal of Educational Research and Practice*, *12*(1), 102-115. https://doi.org/10.5590/JERAP.2022.12.1.08

Insorio, A. O. (2024a). Addressing student diversity to improve mathematics achievement through differentiated instruction. *International Journal of Professional Development, Learners and Learning*, *6*(1), ep2406. https://doi.org/10.30935/ijpdll/14462 Cited by: 16

Insorio, A. O. (2024b). Enhancing students' academic performance by making the mathematics learning experience meaningful through differentiated instruction. *ConMaths: Journal of Mathematics Education*, *6*(2).

Lee, S., Park, J., & Kim, H. (2021). Early mathematics education frameworks and STEM retention: A cross-country analysis. *International Journal of STEM Education Research, 7*(3), 211–230. https://doi.org/10.1186/s40594-021-00286-y

Lopez, S., & Basilio, R. (2019). The effect of senior high school strand on engineering math performance. *Philippine STEM Research Journal, 10*(1), 15–31. https://philstemjournals.org/

Luna, M. P., & Morales, A. G. (2018). Conceptual and procedural understanding in the division of algebraic fractions. *e-Journal of Science and Technology, 10*(2),45–60. https://ejournals.ph/article.php?id=25294

Macaso, K. M. J., & Dagohoy, R. G. (2022). Predictors of performance in mathematics of Science, Technology, Engineering, and Mathematics (STEM) students in a secondary school in the Philippines. *Journal of Education*, *2*(4), 311–326.

Malacapay, M. C. (2024). The Influence of Learning Styles and Attitudes on Academic Performance of College Students in a Flipped Learning Environment. *International Journal of Instruction*, *17*(4), 623-644. https://doi.org/10.29333/iji.2024.17435a Cited by: 8

Malusay, J. T., Cortes, S. T., Ontolan, J. M., Englis, T. P., Pagaran, G. M., & Dizon, R. L. (2024). Strengthening STEM education through a professional development program on enhancing teachers' TPACK in selected calculus topics. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1487350

Matondang, Z., Saragih, S., & Maharani, S. (2023). Investigating student difficulties on integral calculus based on critical thinking aspects. *ResearchGate*. https://www.researchgate.net/publication/323145248

Mendoza, J. R. (2021). K–12 STEM instruction challenges in public schools. *Education Policy Analysis, 22*(4), 67–78. https://ejournals.ph/article.php?id=14340

Mendoza, J. R., Santos, K., & Cruz, A. (2023). Remedial programs for mathematics: Initial outcomes and challenges. *Philippine Journal of Educational Innovation, 9*(1), 50–65. https://pjedi.gov.ph/

Moreno, I. F. P., et al. (2025). The correlation of mathematical performance and mathematical anxiety, mathematical confidence and mathematical interest. *Cognizance Journal of Multidisciplinary Studies*.

National Academies of Sciences, Engineering, and Medicine. (2018). *Science and engineering for grades 9–12: Investigation and design at the center*. National Academies Press. https://doi.org/10.17226/25216

Nolasco, D. (2025). Unearthing mathematics anxiety: A qualitative exploration of student experiences. *Journal of Technology and Science Education*.

Nuñez, M. M. A., Yazon, A. D., Sapin, S. B., Tamban, V. E., & Manaig, K. A. (2023). Improving high school student's performance in basic calculus using the Enhancing Mastery & Expertise in Mathematics supplementary material. *Applied Quantitative Analysis*, *3*(1). https://journals.researchsynergypress.com/index.php/aqa/article/view/1597

Pascual, N. T. (2021). Factors affecting high school students' career preference: A basis for career guidance program. *International Journal of Sciences: Basic and Applied Research*, *58*(1), 16–31.

Picardal, J. P., & Sanchez, R. D. (2022). Effectiveness of localized instructional materials in improving the academic performance of science students. *Journal of Research in Science Education*, *8*(1), 15–30.

Philippine Institute for Development Studies. (2020). *Curricular gaps in Philippine STEM education*. PIDS. https://pids.gov.ph/publications

Philippine Normal University. (2022). Challenges in applying mathematics for STEM graduates. *PNU Education Review, 8*(2), 35–50. https://pnu.edu.ph/research/publications/

Pizon, J., & Ytoc, J. (2023). Self-concept, motivation, and calculus performance among STEM students. *JIP Publication*. https://jippublication.com/index.php/jip/article/view/1088

Reyes, L. M., Santos, K., & Dela Cruz, J. (2020). Curriculum alignment in Philippine STEM education: A mapping study. *Asia-Pacific Journal of Science Education, 21*(3), 123–138. https://doi.org/10.1515/apjse-2020-0011

Rogayan, D. V., Jr., Rafanan, R. J. L., & de Guzman, C. Y. (2021). Challenges in STEM learning: A case of Filipino high school students. *Journal on Science and STEM Education*, *7*(2), 232–244. https://www.researchgate.net/publication/356705218

Santos, C. V. (2020). Engineering students' mathematical understanding based on the quality of mathematical connections activated to solve tasks about function's graph and its derivative. *Educational Process: International Journal, 9*(3), 7–23. https://www.edupij.com/index/arsiv/78/766/

Santos, L., Villanueva, M., & Cruz, A. (2022). Gender gaps in mathematics confidence among Filipino STEM students. *Philippine Journal of Educational Psychology, 18*(1), 23–40. https://www.pjep.org.ph

Semblante, A. P., & Subingsubing, E. T. (2024). Computational skills in solving application problems using basic differentiation rules in differential calculus: An explanatory sequential study. *European Journal of Theoretical and Applied Sciences*, *2*(1), 367–374. https://doi.org/10.59324/ejtas.2024.2(1).34

Siller, H. S., & Ahmad, S. (2024). Analyzing the impact of collaborative learning approach on grade six students' mathematics achievement and attitude towards mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(1), em2395. https://doi.org/10.29333/ejmste/14153

Sulistyaningsih, et al. (2025). Students' problem-solving behavior in differential calculus. *EDUPIJ*. https://doi.org/10.22521/edupij.2025.19.565

Study habits, learning environment, and mathematics performance of Grade 11 STEM students. *Philippine EJournals*. https://www.ejournals.ph/article.php?id=28109

Tambis, D. J. E. (2021). Functions as prerequisite to basic calculus. *International Journal of Mathematics and Physical Sciences Research*, *8*(2), 68–78. https://www.researchpublish.com/upload/book/paperpdf-1612782208.pdf

Villanueva, M., Santos, L., & Cruz, A. (2021). Socioeconomic status and math readiness of STEM students. *Philippine Journal of Social Sciences, 18*(2), 70–84. http://pjssphilippines.org/

Villanueva, R. G. (2024). The psychological weight of mathematics: Persistence and identity among engineering-track STEM students. *Asian Journal of Social Sciences and Humanities*.

Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

World Economic Forum. (2020). *The future of jobs report 2020*. Geneva, Switzerland. https://www.weforum.org/reports/the-future-of-jobs-report-2020