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Predictive Validity of a Diagnostic Mathematics Assessment on Freshmen Calculus Performance in Engineering Programs in a Polytechnic College in Philippines

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ABSTRACT This study emphasises early academic support and performance monitoring in engineering education. It examined the predictive validity of a diagnostic mathematics assessment on Calculus performance among first-year engineering students at Camarines Sur Polytechnic Colleges. It investigated whether scores in Algebra, Trigonometry, Solid Geometry and Analytic Geometry could predict academic outcomes in Calculus. A correlational design was employed, using data from 787 purposively selected students enrolled in the 2022-2023 academic year. A significant negative correlation was found ($r=-0.276$, $p<0.05$), indicating that higher diagnostic scores corresponded to better (lower numerical) Calculus grades. Multiple regression analysis revealed a weak but significant collective effect [$F(5,781) = 18.67$, $p<.001$, $R^2 = 0.09$, $R^2_{adj}=0.08$], with Sex, Strand, Algebra, Trigonometry and Solid Geometry emerging as significant predictors. The findings affirm the value of diagnostic assessments in identifying students at risk and informing early intervention strategies in engineering education.

INTRODUCTION

Diagnostic assessment is a tool to determine what students already know or what content may be missing in their learning before the instruction stage. Thorndike and Hagen (1970) note that, as a pre-assessment tool, diagnostic assessments give a teacher greater insight into the strengths and weaknesses of an individual student that can help work on developing the curriculum and instruction. Unlike summative assessments that provide total or overall scores, diagnostic assessments give disaggregated scores across mathematical subskills or content areas that provide a more accurate picture of readiness. In courses like Calculus, where students' success relies a great deal on success in previous subjects like Algebra, Trigonometry and Geometry, understanding students' readiness is critical to success. Further, diagnosing when a student has not mastered specific topics allows educators to create individualised plans to remediate learning deficiencies and think about differentiated instruction for improving academic success. Therefore, diagnostic assessments serve two purposes when used in education, first, as assessments for learning, and second, as indicators of how students will likely perform in their foundational courses in Engineering.

Globally, the growing demand for Science, Technology, Engineering, and Mathematics (STEM) professionals has drawn attention to students' mathematical preparedness, particularly in engineering education. Mathematics is central to engineering due to its role in problem-solving, modelling, and quantitative reasoning. However, underperformance in early college mathematics is frequently attributed to weak preparation, which contributes to high attrition rates in STEM fields according to Crisan et al. (2021). Addressing this issue requires institutions to adopt strategies that assess and support students' readiness for advanced mathematical content. Diagnostic assessments can serve as critical entry-level tools to promote success and retention in STEM disciplines. These global concerns resonate at Camarines Sur Polytechnic Colleges (CSPC), where many first-year students pursue engineering degrees despite varied academic backgrounds.

Recent scholarship continues to affirm the importance of diagnostic assessments in supporting mathematics readiness in higher education. Chan and Rivera (2023) found that first-year engineering students who underwent structured diagnostic testing in Algebra and Trigonometry demonstrated significantly improved persistence and performance in introductory Calculus compared to those who did not receive early screening and support. Similarly, Gomez et al. (2023) emphasised that disaggregated diagnostic data can guide targeted bridging programs, reducing performance gaps between STEM and non-STEM high school graduates entering engineering programs. In a Philippine context, Ponce and Arandia (2024) reported that diagnostic assessment scores in Pre-Calculus strongly predicted outcomes in Calculus I among engineering freshmen, highlighting the need for institutions to integrate placement testing into their admissions or orientation procedures. More recently, Tan and Villaflor (2025) demonstrated that early diagnostic-based interventions not only improved pass rates in Calculus but also enhanced student confidence and engagement, suggesting that diagnostic assessments may serve both cognitive and affective functions in mathematics learning and retention.CSPC, a state college in the Bicol Region, receives a substantial number of Senior High School (SHS) graduates from diverse strands under the Philippine K to 12 curriculum. In 2021, of the 4,588 applicants, 3,902 enrolled, with nearly 24 percent opting for engineering programs (Salcedo, personal communication, May 11, 2022; Malaya, personal communication, May 11, 2022). Despite this high enrollment, CSPC's average engineering licensure examination passing rate was 50.49 percent from 2019 to 2021, below the national average of 58.37 percent (ACCESS Annual Report 2022). This underperformance reflects possible gaps in foundational competencies essential for engineering success. Since Calculus is a gateway subject in engineering programs, assessing students' readiness for this subject is critical to improving academic outcomes and licensure performance.

Republic Act No. 10533, or the Enhanced Basic Education Act of 2013, introduced two additional years of SHS intended to prepare students for either college or employment. All SHS students complete General Mathematics and Statistics and Probability, while only STEM students are exposed to Pre-Calculus and Basic Calculus. In parallel, Republic Act No. 10931, or the Universal Access to Quality Tertiary Education Act, has expanded access to higher education, increasing academic diversity among incoming college students, as noted by Rocamora (2021). While this surge in enrollment is promising, it also results in differing levels of mathematical preparation, particularly among non-STEM strand graduates entering engineering programs. Currently, CSPC does not employ a standardised diagnostic process, which means students are often placed in advanced mathematics courses like Calculus without a clear understanding of their preparedness. This gap highlights the need for a formal diagnostic mechanism to identify at-risk students early.

Despite the recognised importance of early assessment, CSPC does not have a standardised diagnostic testing system for mathematics. While subjects like Algebra, Trigonometry, and Geometry are part of the engineering curriculum, there is no organised method to check if students have kept the necessary skills. The lack of a systematic diagnostic assessment process is surprising, especially given the strong international evidence that shows diagnostic assessments can predict success in college mathematics and help inform teaching support, according to Engelbert et al. (2017). In the absence of these evaluations, CSPC does not have the necessary information to recognise students who are at risk and offer them prompt, personalised academic support. Consequently, this study fills a meaningful and practical void in both institutional methods and local research.

Despite the central role of mathematics in engineering education, many first-year students at CSPC begin Calculus with uneven levels of preparedness due to varied senior high school backgrounds and inconsistent exposure to prerequisite mathematical concepts. This academic disparity contributes to difficulties in gateway courses, affects student confidence, and may ultimately influence program retention and licensure performance. However, CSPC currently lacks a standardised diagnostic mechanism to assess mathematical readiness at entry, leaving educators without clear indicators of students' strengths and learning gaps. Implementing a diagnostic assessment system may therefore serve as a crucial evidence-based strategy to identify at-risk learners, tailor instructional support, improve academic outcomes, and enhance progression within engineering programs. By determining the predictive validity of diagnostic mathematics scores on Calculus performance, this study addresses a critical institutional need and contributes to broader educational efforts aimed at strengthening STEM readiness and promoting long-term academic success.

Objectives of the Study

The present study aims to investigate the predictive validity of a diagnostic mathematics assessment on the Calculus performance of first-year engineering students at Camarines Sur Polytechnic Colleges. It seeks to describe students' profiles in terms of sex, academic strand, and senior high school background, determine their diagnostic test scores in Algebra, Trigonometry, Geometry, and Analytic Geometry, and assess their Calculus performance during their first semester. Furthermore, the study examines the relationship between diagnostic results and Calculus outcomes and develops a regression model to predict performance based on diagnostic scores and student profile variables.

MATERIAL AND METHODS

This study adopted a research design with correlational quantitative research to determine the predictive validity of a diagnostic mathematics assessment on performance in Calculus amongst first-year engineering students. Correlational designs determine relationships between two or more variables without manipulating the variables (Creswell and Creswell 2018). Researchers can use correlational designs when studying prediction.

The sample comprised all first-year engineering students registered for the initial 2022-2023 academic year semester at Camarines Sur Polytechnic Colleges (CSPC). Katiangdagho et al. (2022) emphasised that total enumeration sampling was used to include any student willing to participate, as Calmorin and Calmorin (2016) noted that total enumeration sampling is an accepted method due to the size of the accessible population and the intended aim of maximising generalizability.

In simple terms, the study collected data from 757 first-year engineering students, including their sex, academic strand, and senior high school background. Their scores in Algebra, Trigonometry, Geometry, and Analytic Geometry were recorded through a diagnostic mathematics test, and their Calculus performance during the first semester was also examined. The study then analysed whether students' diagnostic test scores and background characteristics could predict how well they would perform in Calculus.

Two researcher-developed instruments were used, that is, a student profile sheet and a diagnostic mathematics test. The profile sheet collected basic demographic and academic background data, including sex, type of senior high school attended (public or private), and completed SHS strand (Science, Technology, Engineering and Mathematics (STEM), Accountancy, Business and Management (ABM), Humanities and Social Sciences (HUMSS), or General Academic Strand (GAS)).

The diagnostic assessment measured foundational competencies in Algebra, Trigonometry, Solid Geometry, Plane Geometry, and Analytic Geometry, all critical for Calculus readiness. Content validation was conducted by mathematics educators to ensure alignment with senior high school mathematics standards. The test was pilot-tested on a comparable group of students and demonstrated acceptable reliability based on Kuder-Richardson Formula 20 for Algebra (KR-20 = 0.89), Trigonometry (0.76), Plane and Solid Geometry (0.82), and Analytic Geometry (0.81).

Students' academic performance was measured using their final grades in Calculus, as officially recorded by the Registrar's Office at the end of the semester. These grades reflected cumulative performance in accordance with the institutional grading policy.

Data was collected during the first semester of academic year 2022-2023 at Camarines Sur Polytechnic Colleges (CSPC). After securing approval from the College of Engineering and Registrar's Office, the researcher coordinated with instructors to schedule the administration of the diagnostic mathematics test and student profile sheet. These instruments were distributed to all first-year engineering students during a proctored session at the college gymnasium. Participation was voluntary, with informed consent obtained from each student. All completed forms were collected immediately and encoded for analysis. At the end of the semester, students' final Calculus grades were retrieved from the Registrar and matched with their diagnostic and profile data. This allowed for a comprehensive analysis of how diagnostic scores and background characteristics related to actual academic performance in the course.Descriptive statistics, frequency, mean, and percentage, were used to summarise student profiles and diagnostic scores. To examine the relationship between diagnostic performance and Calculus grades, the Pearson product-moment correlation coefficient (Pearson *r*) was employed. Furthermore, multiple linear regression analysis was used to identify significant predictors and develop a regression model. Data analysis was conducted using SPSS version 25, with significance set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Academic Profile of First Year Engineering Students

By understanding the academic profile of first-year engineering students, the researchers gained insights into their mathematical preparedness. The researchers could further understand the differences in performance in foundational college courses, such as Calculus. In this section, the researchers will discuss the characteristics of students (sex, type of school graduated, and SHS academic strand) and how they may be associated with their results on the diagnostic assessment and consequently, their academic performance.

Sex

As shown in Table 1, 69.3 percent of the respondents were male, and 30.7 percent were female. This significant gender imbalance aligns with national data from CHED (2022), which notes that male enrollment dominates engineering and technology programs across Philippine higher education institutions. The trend is also consistent with global reports by UNESCO (2017), which highlight the underrepresentation of females in STEM fields.

Table 1: Sex distribution of the first-year students

Sex	*Frequency*	*Percent*
Male	545	69.3
Female	242	30.7
Total	787	100.0

Note: Data presented are based on the gathered responses from S/Y 2022-2023

Research suggests that while mathematical aptitude is not determined by sex, factors such as math anxiety, self-efficacy, and classroom participation can differ by gender, as noted by Else-Quest et al. (2010). These affective variables may influence performance in math-intensive courses, particularly in male-dominated environments where females may experience lower academic self-concept. The current sex distribution in the study also reflects patterns observed in the diagnostic test scores and Calculus outcomes, as further discussed in the results section.

Type of School Graduated

Table 2 indicates that 73.1 percent of the students came from public high schools, while 26.9 percent graduated from private institutions. This pattern mirrors national enrolment trends in SUCs, where the Free Higher Education Act (RA 10931) has facilitated access for students from public schools, particularly in the post-pandemic period.

However, Bernardo (2017) and Martin (2018) have found that students from private schools often perform better in mathematics diagnostic tests, attributed to smaller class sizes, greater access to resources, and consistent curricular implementation. In this study, public school graduates comprised the majority of those with lower diagnostic scores, a trend explored further in the discussion of diagnostic performance and regression results.

Table 2: Type of school graduated

Type of school graduated	*Frequency*	*Percent*
Public	575	73.1
Private	212	26.9
Total	787	100.0

Note: Data presented are based on the gathered responses from S/Y 2022-2023

This finding underscores the need for interventions to support public school graduates, many of whom enter college with learning gaps that affect Calculus performance. Bridging or remedial programs informed by diagnostic data may be particularly beneficial for this group.

Academic Strand Completed

The academic strand in SHS plays a critical role in students' preparation for college mathematics. Table 3 shows that 54.8 percent of the participants came from the STEM strand, while 45.2 percent were from non-STEM strands (Accountancy and Business Management, Humanities and Social Sciences, General Academic Strand). While the STEM strand includes Pre-Calculus and Basic Calculus in its curriculum, non-STEM strands typically provide less exposure to advanced math concepts.

Table 3: Academic strand completed

Strand	*Frequency*	*Percent*
STEM	431	54.8
Non-STEM	356	45.2
Total	787	100.0

Note: Data presented are based on the gathered responses from S/Y 2022-2023

This imbalance in academic exposure is reflected in students' diagnostic results (see Table 4) and Calculus performance (see Table 6), where STEM students consistently outperformed their non-STEM counterparts. This supports prior findings by Abarro (2019) and Oruga and Dizon (2020) that STEM graduates are better prepared for higher-level mathematics due to more extensive subject training in SHS.

Despite STEM's slight majority, the significant representation of non-STEM strand students raises concerns about readiness and equity in engineering education. As indicated in the regression analysis (see Section 6), academic strand was a statistically significant predictor of Calculus grades ($p < 001$), with STEM students more likely to perform better.

This reinforces the value of diagnostic testing not only as an assessment-for-learning tool but also as a predictive measure to identify at-risk students early. The results support the integration of targeted support structures, particularly for non-STEM and public school graduates, to close preparation gaps and improve retention and academic success in engineering programs.

Mathematical Diagnostic Assessment Results

This section presents the results of the 100-item diagnostic mathematics test administered to first-year engineering students. Performance is examined across key profile variables, sex, and type of school graduated, and SHS strand, to evaluate mathematical readiness and identify subgroups that may require academic intervention prior to enrolling in Calculus.

By Sex

As shown in Table 4, female students slightly outperformed males, averaging 34.9 percent compared to 34.0 percent. While both groups fall within the moderate performance range (33% to 66%), females posted marginally stronger scores in Bachelor of Science in Electronics Communication Engineering (BSECE) and Bachelor of Science in Mechanical Engineering (BSME).

Despite being underrepresented (see Table 1 showing 30.7% female), females demonstrated slightly better performance. This supports the findings of Else-Quest et al. (2010), who observed minimal gender differences in math achievement, particularly in supportive academic settings. Within the framework of Information Processing Theory, this may reflect more efficient cognitive strategies in encoding and retrieval of mathematical concepts.

By Type of School Graduated

Table 5 reveals that students from private schools scored slightly higher (35.7%) than those from public schools (34.3%). This modest advantage is seen in BSECE, BSME, and Bachelor of Science in Civil Engineering (BSCE), though both groups still fall within the "average" band.

Table 4: Mathematics diagnostic test performance by sex

Program	*Male*		*Female*	
	Score	*VI*	*Score*	*VI*
BSCE	37.9	Average	37.7	Average
BSECE	32.2	Below average	34.8	Average
BSEE	32.4	Below average	32.2	Below average
BSME	33.6	Average	35.0	Average
Mean	34.0	Average	34.9	Average

Note: Data presented are based on the gathered responses from S/Y 2022-2023

With Table 2 showing that 73.1 percent of students graduated from public high schools, the generally lower scores may be linked to known disparities in instructional quality and resource access, as noted by Bernardo (2017). Drawing from the Constructivist Theory, private school students may have benefited from enriched instructional environments that promote deeper conceptual learning. These findings are also supported by recent research. For example, Di Tommaso and Weisz (2024) demonstrated that active, supportive interventions significantly improve girls' mathematics performance, thereby reducing gender gaps. Similarly, Uunk and Blossfeld (2025) found that gender-specific trajectories in math development appear during lower secondary education, suggesting that school-level factors and learning environments contribute to how male and female students grow in mathematical competence over time. These findings reinforce the need for early remediation, especially for public school graduates. Such targeted support can help bridge gaps in foundational knowledge and better prepare students for the cognitive demands of college-level Calculus.

By Senior High School Strand

Strand-level data in Table 6 shows that STEM students performed consistently better, with an average score of 35.9 percent compared to 32.2 percent for non-STEM students. The performance gap is most pronounced in BSME and BSECE, where non-STEM students fell below the 33 percent benchmark for "average".

With Table 3 showing that 45.2 percent of students came from non-STEM strands, and a large proportion (Table 2) from public schools, the data point to overlapping vulnerabilities in math readiness. These students may lack exposure to Pre-Calculus and Basic Calculus topics central to engineering curricula. Previous studies by Oruga and Dizon (2020) and Abarro (2019) confirm that non-STEM students face greater academic hurdles in math-intensive college programs. These local findings are supported by recent research. Dita and Velasco (2025) found that Computer Engineering students from non-STEM SHS strands (for example, ABM, GAS) tend to have lower college academic performance compared to their STEM-strand peers. In addition, a systematic review of non-STEM students' mathematics experiences in tertiary STEM programs highlights repeated weak preparation in key subjects like Algebra and Trigonometry among non-STEM strand graduates, which contributes to their lower readiness for rigorous engineering curricula.

According to Vygotsky's Zone of Proximal Development, non-STEM students likely need

Table 5: Mathematics diagnostic test performance by type of school graduated

Program	*Public*		*Private*	
	Score	*VI*	*Score*	*VI*
BSCE	39.0	Average	37.9	Average
BSECE	32.7	Below average	36.6	Average
BSEE	32.2	Below average	32.2	Below average
BSME	33.2	Average	36.0	Average
Mean	34.3	Average	35.7	Average

Note: Data presented are based on the gathered responses from S/Y 2022-2023

Table 7: Performance in differential calculus by sex

Program	*Male*		*Female*	
	Grade	*VI*	*Grade*	*VI*
BSCE	2.40	Satisfactory	2.40	Satisfactory
BSECE	4.00	Failed	3.20	Failed
BSEE	2.30	Satisfactory	2.20	Good
BSME	2.40	Satisfactory	2.40	Satisfactory
Mean	2.77	Passing	2.55	Satisfactory

Note: Data presented are based on the gathered responses from S/Y 2022-2023

structured scaffolding to bridge foundational gaps in mathematics. Similarly, Information Processing Theory suggests that repeated exposure to math content, more common in the STEM strand, enhances encoding and retrieval, supporting better performance in Calculus. Across all profile variables, diagnostic test scores indicate moderate readiness, with performance slightly favouring females, private school graduates, and STEM strand students. The compounded disadvantage for male, public school, non-STEM students suggests a strong case for targeted interventions. These findings reinforce the value of diagnostic assessments in identifying at-risk groups and tailoring support strategies to improve readiness for Calculus and other math-intensive courses. These ideas are supported by recent researches by Gürel (2025) who demonstrated that dynamic scaffolding in mathematical modelling significantly improves learners' competencies by providing guidance within their Zone of Proximal Development, while Kaldaras et al. (2024) showed that technology-enhanced scaffolding and feedback help students internalise complex STEM content through repeated exposure, gradually moving toward independent problem-solving. Together, these studies reinforce the value of diagnostic assessments in identifying at-risk groups and tailoring support strategies to improve readiness for Calculus and other math-intensive courses.

Academic Performance in First-Year Calculus

This section analyses the performance of first-year engineering students in Differential Calculus, disaggregated by sex, school type (public or private), and senior high school (SHS) strand (STEM or non-STEM). The aim is to examine equity and preparedness gaps among subgroups based on demographic and academic backgrounds.

By Sex

Table 7 presents performance by sex. Female students outperformed males, with a mean grade of 2.55 ("Satisfactory") compared to 2.77 ("Passing") for males. This trend aligns with Table 4, where females had a slightly higher average diagnostic score (34.9% vs. 34.0%). Within specific programs, females maintained equal or better performance, notably in Bachelor of Science in Electrical Engineering (BSEE) (2.20 vs. 2.30) and BSECE (3.20 vs. 4.00), though both sexes struggled in BSECE.

These results support findings by Else-Quest et al. (2010) that female students often perform as well or better than males in structured academic settings. Cross-referencing Table 1, where females comprise only 30.7 percent of the cohort, and Table 6, where STEM students outperform non-STEM peers, suggests that many high-performing female students may have stronger academic foundations or come from STEM/private backgrounds. It also underscores the importance of encouraging greater female participation in engineering programs, as their strong performance in both diagnostic tests and Calculus, despite being underrepresented, suggests untapped academic potential and readiness. Recent research further supports this, wherein a 2025 study found that female students in advanced STEM courses maintained high performance when their prior preparedness was strong and when they were actively engaged (Ram et al. 2025), and another structural model study in a Philippine college context (Susada 2025) showed that psychological and psychosocial factors significantly contribute to female students' superior mathematics performance.

Martin and Ibe (2020) found similar trends in resilience and academic performance among Filipino female engineering students. The Information

Table 7: Performance in differential calculus by sex

Program	*Male*		*Female*	
	Grade	*VI*	*Grade*	*VI*
BSCE	2.40	Satisfactory	2.40	Satisfactory
BSECE	4.00	Failed	3.20	Failed
BSEE	2.30	Satisfactory	2.20	Good
BSME	2.40	Satisfactory	2.40	Satisfactory
Mean	2.77	Passing	2.55	Satisfactory

Note: Data presented are based on the gathered responses from S/Y 2022-2023

Processing Theory by Atkinson and Shiffrin (1968) helps explain this edge, wherein females may engage in more organised, metacognitive study strategies that enhance retention and problem-solving in mathematics, as noted by Else-Quest et al. (2010).

These findings underscore the need for gender-sensitive academic support to foster mathematics engagement across both sexes.

By School Graduated

Table 8 shows that private school graduates had a marginally better mean grade (2.68) than public school graduates (2.72), both within the "Satisfactory" range. Differences were minor in BSCE, BSEE and BSME, while both public and private students performed poorly in BSECE (3.80 vs. 3.73), suggesting program-level challenges.

This pattern aligns with Table 5, where private school students had slightly higher diagnostic scores (35.7% vs. 34.3%). Table 2 confirms that most students (73.1%) came from public schools, hinting at foundational gaps possibly tied to resource disparities noted by Bernardo (2017) and Plamo (2017), for example, teacher availability, instructional materials, and class size.

Heyneman and Loxley (1983) argued that private schools often have structural advantages (smaller classes, more individualised instruction) that support academic success. These advantages may be conceptualised through Vygotsky's Zone of Proximal Development (ZPD), suggesting that private school students may have had more guided learning experiences, aiding their transition to college-level Calculus.

Though differences are modest, these results imply that bridging programs may help public school graduates overcome foundational deficits, especially in math-intensive programs. Such initiatives could focus on strengthening core competencies in algebra, trigonometry and problem-solving to better prepare students for college- level mathematics. In addition, Santos et al. (2025) found that the integration of ICT in public high schools positively correlates with students' mathematics achievement, suggesting that resource disparities, such as lower access to technology in public schools, may contribute to the performance gap between private and public school graduates.

By Strand

Table 9 shows that STEM graduates consistently outperformed non-STEM graduates. STEM students averaged 2.53 ("Satisfactory"), while non-STEM students averaged 2.88 ("Passing"). STEM

Table 8: Performance in differential calculus by school graduated

Program	*Private*		*Public*	
	Grade	*VI*	*Grade*	*VI*
BSCE	2.36	Satisfactory	2.40	Satisfactory
BSECE	3.73	Faile d	3.80	Failed
BSEE	2.27	Satisfactory	2.30	Satisfactory
BSME	2.36	Satisfactory	2.40	Satisfactory
Mean	2.68	Satisfactory	2.72	Satisfactory

Note: Data presented are based on the gathered responses from S/Y 2022-2023

Table 9: Performance in differential calculus by strand

Program	*STEM*		*Non-STEM*	
	Grade	*VI*	*Grade*	*VI*
BSCE	2.37	Satisfactory	2.51	Average
BSECE	3.25	Failed	4.18	Failed
BSEE	2.17	Good	2.39	Satisfactory
BSME	2.36	Satisfactory	2.47	Satisfactory
Mean	2.53	Satisfactory	2.88	Passing

Note: Data presented are based on the gathered responses from S/Y 2022-2023

students likely benefit from prior exposure to advanced math (for example, Pre-Calculus, Calculus), as reflected in diagnostic scores (in Table 6 showing 35.9% vs. 32.2%).

In particular, STEM students in BSEE earned the highest average (2.17, "Good"), while non-STEM students in BSECE had the lowest (4.18, "Failed"). This significant gap reflects curricular misalignment and suggests that non-STEM students may struggle to scaffold higher math concepts without foundational support.

This conclusion aligns with findings from Abad (2020), who studied freshman Civil Engineering students at Eastern Visayas State University and found that those from STEM strands and specialised science high schools significantly outperformed their non-STEM and general high school peers on both diagnostic and Calculus-related tasks. The study demonstrated that SHS strand and school background were strong predictors of early success in tertiary mathematics. Abad (2020) recommended structured numeracy programs for non-STEM students, reinforcing the current study's call for diagnostic-based interventions.

This finding resonates with Giangan and Gurat (2022), who found that although students generally performed very satisfactorily in Pre-Calculus and Basic Calculus during distance learning, their perceptions of learning did not significantly correlate with academic performance. This suggests that high achievement is possible despite instructional format or perception, but it also underscores the importance of conducting further evaluations at the tertiary level. The institution may implement interventions like bridging programs or tutorials to ensure students are prepared for college calculus, considering the differences in how they completed senior high school mathematics through remote learning. This conclusion is further supported by Tanquilan and Lomibao (2025), whose systematic review found that non-STEM strand graduates consistently struggle with foundational mathematical concepts in tertiary STEM programs, underscoring the need for structured numeracy and bridging programs early in college.

These deficiencies emphasise aligning the mathematics prep for SHS with the mathematics required for engineering studies. Bridging programs or preparatory modules may help non-STEM students develop the conceptual basis they need for advancement in mathematics.

Earlier studies validate this progression. Abarro (2019) and Oruga and Dizon (2020) found that college-level math performance was stronger in STEM majors. Dela Cruz and Mijares (2022) concluded that strand alignment would provide a better foundation for technical fields. The Constructivist Theory, as stated by Bruner (1960) and Piaget (1952), states that learners with prior knowledge in mathematics could use this knowledge to assimilate new ideas about Calculus. However, non-STEM learners do not have a cognitive structure to build on, establishing the framework for a scaffolded remediation approach. Tanquilan and Lomibao (2025) reviewed literature on non-STEM SHS graduates in STEM programs and documented significant challenges in their mathematics readiness.

Overall, the strand variable is the most consistent predictor of Calculus performance. Institutions may consider offering bridging programs or math refresher courses for non-STEM students entering engineering, even if they meet basic admission qualifications.

The analysis reveals meaningful trends in Calculus performance by sex, school type, and strand. Female, private school, and STEM-background students performed better overall. These results highlight the importance of foundational preparation and structured support and validate the use of diagnostic assessments (Tables 4 to 6) as early indicators of Calculus readiness.

Relationship Between Mathematical Diagnostic Score and Calculus Performance

The study revealed a statistically significant yet weak negative correlation between students' diagnostic test scores and their final grades in Differential Calculus (Pearson's r/ =/ –0.276, p/ =/ 0.042). Given that lower numeric grades equate to higher performance in the Philippine grading system, this inverse relationship suggests that students with higher diagnostic scores generally achieved better Calculus grades.

This is consistent with the findings of Alipio (2021), who reported a moderate positive correlation ($r = 0.48$, $p < 0.05$) between diagnostic scores and final grades in College Algebra among first-year students in a Philippine state university. His study demonstrated that diagnostic results accounted for 32 percent of grade variance, highlighting the diagnostic test's predictive value.

This result reinforces the predictive validity of the diagnostic tool, consistent with Messick's Theory of Educational Measurement (1995), which emphasises the value of assessments that meaningfully forecast academic performance. The finding validates the diagnostic test as a viable early indicator of readiness for Calculus and supports its use in guiding interventions.

The performance trends mirror results disaggregated by academic profiles. As shown in Table 6, STEM strand students scored higher in the diagnostic test (35.9%) and earned better Calculus grades (mean=2.53, "Satisfactory") compared to non-STEM peers (32.2%, 2.88, "Passing"). Likewise, Tables 5 and 8 show that private school students had slightly higher diagnostic scores (35.7%) and better Calculus grades (2.68) than public school graduates (34.3%, 2.72). These results reflect how prior academic exposure and institutional context influence both readiness and performance.

This aligns with the findings of Jaudinez (2019), who revealed that while SHS mathematics instruction in public schools is designed to be learner-centred and contextualised, it is often hindered by misaligned content, instructional gaps, limited teacher training, and poor foundational skills among students. These systemic challenges in SHS mathematics delivery may contribute to the under preparedness of non-STEM students for Calculus in engineering programs.

The relationship is further substantiated by Tables 4 and 7, which show that although females constituted only 30.7 percent of the cohort (Table 1), they scored slightly higher on the diagnostic test (34.9%) and in Calculus (2.55) than their male counterparts (34.0%, 2.77). This suggests that demographic and academic profiles intersect in shaping academic outcomes.

Piaget's (1977) and Bruner's (1960) Constructivist Learning theories also support the findings, as they, like many learning models, suggest that learners develop new knowledge by building on solid existing cognitive structures. Students from non-STEM areas may not have had experience with advanced mathematics in high school and may have difficulty constructing abstract structures to understand calculus. These performance trends are further supported by Dita and Velasco (2025), who found that Computer Engineering students who graduated from STEM strands in SHS consistently had stronger college academic performance, suggesting that strand misalignment may contribute to weaker foundational preparation among non-STEM students.

In summary, while the correlation between diagnostic scores and Calculus grades is modest, it is statistically significant and educationally meaningful. It confirms that early assessment of mathematical skills can be a powerful tool for identifying at-risk students and designing targeted academic support systems within engineering programs.

Despite the importance of early assessment, CSPC currently does not institutionalise diagnostic testing in mathematics. Although subjects such as Algebra, Trigonometry, and Geometry are included in the engineering curriculum, there is no systematic method to determine whether first-year students have retained key competencies. This lack of institutionalised assessment is notable given the substantial international evidence supporting the use of diagnostic tests to predict college mathematics success and guide instructional interventions (Engelbert et al. 2017).

Regression Equation for Predicting Calculus Performance

The results of the multiple linear regression analysis revealed a statistically significant but weak collective predictive relationship between students' background and diagnostic variables and their Calculus performance, as measured by final grades. The model yielded $F(5, 781)/ = 18.67, p<.001$, with $R^2 = 0.09$ and adjusted $R^2 = 0.08$, indicating that only 9 percent of the variance in Calculus grades could be explained by the predictors included in the model.

The derived regression equation is:

Y = 3.5483 + 0.1245 (Sex) – 0.2633 (Strand) – 0.0280 (Algebra) – 0.0364 (Trigonometry) – 0.0242 (Solid Geometry).

Each coefficient provides insight into how specific variables impact Calculus performance:

- Sex ($\beta = 0.1245, t = 1.978, p = 0.048$): Assuming male = 0 and female = 1, the model predicts that female students will have slightly higher numeric grades than males, indicating lower academic performance under the grading scale. This appears to contrast slightly with the descriptive trend in Table 7, where females outperformed males. However, the effect size is small and may reflect interaction with other variables.

- Strand ($\beta = -0.2633$, $\boldsymbol{t} = -4.251$, $\boldsymbol{p} < .001$): Students from the STEM strand are significantly more likely to earn lower (better) Calculus grades compared to their non-STEM peers. This reinforces the trend observed in Tables 6 and 9, and aligns with the literature emphasising the foundational advantage of the STEM curriculum in higher mathematics (for example, Blotnicky et al. 2018; Abarro 2019).

Among the diagnostic subdomains, all three significant predictors had negative coefficients, meaning higher scores in these components are associated with better Calculus grades:

- Trigonometry ($\beta = -0.0364$, $t = -3.092$, $p = 0.002$) had the strongest influence, emphasising its role as a foundational skill in Calculus concepts.
- Algebra ($\beta = -0.0280$, $t = -2.732$, $p = 0.006$)
- Solid Geometry (â $= -0.0242$, $t = -2.045$, $p = 0.041$) also significantly predicted performance.

These findings support the constructivist framework (Bruner 1960; Piaget 1977), where new knowledge, such as limits, derivatives, and continuity, is best acquired by building on well-structured prior mathematical understanding**.** Students with stronger Algebra, Trigonometry, and Geometry skills are better equipped to grasp Calculus concepts.

In contrast, Type of School Graduated and Plane Geometry were not significant predictors in the model, suggesting that their contribution to explaining variation in Calculus grades is minimal when other factors are accounted for. This is somewhat consistent with earlier observations in Tables 5 and 8, where school type showed minor performance differences.

The intercept (3.5483) represents the expected Calculus grade for a baseline student, defined in the model as a male, non-STEM entrant with zero scores on all diagnostic components. While hypothetical, this baseline situates Calculus success within the context of both demographic background and prior knowledge.

In summary, the regression model confirms the predictive value of selected diagnostic domains and student academic profiles, albeit with modest explanatory power. The findings underscore the importance of early profiling of students' mathematical competencies and suggest practical applications such as:

- Personalised remediation for non-STEM students
- Emphasis on strengthening Algebra and Trigonometry foundations
- Tailored instructional approaches based on diagnostic data

These data-driven strategies can inform institutional interventions designed to enhance first-year engineering students' success in Calculus and related courses.

CONCLUSION

Based on the study's findings, several conclusions were drawn regarding students' mathematical preparedness and performance in Calculus.

First-year engineering students at CSPC were predominantly male, from public high schools, and largely STEM strand graduates, though a significant portion came from non-STEM backgrounds, indicating varied levels of readiness for college-level mathematics.

Students demonstrated moderate proficiency in foundational math areas, with STEM graduates and private school alumni performing better in the diagnostic test. These trends confirm the test's usefulness in identifying learning gaps prior to advanced coursework.

Calculus performance ranged from satisfactory to passing, with STEM students and males generally achieving higher grades, highlighting the value of prior academic exposure to math-intensive subjects.

A significant negative correlation was found between diagnostic scores and Calculus grades, confirming that higher diagnostic performance predicts better Calculus outcomes. This supports the test's validity as an early assessment tool.

The regression model accurately predicted Calculus performance using diagnostic scores and student profile variables, particularly strand and sex. This predictive accuracy highlights how the diagnostic test can help identify students who need tailored academic support in the future. Comparing these variables provides a clear identification of who among the students may need help and understand the possible reasons for the difficulties they encounter, which enables the study to craft plans for support programs based on the real evidence that the study had gathered.

RECOMMENDATIONS

The following actionable recommendations support student learning and build a body of knowledge on improving mathematics instruction in engineering programs at Camarines Sur Polytechnic Colleges. The institution strongly recommends mandating a diagnostic mathematics assessment for all first-year engineering students at Camarines Sur Polytechnic Colleges. An institution-wide diagnostic process enables faculty to assess from the outset whether students possess the necessary understanding of foundational mathematics and to identify timely academic interventions, an approach shown to improve Calculus performance and retention rates.

The institution recommends creating a structured bridging or remediation program to enhance student assistance, particularly for those who have taken non-STEM strands. This bridging or remediation program should address core competencies in algebra, trigonometry, and geometry so that students can enhance their opportunities for achieving success in higher-level mathematics courses. Faculty should be able to access students' diagnostic profiles to create different teaching strategies. These strategies may include targeted reviews, modular activities, or extra tutorials based on students' needs.

Another recommendation is to strengthen the relationship between second-level or senior high school and upper-level or college curricula. Collaboration with partner SHS institutions could ensure that graduate mathematical competencies align with engineering education standards. Furthermore, the regression model created in this study, as a predictive model of performance in engineering, could also be integrated into academic advising systems, so that the academic advising centre and program heads could identify students with the least risk of success. This use of the predictive model could inform decisions about enrollment, interventions, and academic planning.

On a policy level, the institution might look at updating curricula and prerequisites based on the study results. This step could improve STEM readiness by helping the institution create a more organised support system for students unprepared for their studies.

Finally, the researcher identified a clear need for further research. Future studies may track student development through many mathematics subjects, study students' learning experiences through qualitative strategies, or extend the model to include affective variables such as, for example, math anxiety, study habits, or motivation. These activities could be a valuable addition to the ability of the institution to support student success within engineering education.

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