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Impact of Academic Strand Selection on the Performance of Students in Calculus I in Camarines Sur Polytechnic Colleges in Camarines Sur, Philippines

Liezl B. Namoro

College of Arts and Sciences, Camarines Sur Polytechnic Colleges, Nabua, Camarines Sur, Philippines
E-mail: liezlnamoro@cspc.edu.ph

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ABSTRACT A Descriptive-comparative study examined the relationship between Senior High School Strand selection, particularly STEM and non-STEM, and the Calculus I performance of first- and second-year BS Mathematics and BS Applied Mathematics students at Camarines Sur Polytechnic Colleges. Using a peer-reviewed teacher-made test that covered major Calculus I topics, that is, Limits and Continuity, Derivatives and Differentiation, Applications of Derivatives, and Indefinite Integrals and Application, data were gathered through total enumeration. Statistical analyses employed included Kruskal-Wallis H-Test, DSCF post hoc Test, and Brunner-Munzel Test. Results showed that STEM strand students outperformed their non-STEM counterparts, highlighting stronger preparedness and advantage in college-level Calculus. This underscored a noticeable gap between the two groups. To address this disparity, the study recommends the implementation of bridging programs for non-STEM graduates who intend to pursue mathematics-oriented degree programs, thereby enhancing their readiness and improving performance in foundational college mathematics.

INTRODUCTION

In 2012, the K-12 educational reform was implemented in the Philippines (Department of Education 2012). With the aim to produce quality education at par with international standards, Republic Act No. 10533 had been passed. Simultaneously addressing and inaugurating the addition of 2 years in the basic education system, aptly named the Senior High School (Republic Act No. 10533 | GOVPH 2013).

According to the official gazette of the Department of Education (2019), tracks are defined as a guided curriculum a senior high school student may choose. The tracks consist of the Academic (ACAD), Technical-Vocational-Livelihood (TVL), Arts and Design (A&D), and Sports and Arts (S&A). The Academic track also includes subcategories called Strands. These include Accountancy, Business and Management (ABM), Humanities and Social Sciences (HUMSS), General Academic Strand (GAS), and Science, Technology, Engineering and Mathematics (STEM). Through these tracks and specialised strands, the Department of Education aims to produce graduates who are competitive at international standards.

The Academic track primarily focuses on the various academic disciplines described under its strands. STEM capitalises on the theories and principles associated with science, technology, engineering, and mathematics. ABM strand dwells on taxation, capital, and other business, accountancy and management principles. HUMSS strand prioritises ideas relevant to humanities, philosophies, pedagogies and society. GAS is ideal for students who have not yet decided on a particular specialisation. It offers electives that may be a combination of specialisations of other strands. These strands were purposefully drafted and created to provide students with appropriate support and foundational knowledge that would be integral in whatever career path they choose when applying for college. Hence, often, there have been drafted or associated bachelor's degrees related to a specific track or strand.

The implementation of of the K-12 curriculum is also a direct answer to the Sustainable Development Goal #4 of the United Nations (2020). It is the achievement of Quality Education across the globe. Education liberates the intellect and unlocks the imagination. It is fundamental for self-respect and the foundation of knowledge. It is the key to prosperity and opens a world of opportunities. It makes it possible for everyone to contribute to a progressive, healthy society. Learning benefits every human being and should be available to all. Thus, regardless of academic strands, these students should be accepted in college.

Furthermore, the Department of Science and Technology, through its DOST-SEI Undergraduate Scholarship Program provides scholarships to eligible students taking *priority programs*, and these programs are more often than not STEM programs and are usually programs within fields of Healthcare, Engineering and Sciences.

Meanwhile, the regional research and development agenda of the Philippines has been divided into four sectors. It has been aligned with the Ambisyon Natin 2040 (National Economic and Development Authority 2015). These agendas are Agriculture, Aquatic and Natural Resources, Health, Industry, Energy and Emerging Technology, and Basic Research. The present study falls under Basic Research. It aims to foster the impact of academic strand selection of students enrolled in Calculus. It also depicts the generation of knowledge and ideas that will be derived from the study.

Focusing on the program Bachelor of Science in Mathematics (BS Math) and Bachelor of Science in Applied Mathematics (BS Applied Math), it is ideal that students who would wish to enter this heavily math-themed degree would have first undertaken the STEM strand, as these strands would provide rudimentary knowledge and principles necessary to succeed in the various courses offered in such degree. This ideal process, however, would not always be the case. Some students may have entered a non-STEM strand, yet opted to take BS Math during their college. This sudden shift is surely multifactorial. For whatever reason it may be, there have been increasing statistics of non-STEM students in their senior high school taking STEM-related degrees during their college years.

With the influx of students from non-STEM strands taking STEM undergraduate programs like Bachelor of Science in Mathematics and Applied Mathematics, one cannot help to compare and contrast the differences between the academic performances of non-STEM and STEM students during their SHS in their current degree. There have been various studies published seeking answers to similar queries. Fletcher and Dumford (2025) found that STEM students exhibited higher engagement levels in their courses, which was positively correlated with academic performance, suggesting that prior exposure and curriculum alignment play significant roles in student success. Similarly, Waheed et al. (2024) examined the academic outcomes of STEM and non-STEM female freshmen and observed significant differences in performance, indicating that early preparation in STEM-related curricula provides an advantage in higher education. Furthermore, Tanquilan and Lomibao (2025) investigated the success of non-STEM students in introductory mathematics courses and identified that these students often face challenges in foundational skills, which negatively impacts their ability to keep pace with STEM peers. Collectively, these studies reinforce the notion that the strand selection in senior high school, particularly STEM or non-STEM, substantially affects academic performance in college, especially in mathematically intensive courses such as Calculus I. These findings underscore the importance of preparatory interventions and bridging programs to mitigate the observed disparities and enhance the readiness of non-STEM students for higher-level academic challenges.

This current undertaking, on the other hand, seeks to find answers to the difference in performances of Bachelor of Science in Mathematics and Applied Mathematics college students in Camarines Sur Polytechnic Colleges, who may have or have not taken STEM strand. Specifically, it deals with the first and second-year students who have completed Calculus I. Central to this study is the query about which group did it better, and if there is any difference? These are just some of two bewildering questions the researcher aims to answer, using both descriptive-comparative methods of study. Along the run, the researcher had attempted to craft recommendations that would reflect the results of the current study aimed at resolving issues or conflicts that have arisen during the investigation.

Objectives of the Study

The primary objective of this research was to analyse and compare the performance of students within the Bachelor of Science in Mathematics and Applied Mathematics program who have completed Calculus 1 with reference to their academic strands (STEM or non-STEM) at Camarines Sur Polytechnic Colleges. Specific objectives include:

1. To assess the profile of the respondents in terms of:
   a. SHS Academic Track
   b. Final Grades in Calculus I
2. To analyse the performance of the respondents in Calculus I along:
   a. Limits and Continuity
   b. Derivatives and Differentiation
   c. Applications of Differentiation
   d. Antiderivatives, Indefinite Integral and its Applications
3. To determine whether there is a significant difference in the performance of STEM and non-STEM students in Calculus I.
4. To identify if there is a significant difference in the final grades of STEM and non-STEM students in Calculus I.
5. To be able to evaluate the need for a bridging program for non-STEM BS Math and Applied Math students.

MATERIAL AND METHODS

The main objective of this study was to determine and compare the performance of STEM and non-STEM students enrolled in the Bachelor of Science in Mathematics and Bachelor of Science in Applied Mathematics programs at Camarines Sur Polytechnic Colleges in Calculus I. The respondents included first- and second-year students who have completed Calculus I, with dropouts excluded from the sample. Out of a total population of 138 students, 116 participated in the study, which was deemed acceptable given the 5 percent allowable margin of error. This sampling method was chosen since the total population was relatively small, and total enumeration of available students allowed for a more accurate representation of the groups being compared. The inclusion criteria ensured that only students under the Philippine K-12 system were considered, excluding transferees and those without the required academic background to maintain uniformity in the study.

A descriptive-comparative research design was employed to capture both the current performance level of students and the differences between STEM and non-STEM graduates. The descriptive aspect allowed for the analysis of students' status in Calculus I, while the comparative component facilitated the evaluation of academic gaps between the two groups. This design was chosen because it provides not only a snapshot of student performance but also a meaningful comparison across academic strands, which is crucial for understanding preparedness for mathematics-oriented programs. Data were grouped and compared according to strand, with results analysed through descriptive and inferential methods to establish whether prior academic background contributed to significant differences in Calculus I performance.

The primary instrument used was a teacher-made test designed to align directly with the Calculus I syllabus. The test included 60 multiple-choice items covering major topics including Limits and Continuity, Derivatives and Differentiation, Applications of Differentiation, Antiderivatives, and Indefinite Integrals with Applications. To ensure validity and reliability, the researcher constructed a Table of Specification (TOS) to guide item development, guaranteeing balanced coverage of content areas and cognitive levels. A dry run of the test was administered to third-year students who had already completed Calculus I, and item analysis was conducted to refine or discard weak items based on difficulty and discrimination indices. This step ensured that the final instrument was appropriate, accurate, and fair in measuring the intended outcomes.

Content validation was also carried out by mathematics faculty members to confirm the test's alignment with the course objectives and learning competencies. This rigorous validation process strengthened the credibility of the data-gathering tool, ensuring that results genuinely reflected the students' mastery of Calculus I concepts. These methodological choices were deliberately made to uphold the reliability and validity of findings, as the study sought to uncover performance differences that could inform curriculum design and intervention programs. By anchoring the test to the syllabus, carefully validating its content, and refining it through item analysis, the study ensured that its findings were grounded in robust data. Ultimately, these decisions were necessary to provide actionable recommendations, such as the potential implementation of a bridging program for non-STEM graduates entering mathematics-intensive courses.

RESULTS AND DISCUSSION

Respondents Profile

Senior high school strand/track in this study is integral in grouping the individuals involved. As presented in Table 1, among the 116 student respondents involved in this study, 82 graduated from the STEM strand, while 16, 9 and 7 graduated from GAS, ABM and HUMSS respectively, while 2 graduated from the TVL track. With splits of 82 and 34 from STEM and non-STEM senior high school graduates. This represents a varied background with respect to what kind of senior high school education the respondents of the study have.

In addressing their performance in Calculus I. The involved students' final grades in the course had been collected and tabulated in Table 2. None of the students have garnered a grade higher than 1.39, while 5 have a grade in the range of 1.40-1.79. 16 have a grade between 1.80 and 2.19, and the majority of the students managed a grade in the 2.20-2.59 range. Lastly, 43 students have a grade in the last range of 2.60-3.00. This data set suggests that distribution of student grades in calculus I is skewed to the right, having more of the students have a lower grade equivalent. This also implies that struggle with the course is present across the population as shown with the bulk of the population having poor final grades in the course.

Table 1: Senior high school strand/track profile of respondents

Strand/Track	*Frequency*	*Percentage*
STEM	82	70.70
GAS	16	13.80
ABM	9	7.80
HUMSS	7	6.00
TVL	2	1.70
Total	116	100

Source: Performance of respondents in the validated Teacher-made Test in 2024

Table 2: Final grades in Calculus I

Final grade	*Frequency*	*Percentage*
1.00-1.39	0	0
1.40-1.79	5	4.3
1.80-2.19	16	13.8
2.20-2.59	52	44.8
2.60-3.00	43	37.1
Total	116	100

Source: Performance of respondents in the validated Teacher-made Test in 2024

A Shapiro-Wilk test for normality was conducted on the data to be able to determine what the appropriate statistical tests to be applied are. In Table 3 it was identified that none of the data sets are a normal distribution due to all p-values being less than 0.05. This signifies the appropriate use of nonparametric statistical tests in this study.

In Table 4, a summary of the data from the performance of the respondents in the teacher-made test is compiled. Showing the splits from each subtopic, an analysis of the results are as follows.

Limits and Continuity

The data in this subtopic reflect a fairly spread-out distribution of performance levels. 1 student performed outstanding while 12 had very satisfactory remarks. 24 were satisfactory and the majority of students at 79 were marked as needing improvement. Despite the relatively low performance, it emphasises that senior high school strand selection plays a significant role in determining performance as limits and continuity is one of the early topics taught in senior high school Calculus classes in the STEM strand, it was the subtopic in the teacher-made test that the respondents performed best. This suggests that the strand had prepared the students to some degree to be able to cope with more rigorous math classes in college. This finding is consistent with Aleksic (2025), who noted that limits are generally more accessible for students when taught with structured examples, often resulting in relatively stronger performance compared to advanced calculus concepts. This suggests that the strand had prepared the students to some degree to be able to cope with more rigorous math classes in college.

Table 3: Test for normality of the data

Test	*Shapiro-Wilk W*	*p-Value*
Limits and Continuity	0.985	0.001
Derivatives and Differentiation	0.947	<0.001
Application of Derivatives	0.923	<0.001
Antiderivatives, Indefinite Integrals and Applications	0.943	<0.001
Final Grades	0.966	<0.005

*p<0.05: significant; >0.5: not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

Table 4: Performance in Calculus I results from the teacher-made test

Performance level	*Limits and continuity*		*Derivatives and differentiation*		*Application of derivatives*		*Antiderivatives indefinite integrals and its applications*	
	F	*%*	*F*	*%*	*F*	*%*	*F*	*%*
Outstanding	1	0.9	0	0	0	0	0	0
Very Satisfactory	12	10.3	9	7.8	1	0.9	0	0
Satisfactory	24	20.7	20	17.2	10	8.6	8	6.9
Needs Improvement	79	68.1	87	75	105	90.5	108	93.1

Source: Performance of respondents in the validated Teacher-made Test in 2024

Derivatives and Differentiation

Following a progression of more difficult topics, the performance of the respondents decreased in this subtopic. With none performing outstandingly and with 9 performing very satisfactorily. The majority of the students were found to have performed in the lower half of the performance level scale, 20 were satisfactory and 87 needed improvements, which is an increase from the previous subtopic. This is consistent with the notion that fundamental understanding of mathematics as a foundation of higher-level mathematics is crucial in performing well in these topics. Litteck (2025) confirmed that student knowledge of derivatives is often fragmented, especially in distinguishing between process and object perspectives, which likely contributed to the observed decline in performance.

Application of Derivatives

In this subtopic of the test, another decline in overall performance has been observed. Less than 10 percent of all respondents have performed at least satisfactorily. Once again, none performed outstanding while only 1 had performed very satisfactorily and 10 other students were labelled as satisfactory. The rest of the respondents at 105 students have a remark that needs improvement. This decrease in performance is consistent with the study of Nie (2024) claiming that an incomplete understanding of derivatives leads to higher difficulty in understanding its applications. This implies that students have continually struggled with derivatives across the semester and do not have a firm grasp on how it relates and is used in practical situations. More recently, Hiltrimartin and Pratiwi (2025) highlighted that students' problem-solving skills and achievement emotions significantly affect outcomes in derivative-related tasks, reinforcing the observation that students continually struggle to apply derivatives in practical situations.

Antiderivatives, Indefinite Integrals and Its Applications

Lastly, this subtopic had reflected the lowest performance level among all of the subtopics of the teacher-made test. None of the student respondents performed with a remark of outstanding nor very satisfactory while only 8 had performed satisfactorily. The vast majority of the students qualified for a remark of needs improvement with 108 students. This highlights what Orton (1983) concluded in his study. Claiming that the introduction of antiderivatives and integrals cannot be done effectively when a student does not have a clear grasp of the material beforehand. The lack of satisfactory performance from the previous subtopics contributed to the poor performance in the antiderivatives portion of the teacher-made test. Tashtoush (2024) found that without enhanced STEM-based preparation, students tend to underperform in integral concepts, while Milenkoviæ et al. (2024) emphasised that digital technologies can significantly aid visualisation and understanding of integrals, a tool not always accessible to all learners. The lack of satisfactory performance from the previous subtopics therefore contributed to the poor performance in the antiderivatives portion of the teacher-made test.

As a whole, the data show that the overall performance of BS Math and Applied Math students participating in this study had been poor, with the majority of the students in each subtopic performing with a need's improvement remark. This indicates that the overall skill retention or fluency in Calculus I is not yet on par with the prescribed level of performance by the college curriculum. This may be due to multiple factors, with senior high school strand selection, specifically STEM or non-STEM, being a large impact factor.

Test for Significant Differences: Limits and Continuity

The Kruskal-Wallis test presented in Table 5 revealed a significant difference in students' performance on the Limits and Continuity subtopic across the five senior high school strands, H (4) = 18.10, p = 0.001. Among the groups, STEM students obtained the highest mean rank (66.78), indicating stronger performance compared to their peers from HUMSS (47.29), GAS (38.16), ABM (34.61), and TVL (28.50). The post hoc Dwass-Steel-Critchlow-Fligner test further confirmed that STEM students significantly outperformed ABM (p = 0.041) and GAS (p = 0.015) students, suggesting that prior exposure to advanced mathematics in the STEM curriculum provided them with a clear advantage in grasping fundamental calculus concepts. This result reinforces the claim of Atindama et al. (2025) that STEM-prepared students tend to achieve higher success rates in foundational mathematics courses such as Calculus I compared to their non-STEM peers.

The consistent superiority of STEM students' performance highlights how curricular background and mathematical preparedness influence success in college-level calculus. The observed differences also suggest that non-STEM strands, particularly ABM and GAS, may require additional instructional support or bridging programs to strengthen their mathematical foundations. While these findings underscore a meaningful relationship between strand selection and calculus performance, caution is warranted as other factors, such as study habits, teaching quality, and motivation, could also contribute to the observed disparities. Nonetheless, the results emphasise the importance of strand alignment with program requirements and the need for early interventions to ensure equitable learning outcomes in foundational mathematics courses. Recent evidence also supports this trend, showing that STEM-prepared students achieved notably higher success rates in foundational courses such as Calculus I compared to their non-STEM peers (Atindama et al. 2025).

The Brunner-Munzel test reflected on Table 5 comparing STEM (mean rank = 66.78) against all non-STEM strands combined (mean rank = 38.53) yielded BM = 4.934, df = 63.6, p < 0.001, indicating a clear and statistically significant advantage for STEM students on the Limits and Continuity subtest. This outcome is plausibly explained by early curricular exposure to Limits and Continuity, which is introduced in senior high calculus mainly to STEM students (and to GAS students only as an elective), so STEM graduates enter college having already practiced these concepts, an observation consistent with Tomas (2025), who reports superior Basic Calculus performance among Grade 11 STEM students. While the mean-rank gap suggests a substantial difference in preparedness, the statistical result alone does not prove causality, as it most directly shows an association between strand selection and measured performance.

Table 5: Comparison of respondents' performance in limits and continuity across SHS strands/tracks, including DSCF Post Hoc analysis and STEM vs. Non-STEM differences

Strands/Track	*n*	*Mean rank*	*Kruskal-Wallis H*	*p-value*	*Interpretation*
STEM	82	66.78	18.1	0.001	Significant
GAS	16	38.16			
ABM	9	34.61			
HUMSS	7	47.29			
TVL	2	28.5			
Total	116				
Strand/Track pair		*Mean ranks*	*W-score*	*p-value*	*Interpretation*
ABM/GAS		12.75/13.15	0.204	1	Not significant
ABM/HUMSS		7.94/9.21	0.763	0.983	Not significant
ABM/STEM		22.83/48.54	3.955	0.041	Significant
ABM/TVL		6.11/5.5	-0.341	0.999	Not significant
GAS/HUMMS		11.56/13.00	0.671	0.99	Not significant
GAS/STEM		29.38/53.43	4.415	0.015	Significant
GAS/TVL		9.56/9.00	-0.204	1	Not significant
HUMSS/STEM		31.79/46.13	2.012	0.613	Not significant
HUMSS/TVL		33.07/17.00	-0.846	0.975	Not significant
STEM/TVL		43.18/14.5	-2.345	0.46	Not significant
Strands/Track	*n*	*Mean rank*	*Test Statistic*	*p-value*	*Interpretation*
STEM	82	66.78	4.934	<0.001	Significant
Non-STEM	34	38.53			
Total	116				

*p<0.05, significant; >0.5, not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

Critically, several alternative explanations could contribute to the observed disparity and should temper strong claims that prior achievement, self-selection into STEM, differences in teaching quality, and the teacher-made test's alignment with STEM-taught topics may all amplify the apparent advantage of STEM students. Molina (2019) similarly warns that strand alignment with mathematics-oriented degree programs influences proficiency, but recommends adjusting for covariates before inferring direct effects, and following that advice, reporting effect sizes, group Ns, medians/IQRs, and running covariate-adjusted models would clarify how much of the gap is attributable to strand versus other factors. The paper underscores the need for holistic interventions that address the complex and intersecting factors shaping the learning experiences of students who are being treated as a minority in STEM. Although it does not explicitly prescribe diagnostic screening or structured bridging programs for non-STEM entrants, its call for comprehensive curricular reviews implicitly supports such measures. By emphasizing equitable access to foundational calculus concepts, the discussion aligns with the use of diagnostic assessments to identify incoming students' preparedness, as well as targeted bridging or remedial modules to address gaps in prior knowledge. These interventions serve as concrete mechanisms through which curricular equity can be operationalized, ensuring that all incoming students—regardless of academic background—are provided with adequate support to succeed in calculus-intensive programs (Ibrahim et al. 2025).

The Brunner-Munzel analysis reflected in the table above comparing the performance of STEM and non-STEM students on the Application of Derivatives subtopic revealed a statistically significant difference between the two groups (BM = 3.7, df = 69.7, $p < 0.001$). The STEM group recorded a higher mean rank (64.94) compared to the non-STEM group (42.96), indicating a distinct advantage for students who had undergone a more mathematically intensive curriculum in senior high school. This result, consistent with the patterns reflected in earlier analyses (see Table 4), suggests that while the majority of students experience difficulty in applying derivative concepts, STEM graduates demonstrate a relatively higher level of proficiency and conceptual retention. The observed disparity may be attributed to prior exposure to advanced mathematical concepts in the STEM strand, which emphasises calculus-related competencies, thereby enhancing students' preparedness for complex applications at the tertiary level.

These findings corroborate the assertions of Krohn and O'Connor (2005), who found that students' performance in subsequent assessments is highly influenced by earlier academic outcomes, suggesting a recursive relationship between prior success and later achievement. Similarly, Yang (2024) emphasised that regular formative assessments, such as in-class quizzes and problem-based homework, are significant predictors of success in advanced calculus examinations. In the present context, the observed performance gap between STEM and non-STEM students may therefore reflect differences in both academic preparedness and learning continuity. The decline in overall scores across groups implies that conceptual understanding, rather than procedural memorisation, remains a challenge. Consequently, instruction in calculus should emphasise the integration of conceptual mastery with practical applications of derivatives through consistent formative evaluation and problem-based learning approaches to strengthen retention and performance across student groups.

Test for Significant Differences: Derivatives and Differentiation

The Kruskal-Wallis test for the Derivatives and Differentiation as presented in Table 6 is a subtopic produced a highly significant omnibus result ($H(4) = 26.4$, $df = 4$, $p < 0.001$), with STEM students showing the highest mean rank (67.79) compared with HUMSS (51.50), ABM (45.56), TVL (41.00), and GAS (23.41). The markedly higher STEM mean rank, and its apparent improvement relative to the earlier Limits and Continuity subtest, indicates that STEM-prepared students are not only more likely to perform better on derivative items but may also retain or consolidate derivative skills more effectively. However, the statistical significance should be interpreted alongside measures of practical significance (for example, epsilon-squared or rank-based effect sizes) and group sample sizes, since large rank differences can be amplified by uneven Ns or test alignment with STEM-taught content.

Critically, while Malusay (2025) supports the pattern of superior derivative-topic performance among STEM strands, these results remain associational with prior exposure, selection effects, instructor variance, and assessment design, which could all contribute to the observed gaps. To strengthen claims, follow-up analyses are recommended, including effect-size reporting, covariate adjustment (prior math achievement, entrance scores), and item-level diagnostics to determine whether STEM advantage is conceptual or procedural. Pedagogically, the findings point to the need for targeted bridging activities and formative practice for non-STEM entrants, plus curricular review to ensure key derivative concepts are accessible to all students entering Calculus I.

The post hoc analysis reflected on Table 6 identified the GAS/STEM pairing as the primary driver of the omnibus effect, with mean ranks 19.34 (GAS) versus 55.38 (STEM) and $p < 0.001$, indicating a large and statistically robust difference in performance on the Derivatives and Differentiation items. This substantial mean-rank gap suggests that when compared directly, STEM-prepared students demonstrate markedly better readiness for college-level derivative problems than their GAS counterparts, despite GAS offering pre-calculus or basic calculus as elective options for some students. The finding therefore signals more than just a marginal advantage, as it points to systematic differences in curriculum intensity, depth of mathematical practice, or the proportion of GAS students who actually elect and complete those math electives.

Critically, the result remains correlational and may reflect selection effects (students with stronger math aptitude self-selecting into STEM), differences in elective uptake within GAS, variation in instructional quality, or alignment of the teacher-made test with STEM-taught content. To strengthen inference, report effect-

Table 6: Comparison of respondents' performance in derivatives and differentiation across SHS strands/ tracks, including DSCF post hoc analysis and STEM vs. Non-STEM differences

Strands/Track	*n*	*Mean rank*	*Kruskal-Wallis H*	*p-value*	*Interpretation*
STEM	82	67.79	26.4	<0.001	Significant
GAS	16	23.41			
ABM	9	45.56			
HUMSS	7	51.5			
TVL	2	41			
Total	116				
Strand/Track pair		*Mean ranks*	*W-score*	*p-value*	*Interpretation*
ABM/GAS		16.72/10.91	-2.754	0.292	Not significant
ABM/HUMSS		7.50/9.79	1.431	0.85	Not significant
ABM/STEM		30.44/47.71	2.652	0.331	Not significant
ABM/TVL		5.89/6.50	0.364	0.999	Not significant
GAS/HUMMS		9.69/17.29	3.608	0.08	Not significant
GAS/STEM		19.34/55.38	6.604	<0.001	Significant
GAS/TVL		8.97/13.75	1.734	0.736	Not significant
HUMSS/STEM		31.14/46.18	2.108	0.569	Not significant
HUMSS/TVL		32.43/23.75	-0.926	0.966	Not significant
STEM/TVL		43.02/20.50	-1.776	0.719	Not significant
Strands/Track	*n*	*Mean rank*	*Test Statistic*	*p-value*	*Interpretation*
STEM	82	67.79	5.99	<0.001	Significant
Non-STEM	34	36.09			
Total	116				

*p<0.05: significant; p>0.05: not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

size estimates and group Ns, and run adjusted analyses that include prior achievement, elective participation, and other covariates, item-level diagnostics would clarify whether STEM advantage is conceptual or procedural. Practically, the pronounced GAS-STEM gap underscores the need for diagnostic screening at course entry and for targeted bridging or scaffold instruction that can mitigate preparedness differences and broaden access to calculus success for GAS students.

The Brunner-Munzel test as presented in the table, which is a comparison of STEM (mean rank = 67.79) and non-STEM (mean rank = 36.09) students, yielded BM = 5.99, df = 76.4, $p < 0.001$, indicating a robust and statistically significant advantage for STEM entrants in this derivatives-related subtopic. Given that this material is typically taught in the first half of senior high calculus, the result plausibly reflects curriculum exposure, wherein STEM students more often receive sustained, structured instruction in these topics, consistent with broader findings that early foundational learning predicts later success in calculus (Ferenstein and Hershbein 2013).

However, the observed gap should be interpreted cautiously, as the analysis demonstrates association rather than causation and may be influenced by selection effects, prior achievement, differential elective uptake, or the alignment of the teacher-made test with STEM-oriented pedagogy. Reporting effect sizes, group Ns, medians/IQRs, and running covariate-adjusted models (for example, controlling for prior math grades or entrance scores) would clarify how much of the BM difference is attributable to strand per se. Nonetheless, the pattern aligns with Santelices et al. (2024) and supports implementing diagnostic screening and targeted bridging to mitigate readiness gaps for non-STEM entrants.

Test for Significant Differences: Application of Derivatives

The Kruskal-Wallis analysis reported in Table 7 indicates a statistically significant difference in Derivatives and Differentiation performance across strands (H (4) = 14.40, df = 4, p =

Table 7: Performance in application of derivatives by SHS strand/track: Overall comparison, DSCF post hoc results, and STEM vs. Non-STEM differences

Strands/Track	*n*	*Mean rank*	*Kruskal-Wallis H*	*p-value*	*Interpretation*
STEM	82	64.95	14.4	0.006	Significant
GAS	16	49.34			
ABM	9	29.94			
HUMSS	7	52.57			
TVL	2	16.75			
Total	116				
Strand/Track pair		*Mean ranks*	*W-score*	*p-value*	*Interpretation*
ABM/GAS		9.78/14.81	2.394	0.439	Not significant
ABM/HUMSS		7.17/10.21	1.884	0.671	Not significant
ABM/STEM		21.67/48.67	4.181	0.026	Significant
ABM/TVL		6.33/4.50	-1.093	0.939	Not significant
GAS/HUMMS		11.91/12.21	0.147	1	Not significant
GAS/STEM		37.97/51.75	2.546	0.374	Not significant
GAS/TVL		10.15/4.25	-2.167	0.542	Not significant
HUMSS/STEM		36.50/45.73	1.3	0.89	Not significant
HUMSS/TVL		38.14/11.00	-1.92	0.655	Not significant
STEM/TVL		43.30/9.75	-2.755	0.292	Not significant
Strands/Track	*n*	*Mean rank*	*Test Statistic*	*p-value*	*Interpretation*
STEM	82	64.94	3.7	<0.001	Significant
Non-STEM	34	42.96			
Total	116				

*p<0.05: significant; p>0.05: not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

0.006). Although STEM students still rank highest (mean rank = 64.95), this represents a decline from earlier subtests, while other mean ranks were HUMSS 52.57, GAS 49.34, ABM 29.94, and TVL 16.75. The omnibus result therefore confirms heterogeneity in group performance, and when read together with the downward trend noted in Table 4, it suggests a general drop in student achievement for this subtopic that affects strands unevenly.

The observed reduction in the STEM mean rank relative to prior subtests warrants closer scrutiny rather than simple interpretation as a weakening of STEM preparation. Possible explanations include increasing conceptual complexity in adjacent items, cumulative cognitive load across the instrument, misalignment between the teacher-made items and the specific emphases of STEM curricula, or differential attrition and sample composition across strands. Importantly, mean ranks are rank-based summaries and do not convey effect magnitude, reporting medians, interquartile ranges, and a rank-based effect size (for example, epsilon-squared) would clarify the practical significance of the apparent decline.

The post hoc pairwise testing reflected in Table 7 identified the ABM/STEM pairing as significantly different (mean ranks 21.67 vs. 48.67, p = 0.026), implicating curriculum exposure as a likely mechanism, wherein ABM students are typically not offered instruction in many derivative topics at senior high and therefore may lack prior practice with these applications. Nevertheless, alternative explanations, self-selection into STEM by mathematically stronger students, unequal Ns and statistical power across strands, or differential elective uptake within ABM, could also produce the observed gap. Item-level analysis would be particularly useful here to determine whether the ABM deficit is concentrated on procedural, algebraic, or conceptual items.

To strengthen internal validity and pedagogical inference, the manuscript should present group sample sizes, medians/IQRs, exact post hoc test statistics, and an effect-size estimate, and then test robustness using covariate-adjusted models (for example, controlling for prior math grades or entrance exam scores). From a practice standpoint, the findings support Molina's (2019) as cited by Tanquilan and Lomibao (2025) assertion that strand alignment influences proficiency and argue for early diagnostic screening and targeted bridging modules for ABM and other non-STEM entrants to bolster retention and concept mastery. Future work should replicate these results with larger, balanced samples and include qualitative probes (student interviews, instructor reports) to unpack curricular and motivational contributors to the strand gaps.

The results presented in Table 7 reveal a statistically significant difference in the performance of STEM and non-STEM students in the Application of Derivatives subtopic, as evidenced by the Brunner-Munzel test (BM = 3.7, df = 69.7, $p < 0.001$). The STEM group attained a mean rank of 64.94, markedly higher than the 42.96 mean rank of the non-STEM group, suggesting that STEM students demonstrated greater proficiency and confidence in applying derivative concepts. This finding aligns with the data trends in Table 4, indicating that while calculus remains a challenging subject for most, STEM graduates possess a distinct advantage rooted in their prior exposure to advanced mathematical topics. These results affirm the continuing influence of strand preparation on college-level calculus performance, emphasising the curricular alignment advantage held by STEM students.

From a pedagogical standpoint, this outcome resonates with the findings of Krohn and O'Connor (2005), who observed that students' current performances are often shaped by prior successes or struggles, reinforcing the cumulative nature of mathematical learning. The relatively lower performance of non-STEM students may thus be attributed to limited exposure to calculus concepts during senior high school, resulting in weaker conceptual retention and lower procedural fluency. To address these disparities, instructors must emphasise conceptual understanding alongside procedural mastery by integrating contextualised applications of derivatives in instruction. Supporting this approach, Yang (2024) found that consistent engagement through in-class quizzes and practice assignments significantly improved students' final calculus outcomes, highlighting the importance of formative reinforcement and continuous learning in sustaining long-term mathematical competence.

Test for Significant Differences: Antiderivatives, Indefinite Integral and its Applications

As shown in Table 8, the performance comparison for the subtopic Antiderivatives, Indefinite Integral and its Applications revealed a statistically significant difference among the strands, as indicated by the Kruskal-Wallis test (H(4) = 27.9, df = 4, $p < 0.001$). The STEM strand achieved the highest mean rank of 68.77, substantially outperforming GAS (34.78), ABM (34.17), HUMSS (37.79), and TVL (9.00). This pattern highlights the consistent dominance of STEM students in higher-order calculus topics, likely reflecting their systematic exposure to advanced mathematical reasoning and problem-solving in their senior high curriculum. The sharp performance contrast underscores how curricular alignment, particularly prior engagement with calculus-based content, enhances readiness for complex integrative applications in college mathematics.

Critically, these findings illuminate the persistent learning gap between students with and without pre-college calculus training. Integration and antiderivatives require abstract thinking, algebraic dexterity, and conceptual fluency, skills that STEM students are more likely to have cultivated. The significant disparity also implies that non-STEM strands may not provide adequate scaffolding for these higher-order mathematical concepts, resulting in conceptual fragmentation when transitioning to tertiary education. This aligns with broader educational research emphasising the role of curricular coherence and mathematical maturity in facilitating deeper understanding of integrative calculus concepts. Hence, strategic instructional interventions, such as calculus bridging programs or remedial modules contextualised for non-STEM learners, are warranted to foster equitable learning outcomes across strands.

As presented in Table 8, the pairwise comparison of strand performance in Antiderivatives, Indefinite Integral, and its applications revealed

Table 8: Performance in antiderivatives and indefinite integrals by SHS Strand/Track: Overall comparison, DSCF post hoc results, and STEM vs. Non-STEM differences

Strands/Track	*n*	*Mean rank*	*Kruskal-Wallis H*	*p-value*	*Interpretation*
STEM	82	68.77	27.9	<0.001	Significant
GAS	16	34.78			
ABM	9	34.17			
HUMSS	7	37.79			
TVL	2	9			
Total	116				
Strand/Track pair		*Mean ranks*	*W-score*	*p-value*	*Interpretation*
ABM/GAS		12.94/13.03	0.041	1	Not significant
ABM/HUMSS		8.50/8.50	0	1	Not significant
ABM/STEM		21.06/48.74	4.263	0.022	Significant
ABM/TVL		6.67/3.00	-2.062	0.59	Not significant
GAS/HUMMS		12.16/11.64	-0.243	1	Not significant
GAS/STEM		24.97/54.29	5.389	0.001	Significant
GAS/TVL		10.12/4.50	-2.04	0.6	Not significant
HUMSS/STEM		23.86/46.80	3.223	0.152	Not significant
HUMSS/TVL		25.64/4.50	-2.423	0.426	Not significant
STEM/TVL		43.45/3.75	-3.247	0.146	Not significant
Strands/Track	*n*	*Mean rank*	*Test Statistic*	*p-value*	*Interpretation*
STEM	82	68.77	7.08	<0.001	Significant
Non-STEM	34	33.72			
Total	116				

*p<0.05, significant; >0.5, not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

statistically significant differences between ABM/STEM (p = 0.022) and GAS/STEM (p = 0.001) pairings. The mean rank disparities, 21.06/48.74 for ABM/STEM and 24.97/54.29 for GAS/STEM, clearly indicate that STEM students substantially outperformed their non-STEM peers in both cases. This reinforces the recurring trend observed across previous subtopics, where STEM strand preparation serves as a strong predictor of success in college-level calculus. The results underscore that exposure to calculus during senior high school equips STEM students with the analytical tools and conceptual fluency necessary to navigate complex integration problems with greater ease and confidence.

From a broader pedagogical perspective, these findings highlight the systemic advantage that curricular continuity confers upon STEM graduates. The statistically significant differences between STEM and both ABM and GAS strands may reflect disparities not merely in mathematical exposure but also in cognitive readiness and familiarity with higher-order reasoning tasks. While GAS students have optional calculus electives, the rigour and continuity of the STEM curriculum appear more effective in fostering transferable problem-solving skills. These findings point to an urgent need for curriculum designers to reconsider how non-STEM strands integrate mathematical literacy and conceptual application, ensuring that students across all academic tracks gain equitable access to foundational calculus competencies essential for tertiary success.

The data presented in Table 8 reveal a statistically significant difference between the performances of STEM and non-STEM students in the subtopic Antiderivatives and Indefinite Integrals, as shown by the Brunner-Munzel test (BM = 7.08, df = 71.1, p < 0.001). The STEM group achieved a substantially higher mean rank (68.77) compared to the 33.72 of the non-STEM group, underscoring the considerable advantage held by STEM students in mastering this complex area of calculus. This trend mirrors earlier findings and highlights how the vertically structured mathematical curriculum in STEM strands strengthens both procedural and conceptual understanding necessary for higher-level calculus topics. The consistency of this performance gap reinforces the premise that prior curricular exposure to calculus significantly influences success in tertiary-level mathematics.

Critically, the observed decline in the performance of non-STEM students suggests a progressive conceptual gap rooted in foundational weaknesses in derivatives, echoing Sealey's (2014) assertion that proficiency in derivatives directly predicts competence in antiderivatives. Students who lack fluency in differentiating functions naturally face difficulty in reversing these operations to compute integrals, revealing a break in conceptual continuity essential for success in calculus learning. The findings of Barniol et al. (2024) further validate this interpretation, as they identified that students' errors in antiderivative problem-solving often stem from insufficient internalisation of derivative concepts. These results emphasise the need for pedagogical reforms that reinforce conceptual retention, emphasising the interconnectedness of calculus topics through iterative and context-based learning strategies that help bridge gaps between foundational and advanced mathematical operations.

Test for Significant Differences: Final Grades of the Students

Table 9 provided the comparison of participants' final grades revealed statistically significant differences among the strands, as indicated by the Kruskal-Wallis test H (4) = 11.7, df = 4, p = 0.020). The mean rank distribution showed STEM (64.28) as the highest among the academic strands, followed by HUMSS (44.07), GAS (43.00), and ABM (38.56), while TVL (85.75) displayed an unexpectedly high rank, possibly due to outlier effects or smaller subgroup size. The observed differences suggest that strand background continues to exert an influence on over-

Table 9: Comparison of respondents' final grades across SHS strands and STEM/Non-STEM groups with post hoc analysis

Strands/Track	*n*	*Mean rank*	*Kruskal-Wallis H*	*p-value*	*Interpretation*
STEM	82	64.28	11.7	0.02	Significant
GAS	16	43			
ABM	9	38.7956			
HUMSS	7	44.07			
TVL	2	85.75			
Total	116				

Strand/Track pair	*Mean ranks*	*W-score*	*p-value*	*Interpretation*
ABM/GAS	13.78/12.56	-0.563	0.995	Not significant
ABM/HUMSS	8.83/8.07	-0.458	0.998	Not significant
ABM/STEM	44.02/64.00	-3.057	0.015	Significant
ABM/TVL	6.83/2.25	-2.571	0.363	Not significant
GAS/HUMMS	11.84/12.79	0.239	1	Not significant
GAS/STEM	46.49/64.91	-3.362	0.022	Significant
GAS/TVL	10.19/4.00	-2.198	0.527	Not significant
HUMSS/STEM	58.79/43.82	-2.087	0.579	Not significant
HUMSS/TVL	31.50/64.00	-2.106	0.57	Not significant
STEM/TVL	42.88/27.00	-1.291	0.892	Not significant

Strands/Track	*n*	*Mean rank*	*Test Statistic*	*p-value*	*Interpretation*
STEM	82	64.28	-3.114	0.003	Significant
Non-STEM	34	44.56			
Total	116				

*p<0.05, significant; >0.5, not significant
Source: Performance of respondents in the validated Teacher-made Test in 2024

all academic performance, extending beyond topic-specific calculus results. This reinforces earlier findings that curricular alignment and mathematical preparedness play key roles in shaping not only topic-based outcomes but also cumulative course performance.

Critically, these results highlight the compounding effects of prior learning pathways on long-term academic achievement. The superior performance of STEM students aligns with their sustained advantage in earlier subtopics, reflecting the cumulative benefit of a strong mathematical foundation. However, the anomalously high mean rank of the TVL strand warrants further scrutiny, as it may reflect heterogeneity in assessment contexts or grade weighting rather than true superiority in calculus performance. These findings collectively affirm that a student's senior high school strand serves as a determinant of readiness for mathematically intensive coursework, underscoring the need for institutional support systems that bridge foundational gaps for non-STEM learners to promote equitable performance outcomes in higher education.

As shown in Table 9, the results of the Dwass-Steel-Critchlow-Fligner (DSCF) pairwise test revealed significant differences in final grades between the strand pairings of ABM-STEM ($p = 0.015$) and GAS-STEM ($p = 0.022$), with corresponding mean ranks of 44.02/64.00 and 46.49/64.91, respectively. These results reinforce the consistent performance advantage of STEM students observed throughout the study, suggesting that their preparatory background continues to influence final academic outcomes in calculus. The magnitude of these differences demonstrates how early curricular exposure to advanced mathematics not only benefits topic-specific mastery but also translates into stronger cumulative achievement in related higher education courses.

This pattern supports the premise that strand-based curricular alignment plays a pivotal role in shaping students' overall learning trajectories and achievement patterns. The evident gap between STEM and non-STEM strands may be attributed to both cognitive and structural factors, as STEM curricula emphasise iterative problem-solving and cumulative skill development, whereas non-STEM strands often lack sustained exposure to quantitative reasoning. The findings emphasise the need for bridging programs or contextualised calculus instruction to mitigate performance disparities and foster equitable learning opportunities across academic tracks. In this sense, the significant differences identified in Table 9 reflects academic stratification but highlight systemic imbalances in curriculum design that merit pedagogical and institutional response.

The Brunner-Munzel test reflected in Table 9 comparing final grades of STEM (mean rank = 64.28) and non-STEM (mean rank = 44.56) students yielded $BM = -3.114$, $df = 64.7$, $p = 0.003$, indicating a statistically significant advantage for STEM entrants in overall course performance. This result reinforces the pattern observed throughout the subtopic analyses and aligns with prior work suggesting a persistent performance gap between STEM-prepared and non-STEM students (Rubas 2023). The consistency across tests implies that prior mathematical exposure in senior high, both curricular breadth and practice, contributes meaningfully to students' ability to meet the rigour of college calculus and related professional coursework (Masiglat et al. 2025).

Nevertheless, the statistical difference should be interpreted cautiously, as the association does not establish causation, and the observed gap may reflect selection effects (stronger math students opting for STEM), unmeasured covariates (prior grades, entrance scores, elective uptake), assessment alignment, or subgroup sample-size imbalances that amplify rank differences. To better understand practical importance and policy implications, report nonparametric effect sizes, group Ns, medians/IQRs, and conduct covariate-adjusted analyses, qualitatively probing students' prior coursework and learning experiences would also clarify mechanisms. Pedagogically, however, the findings justify early diagnostic screening and targeted bridging or scaffold interventions for non-STEM entrants to promote conceptual readiness and close the performance gap in Calculus I.

CONCLUSION

The analysis of the data revealed several key insights regarding the relationship between senior high school strand selection and Calculus I performance among BS Mathematics and BS Applied Mathematics students at Camarines Sur Polytechnic Colleges. The participants came from diverse strands and tracks, with most students attaining final grades higher than 2.59. Results from the teacher-made test demonstrated a gradual decline in performance across the subtests, where *Limits and Continuity* emerged as the highest-performing area and *Antiderivatives and Indefinite Integrals with Applications* yielded the lowest mean scores.

Statistical analyses confirmed significant differences between STEM and non-STEM groups across all subtopics, with ABM-STEM and GAS-STEM pairs showing significant variations in three subtopics each. Similar patterns of statistical significance were also observed in the students' final grades. These findings collectively indicate that STEM graduates are better prepared to handle the demands of college-level Calculus compared to their non-STEM counterparts.

The consistent superiority of STEM students aligns with prior research emphasising the impact of early exposure to advanced mathematical subjects such as algebra, trigonometry, and pre-calculus in fostering analytical and problem-solving skills. In contrast, the relative lack of exposure among non-STEM students to these foundational concepts may account for their lower performance and reduced confidence in handling higher-level mathematical coursework.

Overall, this study highlights a clear academic disparity between STEM and non-STEM students in Calculus I, reinforcing the importance of early mathematical preparation as a determinant of success in mathematics-oriented college programs. Addressing this gap is essential to promote equity and academic excellence in higher mathematics education.

RECOMMENDATIONS

In light of the findings, this study recommends the development and institutionalisation of a Mathematics Bridging Program specifically designed for non-STEM senior high school graduates aspiring to enroll in BS Mathematics and BS Applied Mathematics programs. The primary objective of this program is to equip students with the requisite mathematical foundations, particularly in algebra, trigonometry, and pre-calculus, to ensure readiness for college-level Calculus.

The bridging program should adopt a structured curriculum that integrates diagnostic assessments, modular instruction, and targeted skill-building activities. It is also recommended that this initiative employ blended learning approaches, incorporating both face-to-face and digital platforms to maximise accessibility and engagement.

Furthermore, periodic evaluations of student performance should be conducted to monitor the program's effectiveness and inform continuous improvement. Collaboration among mathematics faculty, curriculum planners, and educational researchers is encouraged to refine the program's content, pedagogy, and implementation.

By systematically addressing the preparatory gaps of non-STEM students, institutions can foster greater inclusivity and enhance overall academic achievement in mathematics-oriented disciplines. This strategic intervention not only supports equitable access to learning opportunities but also contributes to the long-term development of competent and confident mathematics graduates.

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