Senior High School Background and Learning Practices as Predictors of First-Year Academic Performance in Board Examination-Related Mathematics Subjects among Civil Engineering Students

Jocelyn G. Garlando*, Wallyn M. Lanzuela, Neil R. Abonita, Alvirie Claire A. Bermejo-Uvero, Beverly S. Gavasan, Marineth O. Haber, Jeremias C. Lopez, Jr., Edmund M. Salvadora, Glenford O. Tamo

College of Engineering and Architecture, University of Saint Anthony

***Corresponding Author**

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ABSTRACT

This study evaluated senior high school background and learning practices as predictors of first-year academic performance in board examination-related mathematics subjects among civil engineering students at the University of Saint Anthony during school year 2025–2026. It described respondents' profiles in terms of sex, senior high school track, type of school attended, and Grade 11 General Mathematics final grade; learning practices in time optimization, resource utilization, and examination readiness; and performance in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus. A descriptive-predictive correlational design was employed involving 48 first-year civil engineering students, with data collected through a structured questionnaire and analyzed using descriptive statistics, independent t-tests, one-way analysis of variance (ANOVA), Pearson correlation, and multiple linear regression (MLR). Results indicated that many respondents were female STEM graduates from private institutions with high Grade 11 General Mathematics performance; learning practices were generally rated "Often," and most students earned grades in the 85–94 range in Differential Calculus, Analytic and Solid Geometry, and Integral Calculus, while Algebra and Plane Trigonometry had the highest concentration of grades in the lowest passing bracket (75–79). No significant differences in academic performance were found when respondents were grouped by sex, track, or school type, but significant differences were found when they were grouped by Grade 11 General Mathematics final grade. Prior mathematics achievement had a positive and significant relationship with first-year subject performance, and multiple regression confirmed Grade 11 General Mathematics final grade as the only significant predictor of overall academic performance. Based on these findings, the study proposes Project IELP, an Integrated Engineering Learning Productivity and Academic Support Framework, to guide initiatives aimed at enhancing learning practices and mathematics performance among first-year civil engineering students.

Keywords: Academic performance, Civil engineering education, Learning practices, Senior High School background, Board examination-related mathematics subjects

INTRODUCTION

Civil engineering is widely recognized as a cognitively demanding undergraduate program that requires advanced analytical, quantitative, and spatial reasoning skills from the outset of study (Mapua University, 2026). The first year is especially critical because it concentrates board examination-related mathematics subjects such as Differential Calculus, Integral Calculus, Algebra and Plane Trigonometry, and Analytic and Solid Geometry. These courses serve as prerequisite gateways to higher-level structural, geotechnical, and hydraulics subjects and prepare students for the civil engineering licensure examination (CHED, 2017; Johnson, 2022; EBSCO, 2022; Evans, 2022; Zimmer, 2022).

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In the Philippines, these curricular demands intersect with national and international commitments to quality tertiary education. Key frameworks include the Enhanced Basic Education Act of 2013, outcomes-based standards for the Bachelor of Science in Civil Engineering program, and global agendas such as Sustainable Development Goal 4 and UNESCO's higher education reports, which call for inclusive, competency-based preparation for a rapidly changing economy (Republic Act No. 10533, 2013; CHED, 2017; Hessen & Schmelkes, 2022; Detmer, 2022). This alignment positions the academic performance of first-year civil engineering students in mathematics not only as an internal institutional concern but also as a matter of public interest linked to national infrastructure development and human capital priorities (Republic Act No. 544, 1950; NEDA, 2023).

Recent evidence reveals a persistent gap between these policy aspirations and actual academic outcomes in civil engineering education. Data from the Professional Regulation Commission show that civil engineering licensure examination passing rates remain below one third of examinees, raising concerns about long-term academic preparedness that likely originate in the first year of college and even earlier in senior high school (PRC Board News, 2023; Professional Regulation Commission [PRC], 2025). Local studies report that substantial proportions of first-year engineering students are not mathematically ready for college, with particular weaknesses in calculus skills such as evaluating differential equations, computing definite integrals, and solving problems involving areas between curves (Perante, 2022). At the secondary level, national data indicate that only a minority of senior high school students enroll in the STEM track. Many prospective civil engineering students come from other strands or from schools with varied resources and instructional quality (Senate of the Philippines, 2023; Technological and Vocational Education Research Center & K–12 Education Administration, 2022). International reports likewise emphasize that differences in secondary track, mathematics exposure, and subject achievement shape readiness for tertiary STEM programs. This suggests that heterogeneous senior high school backgrounds translate into unequal starting points in first-year civil engineering mathematics courses (OECD, 2022, 2023; Second Congressional Commission on Education, 2025; Cariaso, 2026).

The interplay between background preparation and current study behavior in engineering mathematics can be clarified through several educational theories. Walberg's Theory of Educational Productivity explains academic achievement as the result of interactions among learner characteristics, instructional factors, and psychological environments. This perspective implies that prior background and present learning practices must be examined together to understand performance outcomes (Walberg, 1981; Combong & Napil, 2025). Ausubel's Theory of Meaningful Learning highlights prior knowledge as the most important determinant of new learning and distinguishes between rote memorization and meaningful assimilation of new material into existing cognitive structures (Ausubel, 1968; Bryce & Blown, 2024). Zimmerman's Theory of Self-Regulated Learning describes academic learning as a cyclical process of forethought, performance, and self-reflection, in which students plan, monitor, and adjust their study behaviors in response to academic demands (Zimmerman, 1989; Schunk & Zimmerman, 2023).

Building on these perspectives, the present study adopts an integrative framework that treats senior high school background as cognitive capital that students bring into civil engineering mathematics courses. Learning practices in time optimization, resource utilization, and examination readiness are viewed as behavioral capital that students invest during the term, with academic performance in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus conceptualized as the key outcome influenced by these two forms of capital.

Despite the growing literature on STEM readiness, self-regulated learning, and licensure performance, there is limited institution-level empirical evidence in the Philippine context that simultaneously examines senior high school background and learning practices as predictors of first-year academic performance in board examination-related civil engineering mathematics subjects. Many existing investigations focus on single structural variables, such as track or school type, or emphasize general study habits without situating them within the specific demands of engineering mathematics and professional licensure preparation (Han & Guo, 2025; Faza & Lestari, 2025; Caixia et al., 2025; Biber, 2022; Ucol, 2024). As a result, faculty members, program heads, and academic administrators often lack multivariate, data-driven evidence to design early warning mechanisms, bridging courses, and intervention programs that systematically address both cognitive and behavioral dimensions of underperformance in first-year civil engineering mathematics.

In response, the present study examines how senior high school background and learning practices relate to academic performance in key board examination-related mathematics subjects among first-year civil engineering students at a Philippine higher education institution. Specifically, it focuses on background indicators such as sex, senior high school track, type of school attended, and Grade 11 General Mathematics final grade, together with learning practices in time optimization, resource utilization, and examination readiness. These variables are linked to students' performance in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus. The study aims to generate localized evidence that can guide the development of an academic intervention program to strengthen learning practices, address gaps in mathematics preparation, and enhance readiness for the civil engineering licensure examination.

METHODOLOGY

Research Design

This study employed a descriptive-predictive correlational quantitative research design to examine senior high school background and learning practices as predictors of first-year academic performance in board examination-related subjects among civil engineering students. Quantitative research design relies on the systematic collection and statistical analysis of numerical data to uncover patterns, differences, and relationships among specified variables (Slater & Hasson, 2024). This design was appropriate because it allowed the researchers to describe the respondents' profiles and learning practices, determine the strength of relationships between variables, and evaluate the predictive power of senior high school background and learning practices on academic performance without manipulating any conditions.

The descriptive component profiled the respondents in terms of sex, senior high school track, type of school attended, and Grade 11 General Mathematics final grade, as well as their levels of learning practices and academic performance. The correlational component examined whether significant relationships existed between Grade 11 General Mathematics final grade and first-year mathematics performance and between learning practices and academic performance. The predictive component used regression analysis to determine how effectively senior high school background and learning practices could forecast first-year performance in board examination-related mathematics subjects, providing an empirical basis for a proposed academic intervention program.

Respondents and Sampling Technique

The target population of this study consisted of all 74 first-time, regular first-year students officially enrolled in the Bachelor of Science in Civil Engineering program at the University of Saint Anthony during the school year 2025–2026. The researchers initially adopted a total population sampling strategy, inviting all members of this small, clearly defined group to participate in the study (Canonizado, 2024). However, because participation required the voluntary disclosure of official academic grades, only 48 students consented to take part and completed the online questionnaire, resulting in a response rate of 64.86 percent. The final sample thus represents all first-time, regular freshmen who both met the population criteria and agreed to the use of their academic records, and the findings are interpreted within this response-based limitation.

Research Instrument and Validation

The primary data collection tool was a structured, researcher-made questionnaire designed to gather standardized information on the respondents' profiles, learning practices, and academic performance in foundational mathematics subjects (Sharma & Ruikar, 2025). The instrument consisted of three parts. Part I, the Respondent Profile, obtained data on sex, senior high school track, type of senior high school attended, and Grade 11 General Mathematics final grade. In this study, these four variables are collectively referred to as profile variables,

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comprising demographic background (sex, senior high school track, type of school attended) and prior mathematics achievement (Grade 11 General Mathematics final grade). Part II, the Learning Practices Scale, measured behavioral study habits across three subdimensions: time optimization, resource utilization, and examination readiness. Items in this section were rated on a five-point Likert-type scale from 5 to 1, using item-specific descriptors tailored to the targeted behavior, with higher scores indicating more favorable learning practices. For example, an item under time optimization asked respondents how often they prepare a weekly schedule, with response options ranging from “Every single week (4 times a month)” to “0 times a month (Never).” Another item under resource utilization asked how many extra problems students solve, with descriptors ranging from “10 or more extra problems per week” to “0 extra problems (I only do assigned homework)”. These behavior-specific anchors were designed to translate abstract learning practices into concrete, observable study habits while retaining a common five-point structure across items. The full list of these tailored descriptors is available from the corresponding author upon reasonable request. For the final analysis, the overall weighted mean scores were interpreted using standard verbal descriptors such as "Always," "Often," "Sometimes," "Seldom," and "Never" (McLeod, 2025). Part III, the Academic Performance Data, recorded the respondents' final percentage grades in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus.

The questionnaire underwent expert review and pilot testing to ensure content validity and contextual appropriateness. The initial draft was evaluated by the Program Chair of Civil Engineering at the University of Saint Anthony, who examined the clarity, technical accuracy, and alignment of the items with the civil engineering curriculum. The instrument was then pilot tested with ten second year civil engineering students from the same institution, who had already completed the relevant first-year mathematics courses. Their feedback was used to refine item wording and layout, thereby enhancing readability and face validity before full deployment.

Prior to the main data analysis, the internal consistency of the learning practices questionnaire was assessed using McDonald's omega, a reliability coefficient that is well suited for multi-item Likert scales (Warne, 2025). The omega coefficients for the three subscales ranged from 0.818 to 0.845, all of which exceeded the acceptable threshold of 0.70, confirming that the indicators for time optimization, resource utilization, and examination readiness reliably measured their intended constructs.

Data Gathering Procedure

The finalized questionnaire was encoded into Google Forms and disseminated through official institutional communication channels dedicated to freshman civil engineering students. At the beginning of the online instrument, an informed consent section explained the purpose of the study, the voluntary nature of participation, the use of academic grades, and the measures taken to protect confidentiality. Students indicated their consent by clicking an agreement button before gaining access to the main questionnaire items.

Data collection continued until all 48 consenting respondents had completed the online form. After retrieval, the researchers validated the respondents' academic performance data by implementing a grade integration procedure, conducted in coordination with the instructors who handled Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus and in line with institutional data privacy protocols. The instructors submitted official grade sheets for these subjects for use in the approved study, and the researchers matched each respondent's survey data with their corresponding final grades based on these verified records. Names and student numbers were removed during this process, and unique codes were used to link profile, learning practices, and grade data in the final analytical matrix.

Ethical Considerations

This study involved minimal risk and focused on the academic experiences of adult students in a higher education setting. To protect participants' rights and privacy, the researcher followed established ethical principles for research with human participants and complied with national data privacy regulations. Participation was entirely

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voluntary, and respondents retained the right to withdraw at any point without academic penalty. An informed consent statement at the beginning of the online questionnaire explained the purpose of the study, the use of academic grades, and the measures taken to ensure confidentiality. No personally identifiable information was included in the final analytical dataset; all responses were anonymized and stored on a password-protected computer in electronic files accessible only to the primary researcher. After the completion of data analysis and reporting, all identifiable links between codes and individual students were deleted.

Statistical Treatment of Data

The data on respondents' profiles, learning practices, and mathematics grades were organized and cleaned using Microsoft Excel prior to statistical analysis. Descriptive statistics, including frequency counts, percentages, weighted means, and standard deviations, were computed to summarize the distribution of profile variables and to describe the respondents' levels of learning practices and academic performance in the four board examination-related subjects.

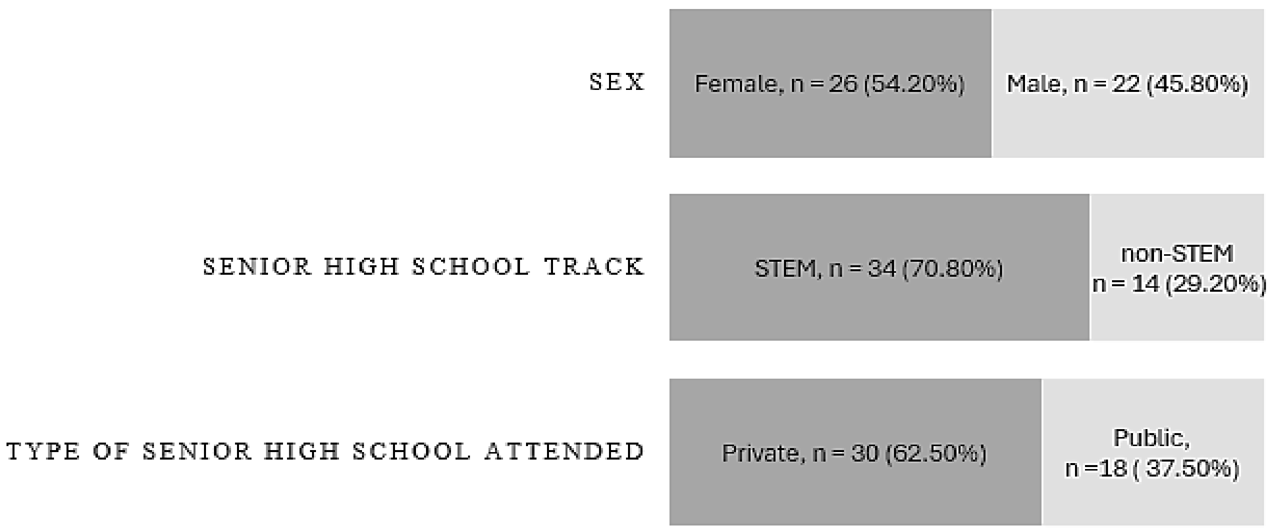
Inferential analyses were conducted to address the specific research questions of the study. Independent samples t-tests were used to determine whether significant differences in first-year academic performance existed when respondents were grouped according to sex, senior high school track, and type of senior high school attended. One-way Analysis of Variance (ANOVA) was applied to test for significant differences in academic performance across categories of Grade 11 General Mathematics final grade. Pearson Product–Moment correlation coefficients were computed to examine the strength and direction of the relationships between (a) Grade 11 General Mathematics final grade and academic performance in each board examination-related subject and (b) the three learning practice subscale scores and mathematics performance. Finally, Multiple Linear Regression (MLR) was used to determine the collective and individual predictive contributions of senior high school background variables and learning practices subscales to first-year academic performance in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus. All inferential tests were evaluated at a 0.05 level of significance. All computational routines and inferential statistics were executed using jamovi (version 2.6.44) to ensure processing precision.

RESULT AND DISCUSSION

Profile of the Respondents

The demographic profile of the 48 first-year civil engineering respondents is summarized in Figure 1, categorizing the group by sex, senior high school track, and type of secondary institution attended.

Figure 1. Percentage Distribution of First-Year Civil Engineering Students by Demographic Profile



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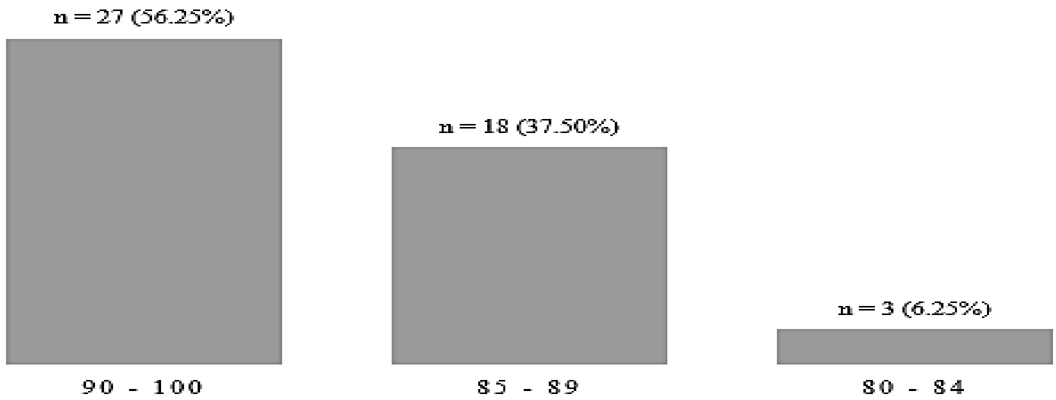
Sex. Twenty-six of the 48 respondents (54.20%) identified as female and 22 (45.80%) as male, indicating a near-balanced group with increasing female representation in civil engineering programs. This pattern is notable given that national data still show a gender gap in technical employment after graduation, underscoring the importance of supportive learning environments for female students (Chi, 2023; Weale, 2024).

Senior High School Track. Thirty-four respondents (70.80%) graduated from the STEM track, while 14 (29.20%) came from non-STEM strands. This means that almost one third of the group entered without standard preparatory training in calculus, analytic geometry, or advanced algebra, creating an uneven baseline of mathematical fluency (Nguyen et al., 2024; OECD, 2022, 2023).

Type of Senior High School Attended. Thirty respondents (62.50%) completed senior high school in private institutions and 18 (37.50%) in public schools. This distribution suggests that students bring diverse study habits and resource access shaped by their prior school environments, which can influence self-regulated learning capacity and readiness for competitive engineering programs (Schunk & Zimmerman, 2023; De Villa, 2026).

Grade 11 General Mathematics Final Grade. As shown in Figure 2, 27 respondents (56.25%) attained grades of 90–100, 18 (37.50%) attained 85–89, and 3 (6.25%) attained 80–84. This concentration of high secondary grades indicates that the program enrolls mathematically capable students, although this does not guarantee a smooth transition into the faster-paced, higher-stakes demands of first-year subjects such as Differential Calculus and Analytic and Solid Geometry. Prior work has shown that these baseline mathematics grades are useful indicators for early warning systems and early collegiate retention (Hanssens et al., 2025), while low mathematics self-efficacy can still undermine strong prior performance, reinforcing the need to use these grades to design responsive academic interventions (Atienza, 2024).

Figure 2. Frequency Distribution of Grade 11 General Mathematics Final Grades



Level of Learning Practices of Civil Engineering Students

Tables 1 to 3 present the respondents' learning practices in terms of Time Optimization, Resource Utilization, and Examination Readiness. Overall, the findings indicate that the respondents generally practiced positive study behaviors, with all three domains obtaining verbal interpretations at the "Often" level. However, some specific indicators suggest that these practices were stronger in routine academic behaviors than in deeper, more strategic forms of self-regulated learning.

Time Optimization. Table 1 shows that the respondents obtained an average weighted mean of 3.74, interpreted as "Often," indicating that they generally managed their study time well. The highest-ranked behaviors were allocating more time to difficult subjects, arriving prepared before lectures, and starting requirements several days before deadlines. In contrast, the lowest-ranked indicators were setting specific daily study goals, eliminating digital distractions, and maintaining a consistent sleep schedule. These findings suggest that while the respondents were able to organize their general study routines, they were less consistent in micro-level self-management behaviors that support sustained academic efficiency. This pattern is consistent with Schunk and

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Zimmerman (2023), who emphasized that effective self-regulated learning depends not only on broad scheduling but also on goal setting, monitoring, and behavioral control.

Table 1. Level of Learning Practices of Civil Engineering Students along Time Optimization

Indicators	Weighted Mean (WM)	Verbal Interpretation (VI)	Standard Deviation (SD)	Rank
1. I prepare a weekly schedule that includes specific time for studying civil engineering subjects.	3.79	Often	0.771	4
2. I allocate more study time to difficult subjects such as mathematics and engineering sciences.	4.13	Often	0.789	1
3. I start working on requirements (assignments, projects) several days before the deadline.	3.85	Often	0.743	3
4. I make it a habit to be settled in the classroom before my civil engineering professor begins the lecture.	3.98	Often	0.729	2
5. I set specific daily goals for what topics to study in my civil engineering subjects.	3.50	Often	0.825	10
6. I dedicate my vacant periods between classes to accomplish assignments or review previous lectures instead of engaging in non-academic activities.	3.73	Often	0.818	5.5
7. I break down large engineering projects or extensive problem sets into smaller tasks distributed across multiple days.	3.73	Often	0.676	5.5
8. I eliminate digital distractions by muting notifications or putting away my mobile phone during my dedicated study hours.	3.52	Often	0.922	9
9. I review and organize my lecture notes on the exact same day the civil engineering class was held.	3.65	Often	0.887	7
10. I prioritize a consistent sleep schedule to ensure mental alertness for my math and engineering classes rather than pulling all-nighters.	3.54	Often	0.874	8
Average Weighted Mean	**3.74**	**Often**	**0.518**	

Resource Utilization. Table 2 shows that Resource Utilization obtained an average weighted mean of 3.56, also interpreted as "Often." The most frequently practiced behaviors were watching online instructional videos, using advanced calculator functions, and drawing visual aids to understand difficult problems. The least practiced behaviors were visiting the university library, consulting professors, and seeking mentorship from senior students. This indicates that respondents relied more heavily on technology-based and independent resources than on institutional or interpersonal forms of academic support. While this pattern reflects active engagement with accessible learning tools, it also suggests limited use of help-seeking strategies that may strengthen understanding in demanding mathematics subjects. This observation is supported by Biber (2022), who noted that high-performing students tend to combine independent study with strategic help-seeking behaviors.

Table 2. Level of Learning Practices of Civil Engineering Students along Resource Utilization

Indicators	WM	VI	SD	Rank
1. I read the recommended textbook or reference materials for my CE courses.	3.60	Often	0.869	4.5
2. I watch online videos (e.g., YouTube, MOOCs) to better understand difficult topics.	4.29	Always	0.824	1

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3. During a typical week, I consult alternative engineering textbooks, reference manuals, or instructional modules beyond what my professor provides.	3.60	Often	0.736	4.5
4. I practice solving extra problems or exercises not assigned by the instructor.	3.56	Often	0.897	6
5. I integrate board exam reviewers, past quizzes, and compiled engineering problem sets into my routine weekly study sessions.	3.48	Often	0.772	7
6. I visit the university library to access civil engineering references.	2.92	Sometimes	1.01	10
7. I maximize the use of my scientific calculator by learning its advanced built-in functions (e.g., equation solvers, shift-solve, table generation) to double-check my manual algebra and calculus computations.	4.00	Often	0.799	2
8. I actively approach my professors to clarify difficult civil engineering concepts.	3.21	Sometimes	1.11	9
9. I draw comprehensive visual aids, such as free-body diagrams or spatial sketches, to better understand complex math and physics problems.	3.71	Often	0.771	3
10. I actively seek academic advice, mentorship, or study techniques from senior civil engineering students.	3.23	Sometimes	0.973	8
Average Weighted Mean	**3.56**	**Often**	**0.522**	

Examination Readiness. Table 3 shows that Examination Readiness obtained an average weighted mean of 3.67, interpreted as "Often," indicating that respondents generally engaged in preparatory behaviors for examinations. The highest-ranked practices were summarizing key formulas and solution steps, analyzing mistakes in quizzes or exams, and using basic test-taking strategies, while explaining concepts to peers, practicing under timed conditions, and integrating past Civil Engineering Licensure Examination (CELE) problems into review were less frequently applied. This pattern suggests that students are more oriented toward routine recall and error checking than toward simulation-based strategies that mirror board examination level demands, consistent with Biber's (2022) observation that higher mathematics performance is associated with deliberate, strategic exam preparation rather than basic review alone.

Table 3. Level of Learning Practices of Civil Engineering Students along Examination Readiness

Indicators	**WM**	**VI**	**SD**	**Rank**
1. I start reviewing for exams several days before the scheduled date.	3.73	Often	0.707	4.5
2. I summarize key formulas, concepts, and problem-solving steps before an exam.	4.19	Often	0.816	1
3. I form or join study groups to review for major exams in CE subjects.	3.56	Often	0.987	7
4. I analyze my mistakes in quizzes or exams to avoid repeating them.	4.04	Often	0.683	2
5. I practice answering problems under time pressure when preparing for exams.	3.27	Sometimes	1.07	9
6. I test my exam readiness by trying to explain or teach complex math concepts and problem-solving steps to my peers.	3.35	Sometimes	1.04	8

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7. I integrate actual past Civil Engineering Licensure Examination (CELE) math problems into my review to align my readiness with board-level difficulty.	3.25	Sometimes	1.02	10
8. I employ strategic test-taking techniques during the exam, such as answering easier problems first before tackling time-consuming ones.	3.90	Often	0.928	3
9. I plan and practice mathematical verification techniques, such as back-substitution or dimensional analysis (unit checking), to validate my final answers during the exam.	3.71	Often	0.771	6
10. I ensure adequate physical preparation (e.g., eating a nutritious meal, proper hydration) immediately before taking a major exam to maintain focus.	3.73	Often	1.03	4.5
Average Weighted Mean	**3.67**	**Often**	**0.566**	

Taken together, the three subscales show that the respondents generally demonstrated favorable learning practices, but these were more evident in routine and accessible study behaviors than in more deliberate, higher-order strategies. This implies that academic support efforts may focus not only on maintaining positive study habits but also on strengthening goal setting, help-seeking, and board examination oriented preparation practices that are less consistently applied across the group.

Academic Performance in First-Year Board Examination-Related Subjects

Table 4 summarizes the respondents' academic performance in four board examination-related mathematics subjects: Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus. The distributions show that most students obtained grades in the mid-to-high passing brackets (85–94) in the calculus and geometry subjects, whereas Algebra and Plane Trigonometry had the largest concentration of grades in the lowest passing bracket (75–79) and one failure, indicating a comparatively weaker profile in this course.

Table 4. Academic Performance in First-year Board Examination-Related Subjects

Academic Performance	Frequency	Percentage	Rank
Differential Calculus			
95–100	1	2.08 %	5
90–94	13	27.08 %	2
85–89	20	41.67 %	1
80–84	12	25.00 %	3
75–79	2	4.17 %	4
TOTAL	**48**	**100.00 %**	
Algebra and Plane Trigonometry			
95–100	2	4.17 %	5
90–94	3	6.25 %	3.5
85–89	3	6.25 %	3.5
80–84	11	22.92 %	2
75–79	28	58.33 %	1
Below 75	1	2.08 %	6
TOTAL	**48**	**100.00 %**	

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Analytic and Solid Geometry			
95–100	2	4.17 %	4.5
90–94	6	12.50 %	3
85–89	23	47.91 %	1
80–84	15	31.25 %	2
75–79	2	4.17 %	4.5
TOTAL	**48**	**100.00 %**	
Integral Calculus			
95–100	2	4.17 %	5
90–94	13	27.08 %	2
85–89	20	41.67 %	1
80–84	8	16.67 %	3
75–79	5	10.41 %	4
TOTAL	**48**	**100.00 %**	

Differential Calculus. Most students obtained grades between 85 and 94, with only a few in the lowest (75–79) and highest (95–100) brackets, indicating solid but not exceptional mastery of introductory calculus concepts. This pattern suggests that the group has adjusted reasonably well to the analytical demands of Differential Calculus, although there is limited movement into the distinction range. Studies such as Dela Cruz et al. (2023) similarly report that students with stronger upper-secondary mathematics backgrounds tend to perform better in early engineering mathematics courses.

Algebra and Plane Trigonometry. In contrast, grades in Algebra and Plane Trigonometry were concentrated in the lower passing range, with many students just above the minimum passing mark and relatively few attaining high or excellent grades. This indicates that algebraic and trigonometric competencies remain a key vulnerability despite course completion, echoing Perante's (2022) finding of moderate to low proficiency in these areas among engineering freshmen.

Analytic and Solid Geometry. For Analytic and Solid Geometry, most respondents earned grades in the 80–89 range, with very few at either the failing or outstanding extremes. This suggests relatively stable spatial and geometric skills across the group and fewer severe underachievers, although there is still scope to develop more students toward the top performance bracket. The distribution is consistent with research highlighting analytic geometry as an important foundation for later civil engineering competencies.

Integral Calculus. Performance in Integral Calculus closely resembled that in Differential Calculus, with a substantial proportion of students in the 85–94 range and only a small number reaching the highest bracket. This indicates that many students were able to maintain satisfactory grades as mathematical difficulty increased, but that very high proficiency in advanced calculus remains uncommon. Mahadewsing et al. (2024) emphasize that success in advanced calculus depends strongly on prior mathematical knowledge, which aligns with the parallel strength observed in Differential Calculus and reinforces the importance of consolidating foundational skills early.

Differences in First-Year Academic Performance by Profile Variables

Independent samples t-tests and one-way analysis of variance (ANOVA) were used to examine whether first-year civil engineering students' grades in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus differed significantly when grouped by sex, senior high school track, type of

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senior high school attended, and Grade 11 General Mathematics final grade. The detailed test statistics for each subject and profile variable are presented in Table 5.

Table 5. Differences in First-Year Academic Performance by Profile Variables

Subject / Profile Variables	Category	N	Mean	SD	*t/F-value*	*p-value*	Conclusion
Differential Calculus							
Sex	Male	22	86.9	4.10	0.122	0.904	Not Significant
	Female	26	86.7	5.41			
Senior High School Track	STEM	34	87.1	5.11	-0.843	0.404	Not Significant
	non-STEM	14	85.9	3.98			
Type of Senior High School Attended	Private	30	86.5	4.72	-0.438	0.663	Not Significant
	Public	18	87.2	5.06			
Grade 11 General Mathematics Final Grade	90–100	27	89.2	3.90	11.83	<0.001	Significant
	85–89	18	84.0	3.99			
	80–84	3	81.7	4.73			
Algebra and Plane Trigonometry							
Sex	Male	22	78.8	6.50	-1.19	0.240	Not Significant
	Female	26	80.9	5.52			
Senior High School Track	STEM	34	80.4	6.25	-0.849	0.400	Not Significant
	non-STEM	14	78.8	5.51			
Type of Senior High School Attended	Private	30	78.7	4.89	-1.769	0.088	Not Significant
	Public	18	82.1	7.19			
Grade 11 General Mathematics Final Grade	90–100	27	81.4	6.91	2.53	0.091	Not Significant
	85–89	18	78.5	4.12			
	80–84	3	75.0	0.00			
Analytic and Solid Geometry							
Sex	Male	22	85.1	4.72	-0.738	0.464	Not Significant
	Female	26	86.1	4.46			
Senior High School Track	STEM	34	85.5	4.65	0.461	0.647	Not Significant
	non-STEM	14	86.1	4.45			
Type of Senior High School Attended	Private	30	84.8	4.21	-1.808	0.077	Not Significant
	Public	18	87.2	4.84			
Grade 11 General Mathematics Final Grade	90–100	27	87.4	4.25	8.26	<0.001	Significant
	85–89	18	84.1	3.18			
	80–84	3	79.0	6.08			
Integral Calculus							
Sex	Male	22	86.9	4.88	0.474	0.638	Not Significant
	Female	26	86.3	4.48			
Senior High School Track	STEM	34	87.0	4.56	-0.951	0.346	Not Significant
	non-STEM	14	85.6	4.80			
Type of Senior High School Attended	Private	30	85.8	4.86	-1.562	0.125	Not Significant
	Public	18	87.9	3.98			
Grade 11 General Mathematics Final Grade	90–100	27	88.9	3.57	11.55	<0.001	Significant
	85–89	18	83.3	4.26			
	80–84	3	85.0	3.61			

Across all four subjects, no significant differences in academic performance were found by sex, track, or school type, indicating that these profile characteristics did not independently account for difference in first-year board examination-related mathematics grades. In contrast, Grade 11 General Mathematics final grade showed significant differences in Differential Calculus, Analytic and Solid Geometry, and Integral Calculus, confirming that stronger upper-secondary mathematics preparation is consistently associated with higher achievement in these courses. This pattern aligns with reports that prior mathematics achievement is a key determinant of success in early engineering mathematics (Dela Cruz et al., 2023) and supports the view that upper-secondary mathematics functions as a critical bridge to tertiary STEM performance (OECD, 2023).

The absence of significant differences by profile, together with the robust effect of Grade 11 General Mathematics final grade, suggests that academic monitoring and intervention are better anchored on verified mathematics competence than on sex, strand, or school type. This provides empirical support for using prior mathematics performance as a primary criterion in early-warning and support systems for first-year civil engineering students.

Relationship between Grade 11 General Mathematics and First-Year Academic Performance in Board Examination-Related Subjects

Pearson product moment correlation was conducted to determine whether the Grade 11 General Mathematics final grade significantly correlates with academic performance in Differential Calculus, Algebra and Plane Trigonometry, Analytic and Solid Geometry, and Integral Calculus. The resulting correlation coefficients for the 48 civil engineering respondents are presented in Table 6.

Table 6. Relationship between Grade 11 General Mathematics and First-Year Academic Performance in Board Examination-Related Subjects

Pair of Variables	*Pearson's r*	*p-value*	95% CI	Conclusion
Grade 11 General Mathematics Final Grade - Differential Calculus	0.631	<0.001	[0.425, 0.776]	Significant Relationship
Grade 11 General Mathematics Final Grade - Algebra and Plane Trigonometry	0.375	0.009	[0.102, 0.596]	Significant Relationship
Grade 11 General Mathematics Final Grade - Analytic and Solid Geometry	0.514	<0.001	[0.269, 0.696]	Significant Relationship
Grade 11 General Mathematics Final Grade - Integral Calculus	0.537	<0.001	[0.298, 0.712]	Significant Relationship

Note: $n = 48$. CI = Confidence Interval. Values in parentheses represent the 95% confidence interval [lower bound, upper bound]. $p < 0.05$

Grade 11 General Mathematics final grade showed statistically significant positive correlations with all four board examination-related subjects, with the strongest association in Differential Calculus and similarly moderate-to-large effects in Integral Calculus and Analytic and Solid Geometry, and a weaker but still significant correlation in Algebra and Plane Trigonometry. This pattern indicates that General Mathematics operates as a broad indicator of mathematical readiness rather than a predictor limited to any single course, suggesting that cognitive and procedural foundations established in senior high school carry forward into more advanced calculus, geometry, and trigonometry work. Consistent with studies showing that weak mathematical prerequisites hinder students' ability to cope with the conceptual demands of calculus and related subjects (Mahadewsing et al., 2024; Perante, 2022), these findings support the use of Grade 11 General Mathematics grades as an early screening metric to identify at-risk students and inform proactive intervention in first-year civil engineering programs.

Relationship between Learning Practices and First-Year Academic Performance in Board Examination-Related Subjects

Pearson correlation analysis was conducted to determine whether respondents' learning practices, operationalized as Time Optimization, Resource Utilization, and Examination Readiness, significantly correlate with academic performance in first-year board examination-related subjects. The correlation coefficients, p values, and 95% confidence intervals for each subscale are summarized in Table 7 (N = 48).

Table 7. Relationship between Learning Practices and First-Year Academic Performance in Board Examination-Related Subjects

Learning Practices	*Pearson's r*	*p-value*	95% CI	Conclusion
Differential Calculus				
Time Optimization	0.081	0.585	[-0.208, 0.357]	No Significant Relationship
Resource Utilization	0.124	0.399	[-0.165, 0.395]	No Significant Relationship
Examination Readiness	0.080	0.589	[-0.209, 0.356]	No Significant Relationship
Algebra and Plane Trigonometry				
Time Optimization	-0.147	0.318	[-0.208, 0.357]	No Significant Relationship
Resource Utilization	-0.147	0.320	[-0.413, 0.144]	No Significant Relationship
Examination Readiness	-0.248	0.089	[-0.497, 0.039]	No Significant Relationship
Analytic and Solid Geometry				
Time Optimization	0.356	0.013	[0.080, 0.582]	Significant Relationship
Resource Utilization	0.303	0.036	[0.021, 0.541]	Significant Relationship
Examination Readiness	0.200	0.172	[-0.089, 0.458]	No Significant Relationship
Integral Calculus				
Time Optimization	0.223	0.127	[-0.065, 0.477]	No Significant Relationship
Resource Utilization	0.175	0.234	[-0.115, 0.438]	No Significant Relationship
Examination Readiness	0.156	0.288	[-0.134, 0.422]	No Significant Relationship
Note :$n = 48$. CI = Confidence Interval. Values in parentheses represent the 95% confidence interval [lower bound, upper bound]. $p < 0.05$				

Correlational analysis showed that the three learning-practice subscales (Time Optimization, Resource Utilization, and Examination Readiness) were not significantly related to performance in Differential Calculus, Algebra and Plane Trigonometry, or Integral Calculus, with all confidence intervals including zero. This pattern suggests that in these subjects, achievement is driven more by cumulative mathematical foundations than by semester-based study behaviors alone, consistent with work indicating that weak prerequisite knowledge limits the impact of learning strategies in calculus and related courses (Mahadewsing et al., 2024; Zhang et al., 2024). In Algebra and Plane Trigonometry, the weak negative correlations may further indicate that students who struggle tend to increase their effort without achieving corresponding gains, likely because algebraic and trigonometric scaffolding is insufficient.

In Analytic and Solid Geometry, by contrast, Time Optimization and Resource Utilization were significantly and positively correlated with academic performance, whereas Examination Readiness was not. This finding implies that disciplined scheduling and active use of learning resources are particularly beneficial in a subject that demands sustained spatial reasoning and multi-step problem solving. It aligns with evidence that effective time management and strategic resource use are associated with higher achievement in mathematically intensive courses (Biber, 2022; Caixia et al., 2025), suggesting that self-regulated learning practices can have subject-specific rather than uniform effects across the first-year mathematics curriculum.

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Predictive Relationship between the Senior High School Background, Learning Practices, and First-Year Academic Performance in Board Examination-Related Subjects

Multiple Linear Regression was conducted to determine whether the Grade 11 General Mathematics final grade and the three learning practice subscales (Time Optimization, Resource Utilization, and Examination Readiness) collectively and individually predict first-year academic performance in board examination-related subjects. The regression coefficients, standard errors, t values, and model fit statistics for the 48 civil engineering respondents are summarized in Table 8.

Table 8. Predictive Relationship between the Senior High School Background, Learning Practices, and First-Year Academic Performance in Board Examination-Related Subjects

Predictor Variable	First-Year Academic Performance in Board Examination-Related Subjects				
	Estimate (β)	**SE**	***t*- value**	***p- value***	**Conclusion**
Grade 11 General Mathematics Final Grade	0.723	0.120	6.0459	<0.001	Significant Predictor
Time Optimization	1.884	1.356	1.3892	0.172	Not a Significant Predictor
Resource Utilization	-0.101	1.265	-0.0796	0.937	Not a Significant Predictor
Examination Readiness	-1.665	1.025	-1.6237	0.112	Not a Significant Predictor
Note. $N = 48$. $R^2 = .474$. Adjusted $R^2 = .425$. $p < .05$.					

The multiple linear regression model yielded $R^2 = .474$ (Adjusted $R^2 = .425$), indicating that senior high school background and learning practices together explained a substantial proportion of the variance in first-year academic performance in board examination-related subjects. Among the four predictors, only Grade 11 General Mathematics final grade was statistically significant (β = 0.723, $p < .001$), while Time Optimization, Resource Utilization, and Examination Readiness did not reach significance. This shows that prior mathematics achievement has a distinct and independent contribution to first-year performance, even after accounting for students' reported study behaviors.

The dominance of Grade 11 General Mathematics as the sole significant predictor suggests that strong secondary-level mathematics competence is the primary driver of success in first-year civil engineering mathematics, with learning practices playing a more limited incremental role once prior achievement is controlled. This pattern is consistent with studies indicating that pre-entry mathematics grades and related indicators are strong predictors of first-year engineering performance and effective tools for identifying at-risk students (Hanssens et al., 2025; Alexan & Karkouti, 2024). It also underscores the importance of institutional efforts to strengthen foundational mathematics preparation as a key strategy for improving outcomes in board examination-related subjects.

Proposed Academic Intervention Program to Improve the Learning Practices and Mathematics Performance of First-Year Civil Engineering Students

This intervention program was developed in response to empirical evidence on the performance of first-year civil engineering students at the University of Saint Anthony. The study showed that Grade 11 General Mathematics final grades are strongly associated with outcomes in board examination-related mathematics subjects, while learning practices in time optimization, resource utilization, and examination readiness are only moderately developed and unevenly applied. Algebra and Plane Trigonometry emerged as a persistent area of weakness, indicating structural gaps in algebraic and trigonometric foundations that particularly affect students entering from non-STEM tracks.

Guided by the Integrated Engineering Learning Productivity (IELP) framework, which treats senior high school mathematics background as intellectual capital and learning practices as behavioral capital, the program is designed to be evidence-based and closely aligned with the first-year Bachelor of Science in Civil Engineering curriculum. It seeks to strengthen prerequisite mathematics competencies while systematically upgrading study behaviors through embedded diagnostic screening, board examination-aligned practice, structured resource use, time-management training, focused algebraic remediation, and continuous monitoring. By integrating these components into existing departmental routines, the program aims to shift students from reactive study habits to sustained, self-regulated learning practices that improve mathematics performance and enhance long-term board examination readiness.

CONCLUSION

This study demonstrates that although first-year civil engineering students at the University of Saint Anthony generally possess strong secondary mathematics foundations, there remains a critical vulnerability in algebraic and trigonometric competencies that is not explained by sex, senior high school track, or school type. Grade 11 General Mathematics' final grade emerged as the primary driver of first-year success in board examination-related mathematics subjects, while learning practices such as time optimization and resource utilization showed subject-specific effects, most notably in Analytic and Solid Geometry. These findings confirm that prior academic achievement functions as the dominant predictor of first-year mathematics performance, indicating that civil engineering programs should move beyond reliance on demographic background alone toward early-warning systems grounded in verified mathematical competence.

At the same time, the study is limited by its single-institution context, relatively small sample size (N = 48), and reliance on voluntary participation, which may introduce response bias and constrain the generalizability of the results. The findings should therefore be interpreted as localized evidence that requires cautious extension to other settings and groups. These limitations highlight the need for future investigations involving larger and more diverse samples drawn from multiple higher education institutions to determine whether similar patterns hold across different institutional contexts, program structures, and student populations. Future studies may also incorporate additional academic, psychological, and environmental variables, such as learning motivation, mathematics anxiety, self-regulated learning, study habits, instructional quality, attendance, and family support, in order to develop a more comprehensive predictive model of first-year mathematics performance.

In response to the documented gaps, the study formulated Project IELP (Integrated Engineering Learning Productivity and Academic Support Framework), which embeds diagnostic screening, targeted algebraic remediation, and board examination-aligned training within existing departmental routines. This framework offers a data-driven model for converting solid early performance into deeper, more consistent proficiency in board examination-related mathematics subjects. Future research may build on these results by experimentally or quasi-experimentally evaluating the effectiveness of Project IELP over multiple semesters, and by conducting longitudinal studies that examine its sustained impact on students' academic performance and board examination readiness across groups.

RECOMMENDATIONS

In view of the findings and conclusions, the following recommendations may be considered by the Civil Engineering Department and related stakeholders to bridge the gap between secondary school preparedness and board examination level expectations:

1. Implementation of Structured Entry Profiling. The department may maintain a structured entry-profiling system that records sex, senior high school track, type of school, and Grade 11 General Mathematics final grade for all first-year civil engineering students and can use this information as a basis for early identification and monitoring of those at risk in board examination-related mathematics subjects.

2. Data-Driven Student Support: Academic administrators and program heads may adopt the Grade 11 General Mathematics final grade as a key criterion in grouping and supporting students, and can prioritize those with

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weaker prior mathematics achievement, particularly non-STEM entrants and those with lower Algebra and Plane Trigonometry performance.

3. Structured Study Protocols and Differentiated Instruction: Mathematics instructors may implement a structured daily study logbook and digital discipline protocol to strengthen time optimization, resource utilization, and examination readiness, and can differentiate learning support and classroom activities according to students' senior high school background and learning practice patterns.

4. Integration of Compulsory Remediation: The department may institutionalize an algebra and trigonometry remediation program for first-year civil engineering students, with compulsory participation for those in the lower performance brackets of Algebra and Plane Trigonometry and can integrate this remediation with regular course delivery rather than treating it as an optional add-on.

5. Continuous Academic Monitoring: The department may develop a continuous, data-driven monitoring system that integrates senior high school background indicators, learning practice scores, and periodic assessment results, ensuring that instructional decisions and academic support can be adjusted in real time throughout the first year.

6. Formal Adoption of Project IELP: The Civil Engineering Department may formally adopt Project IELP as its academic intervention framework for first-year students and can establish a mechanism for periodic review and refinement of its components based on performance data, student feedback, and future evaluation studies.

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