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Research Paper

Mapping Mathematics Unit Allocation in Civil Engineering Programs Across Philippine SUCs: A Basis for Curriculum Enhancement

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Abstract

This study examined mathematics unit allocations in Civil Engineering programs across selected State Universities and Colleges (SUCs) in the Philippines and proposed a data-informed framework for curriculum planning. Using a quantitative document analysis approach, curricular data from 19 SUCs were analyzed using descriptive statistics to determine the total number of mathematics units, the distribution of units across major mathematics courses, and the inclusion of bridging or preparatory mathematics subjects. The Bounded Variability Unit Allocation Model (BVUAM) was applied to generate suggested unit allocations based on observed institutional patterns. Findings revealed considerable variation in the total number of mathematics units across SUCs, particularly in foundational mathematics courses such as Differential and Integral Calculus. Bridging or preparatory mathematics courses also varied widely, with some institutions allocating substantial instructional units while others offered none. In contrast, higher-level and applied mathematics courses remained largely uniform across institutions. The BVUAM-generated recommendations suggested relatively higher allocations for foundational and bridging mathematics while maintaining standard allocations for advanced mathematics courses. The model serves as a descriptive and data-informed framework for examining curriculum allocation patterns and may support curriculum review and planning in Civil Engineering programs.

Keywords: *Engineering Education, Engineering Mathematics, Mathematics Unit Allocation, Curriculum Document Analysis, Civil Engineering Curriculum, Bridging Mathematics Courses*

INTRODUCTION

The implementation of the K–12 reform in the Philippines aimed to produce graduates who are prepared for higher education and specialized disciplines such as engineering. The Senior High School (SHS) program, particularly under the STEM strand, was designed to strengthen competencies in mathematics and science. However, recent studies and reports suggest that many SHS graduates remain insufficiently prepared for the academic demands of engineering programs.

Findings from the Second Congressional Commission on Education indicate that the goal of producing "college-ready" graduates has not yet been fully realized. Reports emphasize that, despite the intent of K–12 reform, a mismatch persists between SHS competencies and higher-education expectations, prompting calls for stronger alignment between basic and tertiary education systems (EDCOM II, 2025).

Mathematical preparedness plays a central role in students' success in engineering programs, as fundamental knowledge in algebra, trigonometry, and analytic geometry is essential for understanding higher-level topics such as calculus. Research has consistently shown that students entering tertiary education often lack these prerequisite competencies. For instance, the Calculus Concept Readiness (CCR) framework, developed by Marilyn Carlson and colleagues, demonstrated that students frequently exhibit weaknesses in the fundamental reasoning and conceptual understanding necessary for success in calculus (Carlson et al., 2010). Further analysis

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shows that students with stronger readiness in these foundational skills perform significantly better in calculus courses, highlighting the importance of pre-calculus preparation (Carlson et al., 2015).

In the Philippines, recent studies have also pointed to gaps in the mathematical preparedness of SHS graduates entering engineering programs. A study of first-year engineering students in Eastern Visayas found that SHS graduates exhibited varying, often insufficient levels of mathematical readiness, particularly in conceptual understanding and problem-solving skills, which are critical for college-level mathematics (Gomba & Perante, 2025). These findings suggest that the transition from SHS to engineering education remains a significant challenge.

These gaps have implications for higher education institutions, particularly in the design and organization of mathematics curricula in engineering programs. Since mathematics courses provide the foundational competencies required in higher engineering subjects, variations in mathematics unit allocation and course sequencing may reflect how institutions structure curricular support for incoming students with diverse academic backgrounds.

Examining these curricular structures may therefore provide insights into how Civil Engineering programs allocate emphasis to foundational mathematics preparation. Several SUCs have implemented curricular structures that include preparatory mathematics courses, revised course sequencing, and varying allocations of mathematics units within Civil Engineering programs. However, the extent and patterns of these curriculum structures across SUCs remain insufficiently documented in existing literature.

Given these concerns, examining the allocation of mathematics units in Civil Engineering curricula may help clarify how SUCs structure foundational mathematics instruction within their programs. As frontline institutions accommodating diverse student readiness levels, SUCs have introduced various adjustments in mathematics instruction, including changes in unit allocations, restructuring of course sequences, and the incorporation of bridging or preparatory courses such as College Algebra and Pre-Calculus.

Despite these efforts, there is limited consolidated evidence to guide curriculum developers in designing responsive and coherent mathematics programs for engineering education. This study, however, focuses specifically on the analysis of curriculum documents and mathematics unit allocations rather than the institutional motivations behind curriculum revisions or the direct measurement of student preparedness.

Despite the recognized importance of mathematics preparation in engineering education, limited studies have systematically analyzed and compared mathematics unit allocations in Civil Engineering programs across Philippine SUCs. Existing studies largely focus on student readiness, academic performance, or conceptual difficulties in mathematics. At the same time, comparatively little attention has been given to how mathematics curricula are structured and allocated at the program level. Addressing this gap may provide useful baseline information for curriculum developers and academic planners to evaluate and enhance mathematics curricula in engineering education.

In this context, the study aimed to develop an evidence-based guide for curricular development in Civil Engineering programs by analyzing adjustments to mathematics curricular units implemented by SUCs in response to preparedness gaps among Senior High School graduates. Specifically, it seeks to answer the following questions:

1. What is the total number of mathematics units in the Civil Engineering programs of various State Universities and Colleges (SUCs)?
2. How are mathematics units allocated across key Civil Engineering courses, specifically:
    a. Differential Calculus
    b. Integral Calculus

   c. Differential Equations
   d. Engineering Data Analysis?
3. How many units are allocated to mathematics bridging or preparatory courses in the Civil Engineering programs of SUCs?
4. What are the suggested unit allocations for each mathematics course in Civil Engineering programs using the Bounded Variability Unit Allocation Model (BVUAM)?

LITERATURE REVIEW

Mathematical Preparedness of Senior High School Graduates

Mathematics plays a central role in engineering education, particularly in Civil Engineering programs, where analytical and problem-solving skills are essential. However, a recurring concern across countries is the inadequate mathematical preparation of incoming students, which affects their ability to succeed in advanced engineering mathematics. Studies have consistently shown that students entering tertiary education often exhibit gaps in foundational competencies such as algebra, trigonometry, and pre-calculus concepts, which are critical for success in calculus and higher-level mathematics (Hodara, 2013; Bahr, 2010).

Mathematical preparedness remains a key concern in the transition from Senior High School (SHS) to engineering programs. Studies in the Philippine context show that many SHS graduates lack the necessary competencies for college-level mathematics. For instance, only a portion of first-year engineering students were found to be college-ready, with many demonstrating weaknesses in algebra, trigonometry, and calculus concepts (Perante, 2022). These gaps often necessitate remediation or bridging courses at the tertiary level.

Similarly, research indicates that students struggle with fundamental mathematical skills such as problem-solving and conceptual understanding, regardless of instructional modality (Gomba & Perante, 2025). Learner perceptions also highlight difficulties in applying mathematical concepts, suggesting a misalignment between SHS preparation and higher-education expectations (Cabuquin & Abocejo, 2025).

Collectively, these studies suggest that insufficient mathematical preparation remains a persistent challenge in engineering education. While prior research has largely focused on measuring student readiness, conceptual understanding, and academic performance, comparatively little attention has been paid to how higher education institutions structure mathematics curricula to accommodate varying levels of student preparedness. This highlights the need to examine curriculum-level responses, particularly the allocation of mathematics units and course sequencing in engineering programs.

Mathematics Readiness and Engineering Education

Mathematical readiness is a strong predictor of success in engineering programs. The Calculus Concept Readiness framework emphasizes that students must possess solid pre-calculus knowledge, including functions and algebraic reasoning, to succeed in calculus (Carlson et al., 2010). Empirical studies further confirm that students with stronger foundational skills perform better in higher-level mathematics courses (Carlson et al., 2015).

The transition from secondary to tertiary mathematics has long been recognized as a critical challenge in STEM education. Engelbrecht et al. (2005) found that undergraduate students often demonstrate a significant gap between procedural fluency and conceptual understanding in mathematics.

International research also highlights the importance of mathematics anxiety and cognitive barriers in engineering students. High levels of mathematics anxiety have been associated with lower performance and reduced persistence in STEM programs, particularly when students lack strong foundational preparation (Ashcraft & Krause, 2007). This further supports the need for enhanced instructional time or bridging interventions in early mathematics courses to reduce cognitive strain and improve confidence

In addition, studies on engineering student retention emphasize that early failure in mathematics courses is one of the strongest predictors of attrition in engineering programs. Seymour and Hewitt (1997) found that many students leave engineering not because of a lack of interest, but because of difficulty in foundational mathematics and science courses. This finding underscores the importance of curriculum structures that provide sufficient support in early mathematics education.

These studies collectively reinforce the importance of foundational mathematics in engineering success. However, while student readiness has been extensively examined, there remains limited research on how Civil Engineering curricula operationalize foundational support through mathematics unit allocation, bridging courses, and course sequencing.

Curriculum Alignment, Bridging Courses, and Mathematics Unit Allocation

Curriculum alignment in engineering education is also strongly influenced by competency-based frameworks such as ABET outcomes. Passow (2012) emphasized that engineering graduates and industry stakeholders consistently prioritize competencies such as problem-solving, analytical thinking, and application of mathematics in real-world contexts. Although the K–12 reform aimed to improve college readiness, studies reveal gaps in curriculum alignment. Comparative analyses with international benchmarks show inconsistencies in content depth and cognitive demand (Balagtas et al., 2019). Additionally, many Grade 12 students remain underprepared for college mathematics despite exposure to advanced topics (Mamolo, 2020).

As a result, higher education institutions have implemented curricular adjustments, including bridging courses and modifications in mathematics instruction, to address these deficiencies (Certeza et al., 2019). These responses reflect ongoing challenges in aligning SHS outcomes with engineering program requirements. These curricular practices may include additional preparatory courses, adjustments to course sequencing, and variations in the allocation of mathematics units. However, existing studies primarily describe the presence of such interventions rather than systematically analyzing how mathematics units are distributed across engineering curricula.

Lattuca and Stark (2009) further emphasize that academic programs are shaped not only by formal standards but also by institutional interpretation and contextual adaptation, which explains variations in curriculum implementation across universities. In mathematics education specifically, research shows that foundational courses such as algebra, trigonometry, and analytic geometry remain essential prerequisites for success in higher-level engineering mathematics. Difficulties in mathematization and symbolic reasoning have been observed even in tertiary-level students, suggesting persistent gaps in early mathematical development (Brahmia et al., 2016)

More recent studies in STEM education also advocate for adaptive curriculum design frameworks, in which instructional time and course intensity are adjusted based on diagnostic assessments of student readiness. These approaches are increasingly supported by data analytics and institutional benchmarking, enabling universities to make evidence-based curriculum adjustments rather than relying solely on fixed national standards (Graham, 2018). These studies underscore the importance of curriculum responsiveness but do not provide a systematic model for determining appropriate allocations of mathematics units in engineering programs.

Theoretical Basis and Logic of the BVUAM

Instructional time plays a critical role in learning, as emphasized in Carroll's (1963) "time-on-task" theory, which posits that learning outcomes are influenced by the time students spend engaged in meaningful learning activities. However, curriculum credit units do not directly measure the quality of learning or student engagement. Rather, unit allocation serves as a structural indicator of the amount of formal instructional exposure and academic emphasis assigned to a subject within a curriculum.

Constructive alignment theory further emphasizes the importance of aligning learning outcomes, instructional activities, and assessment structures within academic programs (Biggs, 1996). In engineering mathematics, allocating sufficient curricular space to foundational courses may help align prerequisite competencies with the demands of higher-level engineering. Similarly, Tall's (2008) theory of mathematical transitions highlights the need for scaffolding as students move from procedural mathematics toward formal and abstract reasoning. This suggests that foundational mathematics courses may require sufficient instructional allocation to support conceptual development.

Guided by these theoretical perspectives, the Bounded Variability Unit Allocation Model (BVUAM) uses descriptive statistical patterns from existing SUC curricula to generate data-informed mathematics unit allocations. The model utilizes the mean as a measure of central curricular tendency, representing commonly practiced allocation patterns among SUCs. The standard deviation is used to account for acceptable variability across institutions, recognizing that curriculum structures vary with institutional contexts and implementation strategies. Meanwhile, the observed maximum values serve as practical upper bounds, ensuring that recommended allocations remain grounded in actual institutional practices rather than purely theoretical estimates.

The BVUAM does not claim to determine the "optimal" number of mathematics units nor directly measure student preparedness or learning outcomes. Instead, the model provides an empirical framework for benchmarking and guiding curriculum planning based on existing patterns of mathematics unit allocation among Philippine SUCs.

The literature indicates that SHS graduates often experience challenges in preparing for mathematics in engineering programs, while higher education institutions adopt varying curricular approaches to address foundational mathematics needs. Despite these developments, there remains limited research that systematically analyzes patterns in mathematics unit allocation across Civil Engineering programs and proposes a structured, data-driven framework for curriculum planning. This study addresses this gap by proposing the BVUAM as a model for guiding mathematics curriculum development in Civil Engineering programs.

RESEARCH METHOD

Research Design

This study employed a quantitative document analysis research design. Quantitative document analysis involves the systematic examination of documents to extract and analyze numerical data, making it suitable for studies that utilize structured institutional records such as curricula (Bowen, 2009). In this study, curricular documents from State Universities and Colleges (SUCs) offering Civil Engineering programs were analyzed to obtain quantitative data on the allocation of mathematics units.

Furthermore, the study included a model development component in which the Bounded Variability Unit Allocation Model (BVUAM) was formulated to generate data-driven recommendations for mathematics unit allocation. This component goes beyond description by using measures of central tendency and variability to produce empirically grounded curriculum recommendations. The study specifically focused on the analysis of curriculum structures and mathematics unit allocations reflected in official curricular documents. The study did not examine student performance, learning outcomes, or institutional decision-making processes regarding curriculum revisions.

Data Sources and Sampling

The study utilized documentary analysis of publicly available curricular data. State Universities and Colleges (SUCs) in the Philippines that offer Civil Engineering programs were identified, and their official curricula were accessed through their institutional websites. A total of 85 SUCs offering Bachelor of Science in Civil Engineering (BSCE) programs were initially identified. However, only 19 SUCs were included in the final analysis because their curricula were publicly accessible through official institutional websites during the data collection period. The remaining 66 SUCs were excluded due to the unavailability or inaccessibility of official curriculum documents online. Local Universities and Colleges (LUCs) were excluded from the study to maintain consistency with the classification of State Universities and Colleges.

A purposive sampling technique was employed, including only SUCs with published, accessible online curricula. Documentary analysis is widely used in educational research to examine formal institutional records and curricular structures (Bowen, 2009). Data were collected from December 2025 to March 2026. The extracted data included the total number of mathematics units in the BSCE curriculum, individual mathematics course titles, unit allocations per mathematics course, the presence of bridging or preparatory mathematics courses, course sequencing, and the curriculum revision year, when available.

To standardize data extraction across institutions, a coding guide was developed. Mathematics courses were classified into three categories. Core Mathematics Courses are those that form part of the standard engineering mathematics sequence, such as Differential and Integral Calculus, Differential Equations, and Engineering Data Analysis. Preparatory or Bridging Mathematics Courses are intended to strengthen foundational competencies prior to higher-level mathematics courses, such as College Algebra, Pre-Calculus, and Basic Mathematics. Meanwhile, Non-Mathematics Courses referred to courses outside the scope of the study.

Because course titles varied across SUCs, classification was based primarily on course descriptions, prerequisite structures, and curricular placement rather than title alone. For example, courses labeled “Fundamentals of Mathematics”, “Pre-calculus,” or “Mathematics Enhancement” were classified as bridging courses when their content focused on foundational or remedial competencies.

To ensure data validity, only official and publicly available curricula from SUC websites were used. Data extraction was conducted manually by the researcher using a standardized extraction matrix. Extracted entries were rechecked against the original curriculum documents to verify course titles, unit values, and classifications. When multiple versions of curriculum information were available within institutional websites, preference was given to officially approved curriculum checklists or registrar-posted curricular documents.

Reliability was ensured through data verification, in which extracted values were rechecked and, when possible, compared across multiple sources within institutional platforms. Since the study involved documentary analysis rather than subjective interpretation of qualitative responses, reliability was strengthened through repeated verification of extracted data and consistent application of coding rules. All extracted data and classifications were reviewed twice by the researcher to minimize encoding and classification errors. Cases of ambiguous course classification were resolved by examining course prerequisites, sequencing, and course descriptions where available.

Statistical Treatment of Data

The study employed basic descriptive statistics and a model-based approach to analyze mathematics unit allocations across State Universities and Colleges (SUCs). Frequency counts and summation were used to determine the total number of mathematics units in Civil Engineering programs and the units allocated to individual mathematics courses, including bridging or preparatory subjects. The mean was computed to represent the typical unit allocation for each mathematics course across SUCs.

To generate suggested unit allocations, the Bounded Variability Unit Allocation Model (BVUAM) was applied. This model incorporates both the mean and the standard deviation to capture central tendency and variation in institutional practices. The suggested unit allocation for each course was computed using the formula:

$$U = \min(\mu + \sigma, X_{max}) \quad (1)$$

Where:
$U = suggested\ unit\ allocation$
$\mu = mean\ unit\ allocation$
$\sigma = standard\ deviation$
$X_{max} = maximum\ observed\ unit\ allocation$

The BVUAM assumes that existing curricular practices among SUCs reflect realistic institutional implementations of mathematics instruction within Civil Engineering programs. The mean represents the central tendency or commonly observed allocation practice, while the standard deviation accounts for acceptable institutional variability. Adding one standard deviation to the mean allows the model to recommend allocations slightly above average practice while remaining within empirically observed ranges. Using the observed maximum value as an upper bound prevents the model from generating impractical recommendations that exceed actual institutional practices.

The use of the mean and standard deviation captures central tendency and variability in institutional practices (Field, 2013). Bounding the estimate using observed maximum values ensures that recommendations remain realistic and grounded in empirical data. Only courses classified as mathematics, preparatory, or bridging mathematics courses were included in the BVUAM computations. Courses with zero-unit credit allocations were excluded from statistical computations because they did not contribute to formal curricular unit allocation. All computed unit allocations were rounded to the nearest whole number to align with standard curricular structures. Values with decimal portions of 0.50 and above were rounded upward, while values below 0.50 were rounded downward.

Ethical Considerations

This study utilized publicly available curricular documents from State Universities and Colleges (SUCs) and did not involve human participants; thus, issues of informed consent and confidentiality were not applicable. All data were obtained from official institutional websites and used solely for academic and research purposes. To ensure ethical reporting and avoid institutional bias, SUC names were not disclosed when presenting the results.

Instead, institutions were coded using letters (e.g., SUC A, SUC B) to maintain anonymity and focus the analysis on curricular patterns rather than institutional identity. Proper attribution of sources was observed, and data were presented objectively without alteration or misrepresentation. Overall, the study adhered to ethical standards for document-based and secondary data analysis (Bowen, 2009).

FINDINGS AND DISCUSSION

Mathematics Units in the Civil Engineering Programs of Various SUCs

Table 1. Total Number of Mathematics Units in the Civil Engineering Programs of Various State Universities and Colleges

State University or College	Initial Academic Year of Curriculum Implementation	Total Mathematics Units (Including Bridging/Preparatory Courses)
A	2018-2019	15
B	2025-2026	15
C	2018-2019	22
D	2018-2019	18
E	2024-2025	26
F	2021-2022	28
G	2024-2025	23
H	2018-2019	25
I	2018-2019	24
J	2018-2019	17
K	2022-2023	15
L	2018-2019	21
M	2018-2019	19
N	2020-2021	26
O	2022-2023	15
P	2018-2019	15
Q	2024-2025	18
R	2018-2019	23
S	2023-2024	21
PSG 2017	**2018 (effectivity)**	**15**
PSG 2007	**2008 (effectivity)**	**26**

PSG 2017 – CHED Policies, Standards, and Guidelines (PSG) for BSCE effective A.Y. 2018-2019 (4 years)
PSG 2007 – CHED Policies, Standards, and Guidelines (PSG) for BSCE effective 2008-2009 (5 years)

Table 1 presents the total number of mathematics units offered in Civil Engineering programs at 19 State Universities and Colleges (SUCs), along with the CHED Policy, Standards, and Guidelines (PSG) for BSCE. The table provides a comparative overview of mathematics unit allocations relative to national minimum standards. The table shows a clear split between SUCs that follow the PSG 2017 minimum exactly and those that expand mathematics beyond it.

Five SUCs allocate 15 units, while ten SUCs allocate 21–28 units, indicating that the minimum standard functions as a floor rather than a ceiling. In many cases, mathematics is treated as a flexible curricular space within Civil Engineering programs, especially as students begin to encounter more demanding engineering mathematics. This is consistent with transition studies showing that the move from high school to university mathematics is difficult for many students and often marked by a mismatch between prior preparation and university expectations (Geisler et al., 2023; Perante, 2022).

The distribution also suggests two broad curriculum orientations: one that adheres closely to the national minimum, and another that preserves additional mathematics space within the curriculum. That pattern does not by itself prove why institutions chose higher allocations.

However, it does indicate that several SUCs are using curriculum design to give mathematics greater weight than the baseline requires.

In the broader STEM literature, bridge and transition supports are recognized as responses to uneven preparation and persistence challenges. Ashley et al. (2017) synthesized 46 reports on 30 unique STEM bridge programs, and Bradford et al. (2021) later meta-analyzed the effectiveness of university STEM bridge programs, confirming that this is an established intervention area rather than an isolated practice.

Units Allocated Across Civil Engineering Mathematics Courses

Table 2. Units Allocated Across Civil Engineering Mathematics Courses

SUC	Differential Calculus	Integral Calculus	Differential Equations	Numerical Solutions to CE Problems	Engineering Data Analysis
A	3	3	3	3	3
B	3	3	3	3	3
C	4	4	3	3	3
D	3	3	3	3	3
E	3	3	3	3	3
F	4	4	3	3	3
G	5	5	3	4	3
H	3	3	3	3	3
I	3	3	3	4	3
J	4	4	3	3	3
K	3	3	3	3	3
L	4	4	3	3	3
M	3	3	3	3	3
N	4	4	3	3	3
O	3	3	3	3	3
P	3	3	3	3	3
Q	3	3	3	3	3
R	4	4	3	3	3
S	3	3	3	3	3
Average (μ)	**3.42**	**3.42**	**3.00**	**3.11**	**3.00**
SD (σ)	**0.61**	**0.61**	**0.00**	**0.32**	**0.00**
PSG 2017	**3**	**3**	**3**	**3**	**3**

PSG 2017 – CHED Policies, Standards, and Guidelines (PSG) for BSCE effective A.Y. 2018-2019 (4 years)
SD – Standard Deviation

Table 2 presents the distribution of unit allocations for core mathematics courses in Civil Engineering programs across 19 State Universities and Colleges (SUCs). The courses include Differential Calculus, Integral Calculus, Differential Equations, Numerical Solutions to Civil Engineering Problems, and Engineering Data Analysis. The table also reports the mean (μ) and standard deviation (σ) for each course, alongside the CHED PSG 2017 prescribed units.

The results show that most SUCs adhere to a 3-unit structure across all mathematics courses, consistent with CHED PSG 2017. However, Differential Calculus and Integral Calculus exhibit moderate variability ($\mu = 3.42$; $\sigma = 0.61$), with some SUCs allocating 4-5 units, indicating expansion beyond the minimum requirement. In contrast, Differential Equations and Engineering Data Analysis show no variation ($\sigma = 0.00$), with all institutions assigning 3 units. Meanwhile, Numerical

Solutions to Civil Engineering Problems shows minimal variability (μ = 3.11; σ = 0.32), with only a few institutions increasing units.

Differential and Integral Calculus show the greatest spread in unit allocation, while Differential Equations and Engineering Data Analysis remain fixed at 3 units across all SUCs. This means that curricular variation is concentrated at the gateway stage of engineering mathematics, not in the later courses. That is a meaningful pattern because the literature repeatedly shows that early university mathematics is where students' prior knowledge matters most. Panaoura et al. (2024) found that prior mathematical knowledge was the dominant factor associated with first-year engineering students' performance, and Geisler et al. (2023) likewise describe the transition to university mathematics as a difficult phase that often requires additional support.

The small spread in Numerical Solutions to Civil Engineering Problems and the complete uniformity in Differential Equations and Engineering Data Analysis suggest that SUCs are more willing to adjust the early mathematics sequence than the upper courses. A reasonable inference is that institutions may be concentrating curricular flexibility where they see the greatest pressure for transition, while treating later mathematics courses as stable components of the program. This interpretation is also consistent with math readiness and placement studies showing that readiness influences Calculus enrollment and engineering persistence, and that remedial support can shape who remains on the engineering pathway (Ryan et al., 2025).

Units Allocated to Mathematics Bridging or Preparatory Courses

Table 3. Units Allocated to Mathematics Bridging or Preparatory Courses

State University or College	Unit Allocation
A	0
B	0
C	5
D	3
E	11
F	11
G	3
H	10
I	8
J	0
K	0
L	4
M	4
N	9
O	0
P	0
Q	3
R	6
S	6
Average(μ)	**6.38**
Standard Deviation (σ)	**3.07**

PSG 2017 – CHED Policies, Standards, and Guidelines (PSG) for BSCE effective A.Y. 2018-2019 (4 years)

Table 3 presents the unit allocations for mathematics bridging or preparatory courses across 19 State Universities and Colleges (SUCs) offering Civil Engineering programs. These courses are intended to strengthen foundational competencies prior to or alongside higher-level mathematics subjects. The table shows that some SUCs do not offer bridging courses, while others allocate varying numbers of units. The computed mean ($\mu = 6.38$) and standard deviation ($\sigma = 3.07$) were derived excluding SUCs without bridging courses.

Among the 13 SUCs that offer bridging, the mean is 6.38 units. This indicates that bridging is not a minor add-on where it exists; rather, it is often a substantive part of the curriculum. The six SUCs with zero bridging units represent a different curricular strategy, suggesting that foundational support may be embedded elsewhere in the mathematics sequence rather than delivered as a separate block.

The broader STEM literature treats bridge programs as a long-standing strategy for transition to college. Ashley et al. (2017) describe bridge programs as mechanisms to help students adjust to the college learning environment, while Bradford et al. (2021) synthesize evidence on the effectiveness of university STEM summer bridge programs.

Specifically in engineering, Jones and Melvin (2023) report a bridge program built around calculus review, tutoring, and weekly workshops, with improved calculus readiness scores, higher first-year GPA, and better second-year retention. Taken together, these studies show that bridge courses are not unusual interventions in STEM; they are a recognized curricular response to the transition problem, especially when calculus readiness is a concern.

Proposed Unit Allocations for Each Mathematics Course in Civil Engineering Programs Using BVUAM

Table 4. Proposed Unit Allocations for Each Mathematics Course in Civil Engineering Programs Using BVUAM

Mathematics Course	Mean	Std. Dev.	Units
Bridging/Preparatory	6.38	3.07	9
Differential Calculus	3.42	0.61	4
Integral Calculus	3.42	0.61	4
Differential Equations	3	0.00	3
Numerical Solutions to CE Problems	3.11	0.32	3
Engineering Data Analysis	3	0.00	3

Table 4 presents the proposed unit allocations for mathematics courses in Civil Engineering programs derived using the Bounded Variability Unit Allocation Model (BVUAM). The model integrates the mean and standard deviation of existing unit allocations across SUCs and applies an upper bound based on observed maximum values. The resulting allocations aim to provide a data-driven and empirically grounded guide for curriculum development, reflecting both typical practices and institutional adjustments.

The BVUAM recommendations can be explained directly from the table values. For Bridging/Preparatory Mathematics, the computation is $6.38 + 3.07 = 9.45$, which is bounded by the observed maximum of 11 and then rounded to 9 units. For Differential Calculus and Integral Calculus, the computation is $3.42 + 0.61 = 4.03$, which rounds to 4 units. For Numerical Solutions to Civil Engineering Problems, $3.11 + 0.32 = 3.43$, which rounds to 3 units.

Differential Equations and Engineering Data Analysis remain at 3 units because their means are already 3, and their standard deviations are 0. The model is therefore conservative: it preserves the existing structure while allocating slightly more curricular space to courses where institutional variation is already evident.

That makes the BVUAM less a claim about "optimal" unit counts and more a bounded benchmark for curriculum planning. Its logic is consistent with bridge and placement research showing that engineering programs often use extra structured exposure, tutoring, and readiness support at the calculus gateway rather than assuming a one-size-fits-all curriculum. Ryan et al. (2025) show that placement mechanisms and remedial support can shape Calculus 1 enrollment and persistence, while Jones and Melvin (2023) demonstrate that a calculus-focused bridge program can be used as a structured support pathway for incoming engineering students.

CONCLUSIONS

The study examined mathematics unit allocations in Civil Engineering programs across selected State Universities and Colleges (SUCs) in the Philippines through quantitative document analysis. The findings show that mathematics unit allocations vary across institutions despite the presence of common minimum requirements prescribed by CHED. Some SUCs adhere closely to the minimum, while others allocate more units, particularly in the foundational mathematics sequence. These results indicate that mathematics allocation is an area of curricular variation within Civil Engineering programs and that SUCs exercise flexibility in organizing mathematics content within national policy parameters.

The analysis of individual mathematics courses showed that most SUCs maintain the standard 3-unit allocation for higher-level and applied mathematics subjects. Variation is more visible in Differential and Integral Calculus, where several institutions assign additional units beyond the minimum requirement. This pattern suggests that curriculum adjustments are concentrated mainly in the earlier part of the mathematics sequence, while later courses remain relatively uniform across institutions.

The study also found wide variation in bridging or preparatory mathematics courses. Some SUCs do not include dedicated bridging subjects, while others allocate substantial instructional units to preparatory mathematics. This reflects differing curricular approaches to foundational mathematics support rather than a single standardized model across SUCs. In some institutions, support is provided through separate bridging subjects; in others, foundational reinforcement appears to be embedded within the regular mathematics sequence.

The application of the Bounded Variability Unit Allocation Model (BVUAM) produced unit recommendations based on observed institutional practices. The model generated relatively higher suggested allocations for bridging/preparatory mathematics and calculus courses, while preserving standard allocations for higher-level mathematics subjects. BVUAM serves as a bounded, data-informed curriculum-planning framework that summarizes existing SUC practices and translates them into practical unit recommendations. It does not claim to measure student readiness, instructional quality, or learning outcomes. Its theoretical contribution lies in showing how descriptive curriculum data can be organized into a structured basis for curriculum review and planning.

From a practical standpoint, the findings may serve as a reference point for curriculum planners when reviewing the distribution of mathematics units across Civil Engineering programs. From a theoretical standpoint, the study contributes a bounded model for examining curriculum structure, but it does not extend to explaining student performance or institutional decision-making.

Since the study relied exclusively on curriculum documents, its findings should be interpreted as evidence of curriculum structure and allocation patterns rather than direct indicators of preparedness, teaching effectiveness, or learning outcomes. Future research may complement this work by examining student performance data, institutional policy records, or stakeholder perspectives to understand better how mathematics curricula relate to engineering education outcomes.

LIMITATION & FURTHER RESEARCH

This study is limited by its reliance on publicly available curricular documents, which resulted in the inclusion of only 19 SUCs with accessible online data. As a result, the findings reflect the curriculum structures of institutions with publicly posted BSCE programs and may not fully represent all Civil Engineering programs in the Philippines.

The analysis focused on declared unit allocations in official curricula and did not examine actual instructional practices, classroom delivery, assessment methods, or student learning outcomes. Thus, the findings should be interpreted as evidence of curriculum structure rather than evidence of teaching effectiveness or student preparedness. In addition, the Bounded Variability Unit Allocation Model (BVUAM) was developed from observed patterns in SUC curricula and does not establish causal relationships between unit allocation and student performance. The model is intended as a bounded, data-informed planning framework, not as a predictive model of learning outcomes or academic success.

The computation for bridging or preparatory courses also has an important boundary condition: institutions without bridging offerings were excluded from the bridging-course mean used in the BVUAM recommendation. While this was necessary to avoid distorting the pattern among SUCs that actually provide bridging support, it may also lead to higher recommended values in contexts where bridging is not separately offered. For this reason, the bridging-course recommendation should be interpreted cautiously and in relation to the actual curricular structure of each institution.

Future research may expand the dataset to include more institutions and incorporate outcome-based measures such as student performance, retention, and licensure results. Comparative studies on different curricular support strategies—such as bridging courses versus embedded remediation—may also provide deeper insight into how mathematics support is structured in Civil Engineering programs. Further refinement of the BVUAM may include additional variables, such as contact hours, course sequencing, and student readiness indicators, to support a more adaptive and context-sensitive framework for curriculum development in engineering mathematics.

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