Does the Math Add Up in the Civil Engineering Curriculum?

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Abstract

The civil engineering profession continues to review math preparation of engineering students, considering knowledge and skills necessary for continued academic and professional success while also being sensitive to concerns about math courses serving as a deterrent for some students. The Civil Engineering Body of Knowledge, 3rd Edition, (CEBOK3) includes mathematics as one among 21 "foundational, technical, and professional practice learning outcomes for individuals entering the professional practice of civil engineering" [1]. Mathematics requirements are specified within ABET General Criteria and the Civil Engineering Program Criteria.

A Task Committee formed by the American Society of Civil Engineers (ASCE) is currently reviewing and updating the CEBOK3. A recently distributed but unpublished report generated by the ASCE Task Committee on Transforming our Workforce (TCTOW) [2] included a series of recommended action items intended to transform the modern civil engineering workforce. It is implied that if those recommendations were addressed there would be a resulting increase in the number of engineers entering into the profession of civil engineering, as well as increased retention of members within the profession. One of the thirteen recommended actions included strong advocacy for a review of existing mathematics and basic science requirements within the civil engineering undergraduate degree. Both the review of the CEBOK3 and the recommendations from the TCTOW motivated the present study.

Members of the Civil Engineering Body of Knowledge Task Committee (CEBOKTC) engaged in a study to evaluate the mathematics requirements in ABET accredited civil engineering programs. The objectives of this paper are to:

- Characterize mathematics requirements specified in the TCTOW report, ABET criteria, and the CEBOK3,
- Quantify mathematics requirements in ABET accredited civil engineering programs,

To address these objectives, the authors reviewed recent literature, conducted an in-depth study of mathematics requirements among 281 ABET accredited civil engineering programs, and considered TCTOW requirements in light of ABET criteria and civil engineering curricula.

Introduction

Ask an engineer why they pursued their chosen profession and chances are that somewhere in their background a trusted individual suggested they should pursue engineering because they were "good at math and science." Indeed, there is a justified implication that success as an engineer is strongly linked to a solid foundation in mathematics and science. Given that inherent link between the mathematical and scientific laws that govern engineering, it is not surprising to see a continued emphasis on both mathematics and science in the modern engineering curricula.

The Civil Engineering Body of Knowledge (CEBOK) identifies “foundational, technical, and professional practice learning outcomes” [1] applicable for preparing *all* civil engineers, regardless of their specific future career pathways or subdiscipline area. Quantifying coverage of mathematics - one of the foundational CEBOK outcomes - in civil engineering curricula can help inform evaluations of the need for mathematics in preparing future civil engineers. This study quantifies the amount of mathematics required in civil engineering curricula in the United States at the present time. The research questions posed in this study are as follows:

1. What are the current mathematics courses and credits required by Engineering Accreditation Commission (EAC) ABET accredited civil engineering programs in the United States?
2 What percentage of total program credits required for a degree are associated with mathematics within EAC/ABET accredited civil engineering programs in the United States?
3. What mathematics courses are included in civil engineering curricula other than those implied in the EAC/ABET criteria?

This paper is an update to previous similar studies on this subject that also connect the relevance of preparation in mathematics to ASCE initiatives such as the Civil Engineering Body of Knowledge but is expanded to consider recommendations made by the ASCE Task Committee on Transforming our Workforce (TCTOW).

Background

Several studies conducted in the past 20 years have evaluated the merits of mathematics curriculum in engineering and civil engineering, starting first with a baseline inventory of math coursework in programs. Russell and Stoufer [3] presented a thorough study of mathematics, science, and other curricular requirements in civil engineering programs in 2005. Study results indicated that approximately 11% of the curricula among different programs were specifically made up of courses in mathematics. The authors offered limited opinions on their findings and presented the data mostly to establish a baseline for the balance of math and science within the curriculum. However, in one observation they imply mathematics requirements as having been stagnant in recent history. The authors mention that engineering curricula require a fair number of credit hours, and the demand for engineering credits may result in the loss of mathematics credits. They acknowledge a concern about placing upwards of 27% credit hour effort towards math and science, leaving only 50% of the curriculum to focus on engineering-specific content. Integration of the needed mathematics into engineering courses is suggested to enhance exposure of students to dynamic fields of engineering without denying lessons in applied mathematics. While Russell and Stoufer did not address the merits of mathematics, they did establish baseline data communicating the mathematics course requirements across many programs in the United States.

A longitudinal study of the mathematics requirements within civil engineering curricula is developing because of continued research performed by Swenty and Swenty [4]. While Russell and Stoufer were motivated to establish a baseline for design of future civil engineering curricula, the studies by Swenty and Swenty in 2018 were developed recognizing influences of important factors such as the ASCE Civil Engineering Body of Knowledge, changes in the National Council of Examiners for Engineering and Surveying (NCEES) Fundamentals of Engineering (FE) exam, and changes to ABET General Criteria and Civil Engineering Program Criteria [5]. Citing results from 2002, 2018, and 2024, the authors conclude that mathematics requirements in civil engineering curricula have remained relatively steady. The average shifted slightly from 35 to 34 credit hours while overall program credit hours decreased by about two credit hours to an average of 128 hours. The authors attribute the loss of a credit hour to the 2018 ABET modification allowing programs to revise the combination of mathematics and science credits to meet ABET Criterion 5.

Manseur et al. [6] questioned the merits of mathematics through a 2010 study discussing the development of an engineering program. Their work discussed the challenges of an already overcrowded curriculum and the lack of technology within mathematics courses. Their argument was that mathematics classes prioritize the exercise of mathematical principles with limited application. Additionally, they contemplated the need to integrate technology more appropriately into the mathematics experience, expressing concern about requiring students to focus on activities easily substituted by calculators and simple programing tools. Manseur's study encourages programs to evaluate the opportunity to migrate towards application-based learning and integration of technology.

In 2011, Flegg et al. [7] discussed course design with a similar focus to Manseur's study regarding the lack of courses that included applied problem solving. Most fundamental mathematics courses in their studies focused on theoretical concepts. Homework assignments prioritized significant repetition as the mechanism to aid in student retention of the course learning objectives. Flegg et al. studied student perceptions of the application of mathematics to their engineering majors, and results were mixed. Most students understood the application of mathematics, especially when directly mentioned within engineering problems. Using an applications-based approach, students were more likely to discuss their improved ability to understand the context of a problem, determine an appropriate solution method, and then solve the problems. Survey participants indicated they were not necessarily applying the exact content from their mathematics lessons but understood the value of the mathematics courses as key to learning the basics of problem solving, not just the "math".

Researchers led by Akinci-Ceylan [8] at Iowa State sought to better understand problem solving strategies and studied the differences between the processes that students, faculty, and professional engineers follow for solving ill-defined problems. Averill's 2019 framework [9] for problem solving was referenced within the study, using a framework focused on concepts or fundamental principles as the first category in the process of problem solving. Collectively, the outcomes from these three research efforts show that the training of fundamental principles outside of application is necessary. Their studies show that the learning process for problem solving should be supported by some core fundamental training before students are asked to move into application-based problems.

Curricular evolution in mathematics within civil engineering programs is evident, especially within the past 2-3 years, possibly encouraged by more prevalent advancements introduced by Artificial Intelligence (AI) tools. A review of current civil engineering curricula reveals the evolution of mathematics as well as mathematics-engineering partnerships modifying the landscape of programs. For example, the University of Massachusetts Amherst currently offers a "Probability and Statistics in Civil Engineering" course and University of Nebraska at Lincoln offers "Computational Problem Solving in Civil Engineering". Collaborating to offer an innovative dual degree program, Chapman University has partnered with UC Irvine to create several mathematics courses with emphasis on engineering applications. Since Manseur's paper in 2010, more literature has been presenting collaborative course design efforts, crossing many spectra of mathematics as well as sub-domains of civil engineering [10] [11] [12] [13].

Factors Influencing Mathematics Coverage in Curricula

The civil engineering curriculum at each institution is influenced by both internal and external factors. Internal factors may include faculty expertise and availability, input from faculty and advisory boards, and typical career paths chosen by graduates. External factors may include ABET criteria, requirements of the Fundamentals of Engineering (FE) exam, motivation provided by forward-looking initiatives such as the CEBOK or recommendations developed by other ASCE entities. These external factors are described below.

ABET

ABET is a federation of 34 member societies including ASCE, ASME, and IEEE, who collaborate to establish policies, develop criteria, and conduct accreditation activities on behalf of their respective professions [14]. All member societies participate in development and review of the General Criteria, while individual professional societies serve as a Lead, co-Lead, or Cooperating Society on the development and review of Program Criteria relevant to their area(s) of expertise.

All engineering programs accredited by the Engineering Accreditation Commission (EAC) of ABET must satisfy the General Criteria. EAC/ABET accredited civil engineering programs must also satisfy the Civil Engineering Program Criteria. Curricular requirements identified under Criterion 5 (Curriculum) of the EAC/ABET General Criteria "specify subject areas appropriate to engineering but do not prescribe specific courses." [15]. Criterion 5 requires that the curriculum include "a minimum of 30 semester credit hours (or equivalent) of a combination of college-level mathematics and basic sciences with experimental experience appropriate to the program." [15]. The criteria define college-level mathematics as "mathematics that requires a degree of mathematical sophistication at least equivalent to that of introductory calculus." [15] Examples of college-level mathematics include "calculus, differential equations, probability, statistics, linear algebra, and discrete mathematics." [15] Although Criterion 5 specifies the total number of credit hours of college-level mathematics and basic sciences, the criterion does not specify the number of credit hours within the 30 hours that should be allocated to mathematics. A study of 87 civil engineering programs by Swenty and Swenty [4] found that the average number of credit hours required for graduation is approximately 128. Thus, 30 credit hours of required mathematics and sciences represents less than 25% of the curriculum.

The Civil Engineering Program Criteria (CEPC) "apply to engineering programs that include "civil" or similar modifiers in their titles" [15]. As Lead Society for the CEPC, ASCE reviews and updates the program criteria, as appropriate [16]. The current CEPC, effective beginning the 2024-25 ABET accreditation cycle, require that the curriculum include “mathematics through differential equations, probability and statistics,” [15] among other requirements.

Among the 31 EAC/ABET curricular areas with program criteria, almost all include math requirements, as shown in Appendix A. As shown in Appendix A, seventeen program criteria specifically define some variation of “mathematics through differential equations” and nineteen program criteria include probability and/or statistics.

Program criteria for “Engineering, General Engineering, Engineering Physics, Engineering Science, and Similarly Named Engineering Programs” have no requirements beyond the General Criteria. Three other Program Criteria do not include specific math requirements, but include concepts that require application of mathematics [15]:

- Aerospace and Similarly Named Engineering Programs - include curricular requirements of “modeling, simulation, computing, and testing applied to the design and analysis of aerospace systems or subsystems …. In this context, modeling is the development of abstract representations (mathematical, logical, or computational) of systems…”
- Engineering Management and Similarly Named Engineering Programs - include a curricular requirement for “Modeling topics for decision-making in a stochastic world”
- Fire Protection and Similarly Named Engineering Programs - include the “…integration of … to solve field problems using computational, experimental and performance-based design methods.” [15]

It is important to note that neither Criterion 5 nor the CEPC require that the topic coverage should be achieved through stand-alone courses in math or statistics. Indeed, programs have the flexibility to integrate topics within other courses but must clearly document curricular topics for the purposes of accreditation review. In a review of course requirements in civil engineering programs, Hamilton et al. found that most programs cover topics in distinct courses, and in general, exceed the minimum requirements established in the EAC/ABET General Criteria and the CEPC [17]. Swenty and Swenty [4] found significant variability among courses required in civil engineering programs indicating that programs are adapting curricula to meet the needs of their program constituencies.

Given the universal inclusion of mathematics in program criteria, it appears that coverage of mathematics is relevant to all professional societies with engineering programs accredited by the EAC/ABET. Principles of mathematics, problem solving skills, and their application to solving problems are critical to success in physics courses and to courses taken later in the engineering curriculum such as statics, fluid mechanics, and engineering design. Mathematical models are derived and routinely used to solve problems in water quality, environmental engineering, groundwater, geotechnical engineering, structural engineering, transportation engineering, and other areas. However, over the past two decades, there has been an increasing recognition of the lack of adequate math preparation for students entering civil engineering programs and students’ difficulty in translating math skills to their engineering courses. Efforts to remedy the shortfall or the transition gap include summer bridge programs, project-based math courses, and collaboration among math and engineering faculty to improve student learning [18].

Fundamentals of Engineering Exam

Since 2020, questions on mathematics have represented 7-11% of the total number of questions on the Civil Engineering Fundamentals of Engineering (FE) Exam. The exam specifies that questions can be anticipated in four primary areas of mathematics including analytical geometry, single-variable calculus, vector operations, and statistics [19]. As reported by Swenty and Swenty [5], the percentage has remained relatively unchanged for two decades prior, with the percentage at 7% in 2017-18, which was lower than the 10% reported in 2002-03.

Civil Engineering Body of Knowledge (CEBOK)

The American Society of Civil Engineers (ASCE) Civil Engineering Body of Knowledge (CEBOK) sets the direction for curriculum development and professional practice and establishes an expectation for lifelong learning. The CEBOK, 1st Edition [20], was focused on preparing the future civil engineer for entry into the profession. The original CEBOK was published in 2004 and used ABET Criterion 3 student outcomes a – k (as published at that time) for the first 11 of 15 outcomes. Outcome competency requirements were defined at three levels: Level 1 (Recognition), Level 2 (Understanding), and Level 3 (Ability). The original CEBOK defines Level 3 as simply the capability to perform with competence. Mathematics was incorporated into the first outcome, Technical Core, and the minimum competency requirement was Level 3: Ability. The outcome statement was: "an ability to apply knowledge of mathematics, science, and engineering." That statement was tied directly to the wording of ABET Criterion 3 student outcome "a" that was in use at the time the CEBOK, 1st Edition, was published. The commentary for the Technical Core outcome stated that mathematics through differential equations and probability and statistics are required for "the professional role of the civil engineer as the master integrator and technical leader."

The CEBOK second edition, CEBOK2, was published in 2008 and specified 24 outcomes organized into three categories: Foundation, Technical, and Professional [21]. Fulfillment of each outcome was defined relative to Bloom's Taxonomy for the cognitive domain. Six levels of achievement are included in this taxonomy (1. Knowledge, 2. Comprehension, 3. Application, 4. Analysis, 5. Synthesis, and 6. Evaluation). Thus, CEBOK2 represented an increase in the level of detail of outcome achievement. Mathematics became a stand-alone outcome and was included in the Foundational outcome grouping in the CEBOK2. The outcome statement for mathematics was: "Solve problems in mathematics through differential equations and apply this knowledge to the solution of engineering problems." Clearly different from the original CEBOK, the outcome statement in CEBOK2 was focused only on mathematics and provided a higher degree of specificity by stating "mathematics through differential equations." Notably the mathematics outcome description states that the areas of mathematics relevant to civil engineering are "algebra, analysis, arithmetic, geometry, calculus, numerical analysis, optimization, probability, set theory, statistics and trigonometry." Although the outcome rubric calls out differential equations, the description does not. CEBOK2 introduced a pathway to fulfillment of each outcome which included a bachelor's degree in civil engineering, a master's degree or approximately 30 graduate level credits, and appropriate experience. The mathematics outcome was specified to be fulfilled entirely during the bachelor's degree. The outcome achievement level was defined by taxonomy level 3: Application.

The third edition of the Body of Knowledge (CEBOK3), published in 2019, reduced the number of outcomes to 21 while introducing the use of both cognitive domain (for all outcomes) and affective domain (for select outcomes) [1]. Mathematics remained a stand-alone outcome within the Foundational outcome grouping. The taxonomy achievement level remained at Level 3: Apply (a slight re-wording from the prior Application). The mathematics outcome was only considered relative to the cognitive domain of Bloom's Taxonomy. The outcome statement was reworded as: "Apply concepts and principles of mathematics, including differential equations and numerical methods, to solve civil engineering problems." In the CEBOK3, mathematics studies included both differential equations and numerical methods. Differential equations is identified as the highest level of mathematics required of all civil engineering curricula and thus it is expected that algebra, geometry, trigonometry, and calculus will also be incorporated in preparation for differential equations. Numerical methods were included in recognition of their importance in addressing complex civil engineering problems.

The CEBOK3 identified a typical pathway for fulfillment of each outcome, namely, through undergraduate education, postgraduate education, mentored experience, and self-development. The CEBOK3 specifies that the mathematics outcome will be fully addressed as part of an undergraduate degree in civil engineering. When discussing the level of achievement, the CEBOK3 notes that mathematics is a required aspect in all other "foundational" and "engineering fundamentals" outcomes (natural sciences, materials science, engineering mechanics, experimental methods and data analysis, and critical thinking and problem solving) and is also found within all of the "technical" outcomes (project management, engineering economics, risk and uncertainty, breadth in civil engineering areas, design, depth in civil engineering areas, and sustainability). [1] The Civil Engineering Program Criteria were developed based on outcomes established in the CEBOK3, and therefore, have consistent requirements for preparation in mathematics [16].

The task committee charged with preparing the CEBOK, 4th edition, was established in Fall 2024. Task committee members and corresponding members are currently evaluating existing (CEBOK3) outcomes and considering the need to introduce new outcomes. It is anticipated that the mathematics outcome will remain in CEBOK4 and that the level of achievement and pathway to fulfillment will likely remain unchanged, but that alternative pathways may also be considered. Although the wording of the outcome statement may be edited slightly, it is not anticipated that the highest level of mathematics (differential equations) will be altered.

Task Committee on Transforming Our Workforce (TCTOW)

The ASCE Board of Direction created the Task Committee on Transforming Our Workforce (TCTOW) in early 2024 and charged the committee with defining essential goals to address workforce development, independently as well as in collaboration with other civil engineering entities. The TCTOW presented the Board with a summary report in June 2025 which identified fifteen (15) recommended actions needed to enhance the profession by identifying alternative career pathways, outreach initiatives, curriculum redevelopment, and changes in professional licensure. More than half of the action items were related to curricula and ABET accreditation. One item included recommendations for increased flexibility in curricula and career pathways so the civil engineering profession can meet evolving needs and global challenges [2].

Several observations presented in the TCTOW report specifically recommend providing alternative pathways to attain professional status as a civil engineer. The report includes recommendations to alter or reduce training in mathematics and science. The TCOTW report states that the required minimum 30-credit hours of mathematics and sciences established in the ABET General Criteria limits flexibility for civil engineering programs, although the report does not include evidence to support this statement. The TCOTW report also expresses concern that curricular coverage may not equate to competency in mathematics and notes that there may be a possible disconnect between mathematics requirements and the unique aspects of different civil engineering subdisciplines. The Task Committee questions whether EAC/ABET and CEPC curricular requirements inhibit development of innovative programs and restrict career pathways by including coursework that may not be relevant to all aspects of civil engineering professional services. The report recommends review of course delivery to emphasize relevant topics in mathematics and to integrate these topics into civil engineering courses. The report also questions whether curricular requirements are intended to enforce academic rigor at the expense of student progression through an undergraduate degree.

Questions and actions presented in the report informed the review of curricular requirements presented in this study. Although the basis for some of the recommendations made in the TCTOW report are unclear, they nevertheless raise important questions about whether EAC/ABET criteria or the CEPC are principal drivers of mathematics content in civil engineering programs, and if so, whether accreditation requirements inhibit flexibility and affect retention.

Methods

ABET criteria, the CEBOK, the TCOTW report, and the literature support the need for civil engineers to apply mathematics. Different entities may have different opinions as to the necessary breadth and depth of knowledge in mathematics and the integration of mathematics within the undergraduate civil engineering curriculum. This study was motivated by considering the EAC/ABET criteria, concerns and recommendations presented by the TCOTW, requirements of the FE exam, the CEBOK3 outcomes, and mathematics requirements in civil engineering curricula to inform recommendations for mathematics preparation in the CEBOK4.

To address the research questions, a list of current EAC/ABET accredited civil engineering programs was downloaded from the ABET web site [22] to quantify mathematics requirements in all U.S.-based civil engineering programs. Initially, the team decided to test Artificial Intelligence tools (MS Copilot and ChatGPT) to gather the raw data. An attempt was made to use these large language models (LLM) to generate a list of required mathematics courses, the associated credits, and a total number of required credits to earn a degree in all EAC/ABET accredited civil engineering programs in the United States. However, despite several attempts to refine prompts, each tool seemed to bog down when asked to conduct this search for the entire set of EAC/ABET accredited programs. Efforts to break the request into smaller data sets based on discrete sections of the alphabet resulted in significantly different results and formatting of the results. More importantly, when data sets were evaluated for accuracy, it was determined that the LLM generated results were incorrect nearly 1/3 of the time. Given these inaccuracies, the research team opted to abandon use of LLMs for data collection, and instead, use LLMs to identify the university catalog site for each of the 281 civil engineering programs in list. Although many web links were correct, many were incorrect and were either found manually (with a Google search) or the prompt was rerun to generate new links.

Two members of the research team undertook a review of program websites and university course catalogs to compile a spreadsheet of information for each of the 281 EAC/ABET accredited civil engineering programs examined in this study. To make data analysis more uniform, 8 programs were removed from the data set because of their unique approaches to assigning units to courses. It should be noted that ABET General Criteria do not designate any particular system for assigning units of credit. The final data set included 273 (N) EAC/ABET accredited civil engineering programs in the United States. Basic statistical analysis of that data set allowed the team to generate results described in the next section.

It should be noted that the research team did not undertake an effort to verify the accuracy of catalog content. However, given that EAC/ABET accredited civil engineering programs undergo an ABET review once every six years, programs have a strong incentive to update the catalog periodically. Additionally, student retention and performance in mathematics courses are important questions addressed by others [10] [11] [12] [13] and assessed by EAC/ABET accredited civil engineering programs for compliance with ABET Criterion 4 (Continuous Improvement) but are beyond the scope of this present study.

Results

A distribution of total math credits required by EAC/ABET accredited civil engineering programs in the United States is shown in Figure 1. Among the 273 ABET accredited civil engineering programs included in the final data set, the average number of credits associated with mathematics was 17.5, while the maximum and minimum number of credits were 30 and 10, respectively. Figure 2 presents a histogram of the percent of the total required credits dedicated to mathematics by civil engineering programs in the United States. An average of 13.5 percent of all required credits is dedicated to mathematics.

As shown in Figure 3, 100% of EAC/ABET accredited civil engineering programs require a course named Calculus 1 (or similar), nearly 100% require a course named Calculus 2 (or similar), 87% require a course named Calculus 3 (or similar), over 95% require a course in Differential Equations (or similar), and 73% require additional courses in mathematics. The average number of credits associated with the additional course in mathematics was 3.68. The difference observed between the percentage of programs that require Calculus 3 and those that require Differential Equations indicates that Calculus 3 may not be a prerequisite for Differential Equations at some institutions.

Figure 4 presents the average number of credits associated with particular courses required by the civil engineering programs examined in this study. Error bars indicate one standard deviation from the average. As shown in the figure, Calculus 1 and Calculus 2 are typically offered as 4-credit courses, Calculus 3 is more typically offered as a 4-credit course than a 3-credit course. Differential equations courses appear to be more typically offered as a 3-credit course than a 4-credit course. Other mathematics courses are offered as 3-credit or 4-credit courses. Many programs require more than one additional mathematics course beyond calculus and differential equations for a total of 6 or 8 credits of "other math" courses.

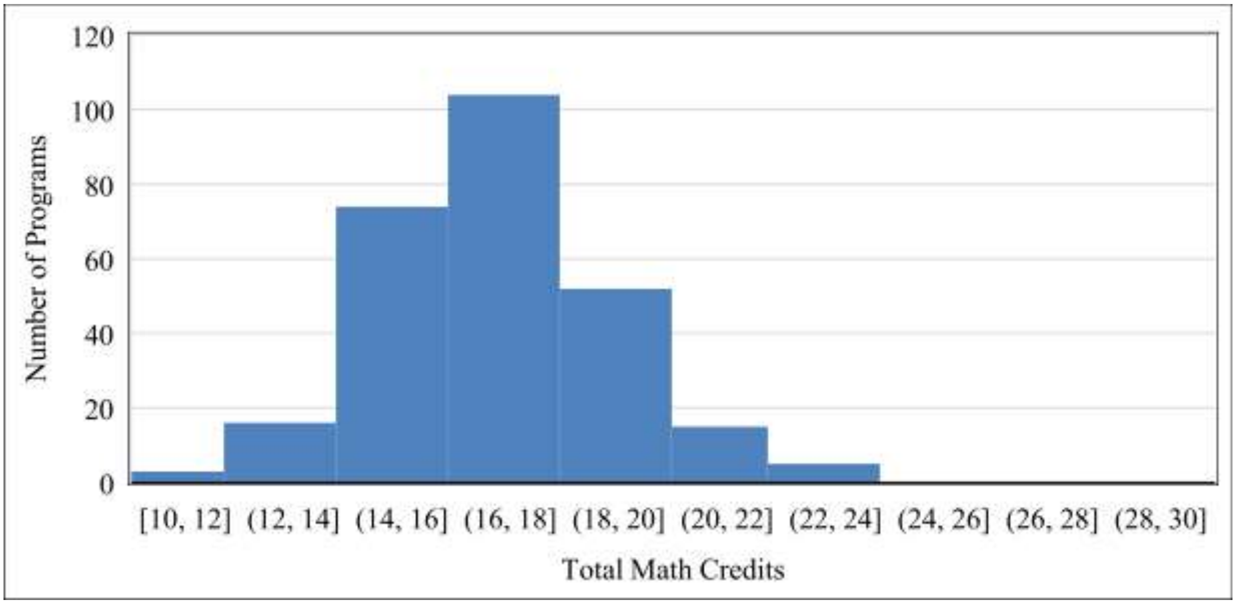

Figure 1. Total Math Credits Dedicated to Mathematics in EAC/ABET Accredited Civil Engineering Programs in the United States.

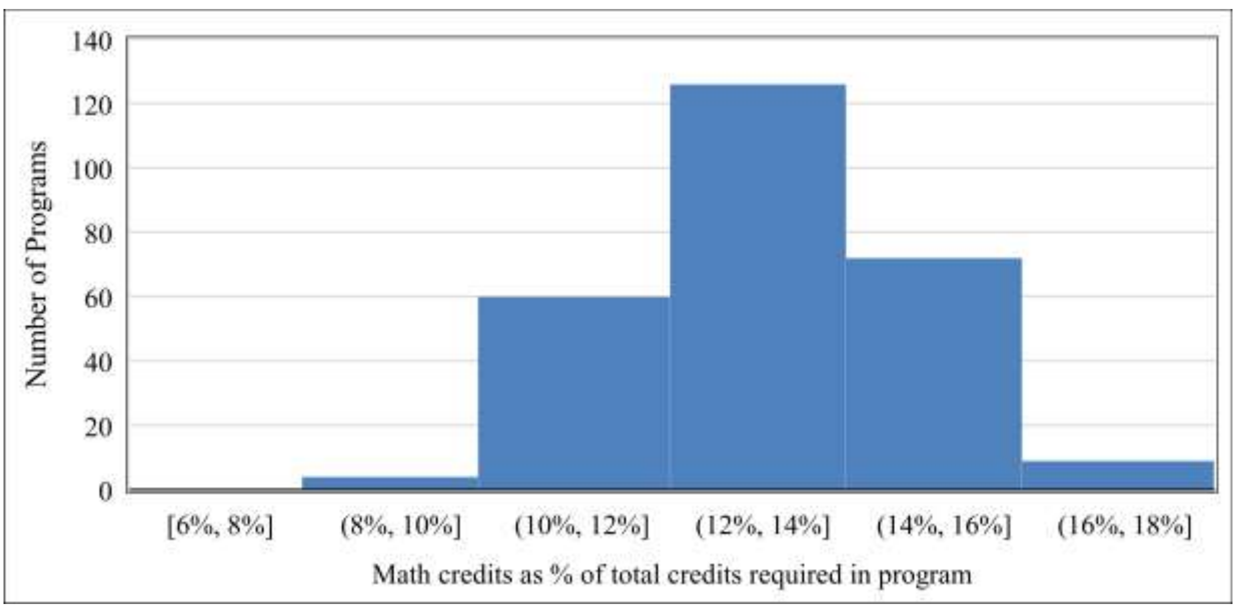

Figure 2. Percent of Required Credits Dedicated to Mathematics in EAC/ABET Accredited Civil Engineering Programs in the United States.

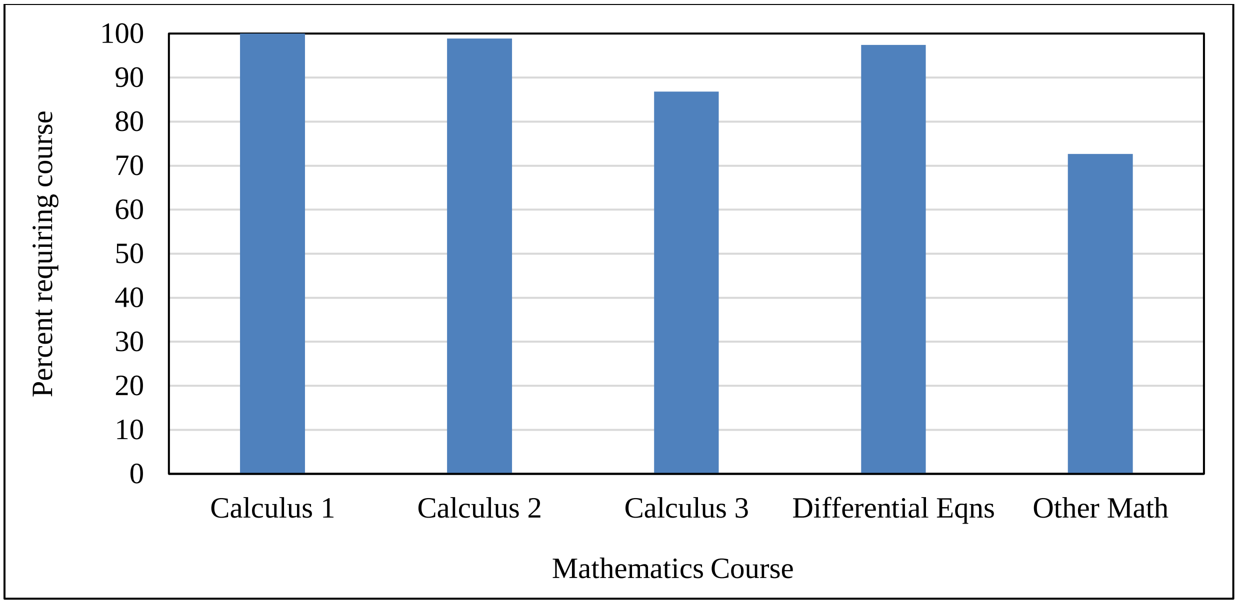

Figure 3. Percent of ABET Accredited Civil Engineering Programs Requiring Particular Math Courses in the United States.

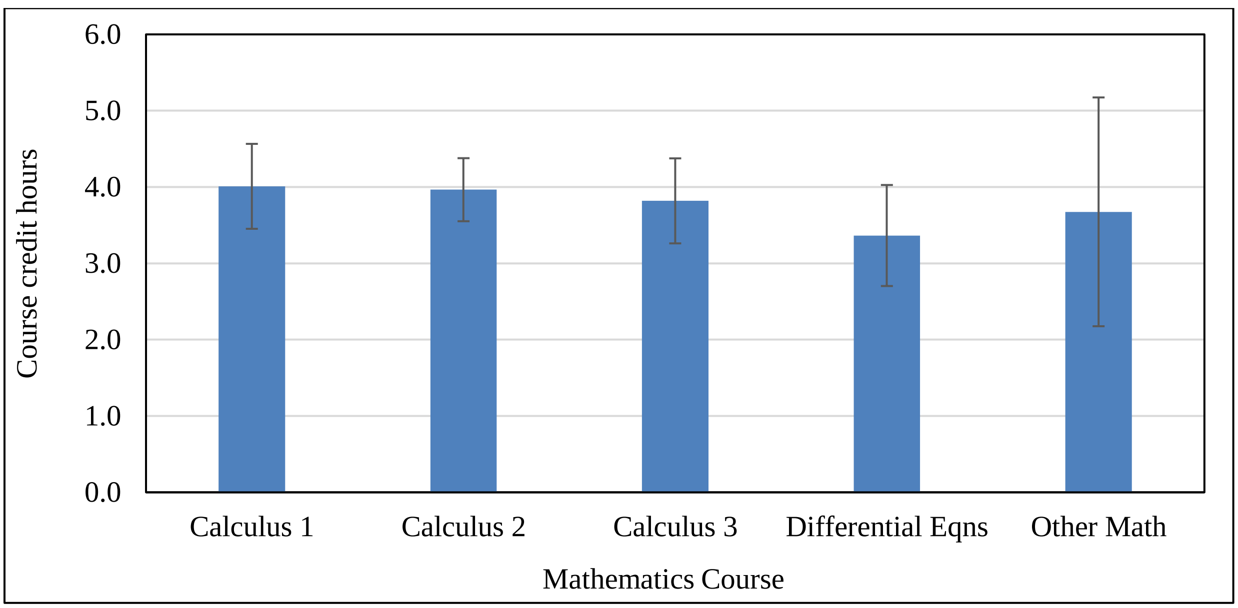

Figure 4. Number of Credits Associated with Math Courses in EAC/ABET Accredited Civil Engineering Programs in the United States.

A comparison of results of the current study and those reported by Swenty and Swenty [4] is shown in Table 1. As seen in the table, the number of programs requiring Calculus and Differential Equations is in close agreement with the prior study, although the number of programs reported to require a course in Probability and Statistics is different. This is likely a result of how programs were counted as requiring a specific course versus programs that require an elective that could include Probability and Statistics. The credits associated with the courses are comparable between the two studies.

Table 1. Summary of Reported Mathematics Courses (current study compared to Swenty & Swenty [4])

	Percent of Programs Requiring Mathematics Course		Average **Number of Credits** Associated with Each Course	
	Current study	Swenty & Swenty study [4]	Current study	Swenty & Swenty study [4]
Calculus 1	100	100 (calculus courses in general)	4.0	11.4 (all courses combined)
Calculus 2	99		4.0	
Calculus 3	87		3.8	
Differential Equations	97	95.4	3.4	3.1
Probability & Statistics	69	93.1	3.6	3.0

Among the programs included in this study, fifty-two were reviewed in the 2024-25 ABET accreditation cycle. Of those programs, 32 (or 62%) required a course in statistics and probability (or a similarly named course). Some programs included other engineering courses that appear to address uncertainty as represented in the course title (e.g., Risk and Uncertainty in Civil Engineering). These courses were not included as part of the present study because catalogs did not clearly indicate the portion of the course, if any, that may be used to satisfy EAC/ABET Criterion 5 requirements for mathematics and sciences.

Discussion

The current literature shows that the knowledge and skills developed through mathematics courses are still relevant in the preparation of engineering students. Mathematics has always been an integral component of civil engineering education. Regardless of civil engineering sub-specialty, a foundational understanding of mathematics and the ability to apply this understanding are critical to the success of a civil engineer and the future of the civil engineering profession. The civil engineering profession, through the ASCE CEBOK, specifies mathematics as a foundational outcome. Although some civil engineers may practice in subdisciplines that have unique knowledge or skills requirements that may need to be met through means beyond the undergraduate curriculum or may need more or less mathematics preparation than other subdisciplines, the purpose of the CEBOK is to consider the needs of the profession broadly.

As shown by the prevalence of mathematics requirements in all EAC/ABET Program Criteria, the engineering professional societies that collaborate to review and update the EAC/ABET General Criteria and the program criteria for the various engineering disciplines clearly value mathematics for preparing undergraduate engineering students. As stated previously, EAC/ABET General Criteria and the Civil Engineering Program Criteria specify curricular topics in mathematics, but these criteria do not mandate specific curricular coursework nor do they mandate that specific courses should be taught within a Mathematics Department.

Civil engineering faculty consider a variety of factors in establishing their curricula. These factors include ABET criteria, CEBOK, external factors such as market demand for graduates, state-mandated requirements, student preparation, faculty expertise, and input from employers, advisory board members, and graduates. Questions raised by the Task Committee on Transforming Our Workforce (TCTOW) as to whether the level of mathematics is still appropriate and necessary may be best answered at the institution level where faculty can engage constituencies including alumni, advisory boards, and employers, to identify appropriate preparation for their students. Mathematics courses are evolving, both within their own departments and in partnership with engineering programs, to address interest and gaps in mathematics skills and to enhance learning of mathematical concepts and their applications in engineering. Many civil engineering programs are innovating in course and curricular design [23], sometimes in consultation with faculty in Mathematics and the Sciences. These innovations, often faculty led, are appropriately managed at the departmental level where faculty can anticipate issues, address opportunities and constraints, and incorporate other necessary changes responsive to internal and external factors influencing the program.

The findings of this study affirm that mathematics knowledge and skills continue to be an integral part of EAC/ABET accredited civil engineering programs. Addressing the research questions posed in this study, the average number of credits in mathematics required in ABET accredited civil engineering programs in the United States of 13.5 credits. The majority of programs require between 14 and 20 credits of mathematics. For about half of programs, credits allocated to mathematics courses represent 12-14% of the total required credits. All EAC/ABET accredited civil engineering programs in the United States require calculus and a vast majority require a course in differential equations, although there is no specific requirement in the Civil Engineering Program Criteria that these mathematics topics be covered in unique courses. Although taking courses does not necessarily equate to knowledge gained, ABET accredited engineering programs are required to assess attainment of student outcomes, including students' ability to "identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics" [15].

The scope of this study has been limited to an investigation of mathematics courses required in the curriculum in EAC/ABET accredited civil engineering programs within the United States. Our conclusions are limited only to those programs. Ideally, a similar study investigating science in the civil engineering curriculum will be conducted at some point in the future.

References

[1] ASCE CEBOK3 Task Committee, "Civil Engineering Body of Knowledge, Preparing the Future Civil Engineer, 3rd Edition," ASCE, Reston, VA, 2019.

[2] ASCE Task Committee on Transforming our Workforce, "Transforming our Workforce Report," ASCE (unpublished), 2025.

[3] J. S. Russell and W. B. Stouffer, "Survey of the national civil engineering curriculum," *Journal of Professional Issues in Engineering Education and Practice,* vol. 131, no. 2, pp. 118-128, 2005.

[4] M. K. Swenty and B. J. Swenty, "A Comparison of Civil Engineering Curriculum and EAC-ABET Civil Engineering Program Criteria," in *ASEE Annual Conference & Exposition*, Portland, OR, 2024.

[5] B. J. Swenty and M. K. Swenty, "The impact of EAC-ABET program criteria on civil engineering curricula," in *ASEE Annual Conference & Exposition*, Salt Lake City, UT, 2018.

[6] Z. Manseur, A. Ieta and R. Manseur, "Modern mathematics requirements in a developing engineering program," in *ASEE Annual Conference & Exposition*, Louisville, KY, 2010.

[7] J. Flegg, D. Mallet and M. Lupton, "Students' perceptions of the relevance of mathematics in engineering," *International journal of mathematical education in science and technology,* vol. 43, no. 6, pp. 717-732, 2012.

[8] S. Akinci-Ceylan, K. S. Cetin, B. Ahn, A. Surovek and B. Cetin, "Investigating problem-solving processes of students, faculty, and practicing engineers in civil engineering," *Journal of Civil Engineering Education,* vol. 148, no. 1, 2022.

[9] R. Averill, "Board 96: The seven C’s of solving engineering problems," in *ASEE Annual Conference & Exposition*, Tampa, FL, 2019.

[10] D. Anitha and D. Kavitha, "Improving problem-solving skills through technology assisted collaborative learning in a first year engineering mathematics course.," *Interactive Technology and Smart Education,* vol. 20, no. 4, pp. 534-553, 2022.

[11] L. M. Sanchez-Ruiz, S. Moll-Lopez, E. Vega-Fleitas, D. Rosello Ferragud, S. Sanchez Lopez and C. Delgado Caro, "Enhancing mathematics education through peer collaboration: Impact of collaborative exam retakes in engineering courses.," in *Proceedings of the 35th Annual Conference of the Australasian Association for Engineering Education*, Christchurch, New Zealand, 2024.

[12] J. Mathias, C. Saville and S. Leech, "Engaging non-mathematics students in mathematics learning through collaborative teaching.," *Teaching Mathematics and its Applications: An International Journal of the IMA,* vol. 43, no. 1, pp. 67-80, 2024.

[13] N. Matzakos and M. Moundridou, "Exploring Large Language Models Integration in Higher Education: A Case Study in a Mathematics Laboratory for Civil Engineering Students.," *Computer Applications in Engineering Education,* vol. 33, no. 3, 2025.

[14] ABET, "Member Societies," 2025. [Online]. Available: https://www.abet.org/member-societies/. [Accessed December 2025].

[15] ABET, "Criteria for Accrediting Engineering Programs, 2026-2027," ABET, 2026. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2026-2027/ . [Accessed December 2025].

[16] L. Nolen, J. Puckett, D. Dzombak and W. Bergstrom, "Preparing the Future Civil Engineer: ASCE’s Proposed Revision of the ABET Civil Engineering Program Criteria," in *ASEE Annual Conference & Exposition,* Minneapolis, MN, 2022.

[17] S. R. Hamilton, D. A. Saftner and C. M. Saviz, "Civil Engineering Program Criteria: A Snapshot of How Programs Meet the Criteria," in *ASEE Annual Conference & Exposition*, Tampa, FL, 2019.

[18] Y. Liu, A. Pezeshki, S. Roy, B. M. Notaros, T. Chen and A. A. Maciejewski, "Why Math Matters: Demonstrating the Relevance of Mathematics in ECE Education," in *2017 ASEE Annual Conference & Exposition,* Columbus, OH, 2017.

[19] NCEES, 2026. [Online]. Available: https://ncees.org/wp-content/uploads/FE-Civil-CBT-specs-1.pdf. [Accessed January 2026].

[20] ASCE CEBOK1 Task Committee, "Civil Engineering Body of Knowledge, 1st edition," ASCE, Reston, VA, 2004.

[21] ASCE CEBOK2 Task Committee, "Civil Engineering Body of Knowledge, 2nd edition," ASCE, Reston, VA, 2008.

[22] ABET, "Accredited Programs," 2026. [Online]. Available: https://amspub.abet.org/aps/category-search. [Accessed January 2026].

[23] J. Sloan, C. Saviz, D. Saftner, L. Nolen, S. Hamilton, T. Kunberger, N. Delatte and A. Morse, "Innovation in Civil Engineering Programs," in *ASEE Annual Conference & Exposition*, Charlotte, NC, 2026.

Appendix A. Mathematics requirements specific in EAC/ABET Program Criteria (ABET 2025)

Program Criteria	**Math requirement (if specified)**
Aerospace	See text of paper
Agriculture	mathematics through differential equations
Architectural	mathematics through differential equations
Bioengineering and Biomedical	mathematics (through differential equations) and statistics
Biological	mathematics through differential equations
Chemical, Biochemical, Biomolecular	mathematics, including differential equations and statistics
Civil	mathematics through differential equations, probability and statistics
Construction	mathematics through differential and integral calculus, probability and statistic
Cybersecurity	Probability, statistics, and cryptographic topics; Discrete mathematics and specialized mathematics appropriate to the program, such as abstract algebra, information theory, number theory, complexity theory, and finite fields.
Ecological	mathematics through differential equations, probability and statistics,
Electrical, Computer, Communications, Telecommunication(s)	probability and statistics; mathematics through differential and integral calculus;
Engineering, General Engineering, Engineering Physics, Engineering Science	no program-specific criteria beyond the General Criteria.
Engineering Management	See text of paper
Engineering Mechanics	mathematical and computational topics
Environmental Engineering	Mathematics through differential equations, probability and statistics
Fire Protection	See text of paper
Geological	mathematics including differential equations,
Industrial	probability, statistics
Manufacturing	analyze, synthesize, and control manufacturing operations using statistical methods
Materials (1), Metallurgical (2), Ceramics (3)	Statistical and computational methods
Mechanical	mathematics (including multivariate calculus and differential equations)
Mechatronics, Robotics	Differential calculus, integral calculus, differential equations, linear algebra
Mineral Processing, Extractive Metallurgical	mathematics through differential equations, probability and statistics
Mining	mathematics through differential equations, probability and statistics
Naval Architecture, Marine Engineering, Ocean Engineering	probability and statistics
Nuclear, Radiological	mathematics
Optical, Photonic	multivariable calculus, differential equations, linear algebra, complex variables, probability, statistics
Petroleum	mathematics through differential equations, probability and statistics
Software	Discrete mathematics, probability, and statistics
Surveying	Mathematics, including statistics
Systems	Advanced mathematics, including probability and statistics