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You're not on your own kid: Integrating General Education into a First Year Civil Engineering Introductory Course

Dr. Angel Ari Perez-Mejia, Quinnipiac University

Ari Perez-Mejia earned his undergraduate degree in Civil Engineering at the Universidad Tecnologica Centroamericana (UNITEC) in Honduras, and did his graduate work at the University of South Carolina. He received his PhD in 2014 and joined the engineering faculty at Quinnipiac University where he helped start a new Civil Engineering program. His research interests are on engineering education, preservation of archaeological sites, and Taylor Swift.

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Abstract

Typically, a large portion of the first year of a student’s undergraduate engineering education is spent on general education courses. Although what satisfies this requirement varies between institutions. ABET’s requirement that programs provide a broad education to accompany the technical components of the curriculum means that engineering programs include general education courses both required and elective to both satisfy the broad education requirement and provide a rich interdisciplinary experience and education to their students. These courses provide both content (e.g. economics, ethics) and skills (e.g. writing, oral presentations) that are useful and necessary for both personal and professional development. However, students can often see these courses as not useful or unrelated to their future careers. In this study, a first semester course in Civil Engineering was designed and delivered to make deliberate and clear the connections between the general education portion of the curriculum and students’ future careers as civil engineers. An existing instrument was adapted to measure student aptitudes towards different skills and knowledge typically presented in general education courses and given to the student pre and post instruction, revealing statistically meaningful increases in the perceived importance of some areas of the general education curriculum.

Introduction

Liberal arts courses covering disciplines in the humanities, social sciences, and fine arts are a general education requirement in many civil engineering programs in the United States. Currently, ABET Criterion 5 (c) states that programs must have: “a broad education component that complements the technical content of the curriculum and is consistent with the program educational objectives” [1]. Previously, ABET had required 16 credit hours of humanities and social sciences. In this framework, engineering programs engaged with the general education requirement only in a perfunctory manner [2]. However, since the adoption of the current requirement, engineering programs have innovated and piloted a variety of approaches to fulfill this requirement in a way that maximizes the benefits of this broad education through the general education curriculum.

That today’s engineer needs to be a humanist has been declared since at least the late 1960s [3] and accepted as true until at least 2008 [2]. Florman[4] makes a strong case for the skills learned through the liberal arts improving scientific and engineering work and design by embracing different ways of thinking and problem-solving as well as increasing creativity. Stouffer and Russell [5] describe a liberal arts education to be essential in developing the professional skills necessary for a modern engineer. Engineers are influenced by the cultural and intellectual context within which they work [6] and should have “a broad understanding of economic and political structures and the relationships between different countries” [7].

In a 2005 national survey of civil engineering programs, general education (as defined by ABET, and primarily encompassing the humanities and social sciences) represented a fifth of the total curriculum or 26.7 credits on average for universities on a semestral schedule [8]. However, there was significant variability in that number, which ranged between 18 and 58 credits for programs in those institutions. Commonly, these courses are taken at the beginning of the engineering curriculum, before students have a strong sense of their future career as civil engineers and the skills and knowledge needed to succeed. This often results in a disregard for general education courses, as students are unaware of the many non-technical aspects of engineering. Technical engineering skills are prized by the students while the skills and knowledge acquired in the common curriculum are disregarded. Efforts to address this issue have been published, as engineering educators have sought to best design “a general education component that truly does complement the technical component” [2] to provide students with the knowledge and skills that improve their overall educational experience and develop an appreciation for general education and its use in engineering practice [2]. To obtain the benefit of this large portion of a student’s total undergraduate education, roughly 20% in civil engineering curriculums[8], it is crucial that students understand the connections between their general education courses and their technical courses as well as the transferability of skills between them, rather than see their liberal arts education as “a preliminary experience that paves the way for “real work” within the major” [9]. One of the reasons for this may be the lack of integration of general education within the technical curriculum [5]. The timing of general education courses, mostly in the first year of a student’s education and before they have developed the vocabulary and knowledge of their engineering profession, results in a loss of effectiveness as the connections and transferability between general education and the technical portion of the civil engineering curriculum, which are apparent to the instructors, are lost on students.

Speaking for the humanities, Ruprecht [10] states that “humanities can only serve their purpose in a technical education if they are really integrated in the curriculum as branches with all the weight that other subjects have”. It would follow that the rest of general education courses would be similar, and their benefit can only be fully unlocked by integration within an engineering context.

Background

The purpose of a general education is “the general development of the intellect in reason, judgement, and communication […] united in the respect that clear thinking, critical analysis, and concise communication are paramount to understanding and interaction in the greater world” [8]. Zarco [11] describes the principal objective of general education as “to give students a broad perspective on knowledge and an awareness of diverse human experiences and cultures”. When discussing about rethinking engineering education for the present, Brito et al [12] defined engineering education as "established in cultural, economic, individual, philosophical, scientific and social advancement […] those who achieve a general education will develop adaptive skills which will serve them while their world evolves". This drive for integration of technical and non-technical education can be seen in engineering classes developed to be part of the general education curriculum, like at the University of the Philippines [11] or the Seattle Pacific University [13]. The University of the Philippines developed 3 general education engineering courses. In those courses, a mix of engineering (roughly 40 % of enrollment) and non-engineering students took a general education engineering course focused on developing general education skills (leadership and teamwork) through engineering design competitions. Teams with mixed enrollment were very successful, with "novel designs originated from team members in non-engineering courses such as Creative Writing, Fine Arts, Journalism, History, and Philosophy" [11]. At Seattle Pacific University, a new version of the general education first year university seminar was offered. This class enrolled both engineering and non-engineering students and sought to teach skills typically focused upon in general education such as writing, public speaking, and teamwork in an engineering setting. They had students write responses to selected publications, present a report on the life of an engineering innovator, and complete a hands-on project to build and design robots. At both institutions, these approaches found success because of their novel approach to bringing engineering into general education to both demonstrate the usefulness of the skills taught in the general education curriculum to the engineering career and deliver information about engineering to a mixed student audience.

The typical approach to general education silos disciplines and makes integration of material across disciplines mostly a missed opportunity. The inherent exploratory nature of many general education curriculums includes a large portion of electives and students are left to decide which disciplines to study. The timing of general education instruction, before students have had the opportunity to develop a strong concept and the technical vocabulary of their profession, means that the general education curriculum can appear irrelevant to students as they struggle to find relevance to their chosen major [8]. There is an additional dimension to consider in creating engineering courses to bridge the gap to the general education curriculum, and that is engineering's place in modern higher education. Florman [14] laments the poor status of engineers in society in the United States, and attributes it partly to the poor knowledge that the general population has about the profession and its profound impact on society. Kelly [2] supports the idea of integrating civil engineering into the general education curriculum stating that "there is no reason why courses suitable for general education for civil engineers, some of which might be taught by civil engineers, should not be valuable for the broader university community". Designing and creating classes meant to serve a general student population and fomenting interactions between engineering and non-engineering students is one way to increase the visibility and prestige of engineering, as well as to correct misconceptions about engineering in the non-technical population. Having more students in non-engineering majors and careers become more knowledgeable about our work and impact will increase their scientific and technological literacy in a time where engineering may have the solutions to the world's most pressing problems. Additionally, as some of those students may become interested in and pursue careers in engineering[13] they may go on themselves to apply their skills to those problems facing our planet. The integration of engineering into the general education curriculum is then beneficial for both engineering students who benefit from exposure to different ways of thinking and solving problems as well as non-engineering students who understand the world they inhabit and its processes better.

A 6-year longitudinal study on the perception of general education amongst students at the University of North Dakota [9] was partly prompted by the disconnection of general education and professional majors, such as engineering. The results of the study showed that students described general education courses as "an incidental, or even irritating, distraction en route to their degree [..] at best, conveying fundamental content knowledge […] as something to get out of the way so they could get on with the "real" academic work of their chose program". As a result of their re-development of the general education curriculum, the University of North Dakota developed specific guidelines for general education courses, combining a breadth requirement with a special emphasis requirement, focusing on specific outcomes, such as oral communication or quantitative reasoning. A benefit of developing these outcome based guidelines was the effort across many departments (including civil engineering) to develop or modify courses in order to deliberately include and focus on general education outcomes in their courses, resulting in both a better integration of general education with majors and a higher perceived relevance for general education in students as they are "reminded of general education goals as they work through the major […] general education will become a longitudinal part of the undergraduate curriculum rather than a preliminary experience that paves the way for "real work" within the major". This also allows for the continued presence of general education at the upper-division level and in the context of their chosen subject matter in their major, resulting in an experience that is "more vertical and intentional, connections across the curriculum are more obvious, and GE [general education] goals often feel more relevant and practical thanks to clear connections faculty are making between those goals and disciplinary content".

In 2019, the American Society of Civil Engineers (ASCE) published the third Civil Engineering Body of Knowledge (CEBOK3)[15]. This document identifies 9 learning outcomes necessary for civil engineers to achieve in the natural sciences, social sciences, and humanities that are typically addressed through undergraduate education. Although ABET classifies the natural sciences outside of the general education curriculum, many institutions, including the one where this study took place, have them as part of the general education curriculum. Rationales for the study of these disciplinary groups are also provided, and both are presented in Table 1. These provide the necessary context for both understanding the importance of general education to Civil Engineers as well as the measurable skills that Civil Engineers must acquire and demonstrate. In these rationales, the benefits of general education to civil engineering practice are clearly stated. In order to achieve these skills, civil engineering programs need to integrate the general education curriculum to develop the appropriate perspective [5].

Table 1– Rationale for the study of disciplinary groups and educational outcomes from CEBOK3

Disciplinary Group	**Rationale**	**Demonstrated Ability**
Natural Sciences	A core of knowledge and breadth of coverage in the natural sciences and the ability to apply this knowledge to analyze and solve engineering problems are essential skills for civil engineers. Civil engineers must have the basic scientific literacy that will enable them to be conversant with technical issues pertaining to environmental and physical systems, public health and safety, durability of construction materials, and other such subjects. With technological advances in science and their applications to civil engineering beyond physics and chemistry, study in an additional area of natural science is required to prepare the civil engineer of the future and to keep the profession relevant. In addition to the technical content of the natural sciences and the application to civil engineering, the study of the natural sciences also develops critical thinking, analytical skills, and problem-solving skills	**Identify** concepts and principles of chemistry, calculus-based physics, and at least one other area of the natural sciences. **Explain** concepts and principles of chemistry, calculus-based physics, and at least one other area of the natural sciences. **Apply** concepts and principles of chemistry, calculus-based physics, and at least one other area of the natural sciences, to solve civil engineering problems.
Social Sciences	Civil engineers must be able to recognize and incorporate various aspects of social science considerations into the development, delivery, and evaluation of civil engineering projects. They must think with an open mind and acknowledge the inputs and impacts from a social sciences perspective. They must also recognize and assess the assumptions, implications, and practical consequences of their work. Continued development of professional competence comes from lifelong learning, mentorship from senior engineers, and practical experience, built on a firm foundation of the social sciences.	**Identify** concepts and principles of social sciences. **Explain** concepts and principles of social sciences. **Apply** concepts and principles of social sciences relevant to civil engineering
Humanities	Civil engineers must think with an open mind within diverse systems of thought, recognizing and assessing, as need be, the assumptions, implications, and perhaps most importantly, the practical consequences of their work. They must	**Recognize** relationships between the humanities and the practice of civil engineering.

	be informed not only by mathematics and the natural and social sciences, but also by the humanities. To be effective, civil engineers must be critical thinkers and possess the ability to raise vital questions and problems and then formulate them clearly and appropriately. They must gather and assess relevant information, use abstract ideas to interpret the information effectively, and come to well-reasoned conclusions and solutions, testing them against relevant criteria and standards. Critical to the success of any civil engineering project is the thoughtful consideration of the impact the project will have on people and the human experience, and the foundation for this thoughtful consideration is a foundational knowledge, understanding, and application of the humanities.	**Explain** relationships between the humanities and the practice of civil engineering. **Apply** aspects of the humanities to the solution of civil engineering problems.

Due to the exclusion of natural sciences from the ABET guidelines, when reporting the composition of the average general education topics, Russell and Stouffer [8] also excluded those courses. The distribution of general education topics of the average 26.7 credits taken by civil engineering students is presented in Figure 1. After a period of experimentation with loosening general education requirements at many universities in the 1960s, a strengthening of the core curriculum happened at many schools in the 1980s with the result being an increase in the number of required courses [16]. On average, 15.7 credits of general education are offered through elective courses, with the required course balance being represented primarily by English composition, by economics, philosophy, history, or communications related courses.

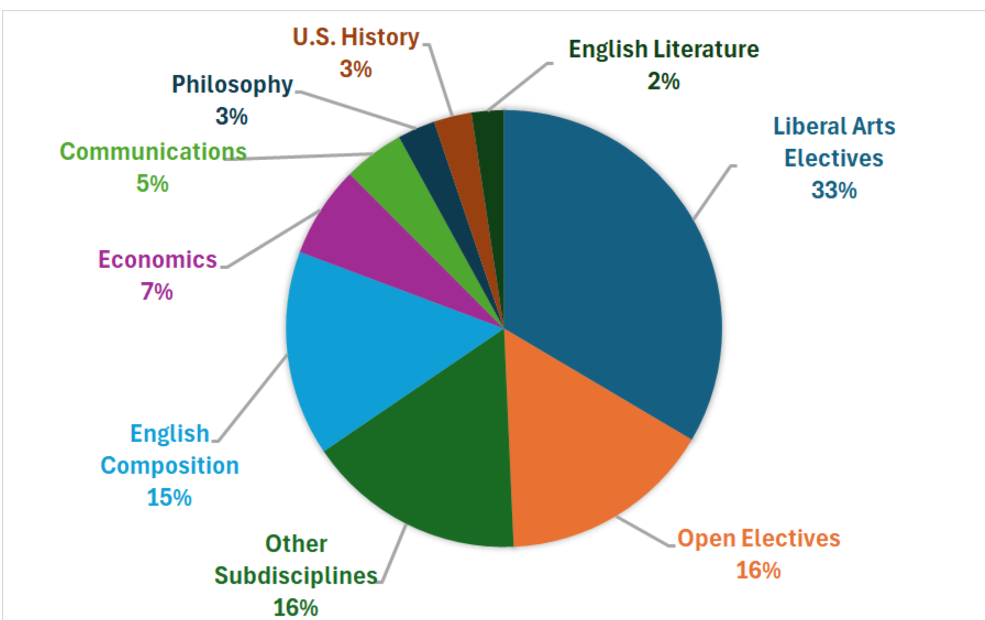

Figure 1 – Percentage of average general education topic distribution in Civil Engineering programs (adapted from Russell and Stouffer [8])

In 1996, ABET introduced 6 professional skills into its set of engineering criteria: communication, teamwork, understanding ethics and professionalism, engineering within a global and societal context, lifelong learning, and a knowledge of contemporary issues [17]. These skills became the foundation for 6 of the 11 outcomes that all engineering graduates should possess: (d) an ability to function on multidisciplinary teams, (f) an understanding of professional and ethical responsibility, (g) an ability to communicate effectively, (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context, (i) a recognition of the need for, and an ability to engage in life-long learning, and (j) a knowledge of contemporary issues. Additionally, outcome (c) "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" involves some of those professional skills. While these ABET outcomes can be met through engineering education [17] or even co-curricular activities [18], they are fertile ground for integration of general education objectives. In 2008, 7 of the 11 required outcomes were either met or enhanced by general education [2]. Currently, the original 11 outcomes in Criterion 3 have condensed into 7 outcomes. Of those, 5 can be selected for at least partial completion through the general education curriculum as they are directly derived from the previous outcomes. Those are: (2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; (3) an ability to communicate effectively with a range of audiences; (4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; (5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives; and (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Objectives and Hypothesis

To address the lack of interest engineering students in the general education curriculum and to reinforce ABET student outcomes by leveraging the large amount of credits invested in the general education curriculum, an introductory course to Civil Engineering inspired on the work at Seattle Pacific University[13] was created. This course was designed to meet the goals of general education and to serve as both a first-year introductory course to the major as well as a general education course for non-engineering students. This course was developed and taught in a small engineering program in a medium sized college traditionally centered around the liberal arts. The class has three aims: 1.) to introduce students to the work and vocabulary of Civil Engineering; 2.) to introduce non-technical skills typically addressed in the general education curriculum in an engineering context, and 3.) to make the connections between the liberal arts curriculum and the practice of engineering apparent to students. Additionally, as the class was designed and open for students of any major, it also serves as an introduction to engineering for students in other majors so they may better understand the work and impact that civil engineers have on the built environment and society.

The hypothesis was that students who take this class would see an increase in their perception of the importance of skills and knowledge gained through their general education for their chosen major of civil engineering. As the connections between different fields covered in the general education curriculum (such as archaeology, history, or political science) and civil engineering are made deliberately clear, the author hypothesized that there would be an increase in the students' perception of those fields to their chosen career. This increase in perception might then motivate those students to increase their engagement with the general education curriculum. This study was conducted to test the initial hypothesis of whether enrollment in this course would increase the perceived importance of general education to a career in civil engineering.

Course Design

In this introductory course, the students in the major are introduced to the field and history of civil engineering and have connections to other disciplines made apparent during their first semester, as they work on the liberal arts portion of their curriculum. The goal is for students to experience higher satisfaction with their general education curriculum and see it complement their technical education and provide them with a deeper understanding of the wider societal forces and movements that shape the history and practice of civil engineering. Aligning with general education outcomes, the class focused on information literacy, oral communication, and teamwork applied in the context and practice of civil engineering. This follows the recommendation from Florman [14] to imbue engineering coursework with writing, presentations, and teamwork. Florman also recommends a two-pronged approach from these skills: both in general context in the general education curriculum as well as in an engineering context in the engineering curriculum. This also provided alignment with the stated essential learning outcomes of the host institution such as Disciplinary Knowledge, Effective Communication, Higher-Order Thinking, Creative Thinking, Inquiry and Analysis, and Recognition of Differences and Equity.

The course structure consists of multiple units centered around one aspect of civil engineering and set in different time periods and geographical locations to showcase the different contexts in which civil engineers have played a crucial role in civilization. Each unit revolves around an engineering topic and is supported by a variety of active learning in class activities as well as a selection of peer-reviewed publications from both engineering and non-technical disciplines meant to help the students better understand the interaction of those disciplines with civil engineering. There are 4 major units centered around environmental, water resources, structural, and geotechnical engineering. Additionally, there are 4 minor units focusing on the impact of societal forces on engineering development and projects, on the technical and non-technical skills of a civil engineer, on construction management and engineering economics, and on professionalism and ethics. Each of the major units has 6 publications associated with it which are drawn from a variety of disciplines and provide the necessary technical and non-technical information for that unit. The minor units use 2 publications and are not tied to a specific time or place, except for the unit on societal forces' impact on engineering which serves as the introductory unit to the course. As the introductory unit, it models the process of the four major units and provides an opportunity for the students to practice making connections between civil engineering and other processes in a low-stakes environment. That unit was developed in conjunction with the Director of General Education at Quinnipiac University who is a humanities professor and served as the template to develop all other units in the course. The unit topics, length of instruction, their geographic and temporal context, and the sources used for instruction are presented in Table 2.

Table 2 – Summary of unit topics and sources

Unit	Weeks	Geographic and Temporal Context	Sources used
Societal Forces and Civil Engineering	1-2	Florence, Italy in the 15th Century	[19], [20]
Skills of a Civil Engineer	3	N/A	[21], [22]
Environmental Engineering	4-5	Dindigul, India in the 21st Century	[23], [24], [25], [26], [27], [28]
Water Resources Engineering	6-7	Drobeta-Turnu Severin, Romania in the 2nd Century	[29], [30], [31], [32], [33], [34]
Structural Engineering	8-9	Kantō Plain, Japan in the 20th Century	[35], [36], [37], [38], [39], [40]
Geotechnical Engineering	10-11	Mexico City. Mexico in the 19th Century	[41], [42], [43], [44], [45], [46]
Construction Management & Engineering Economics	12	N/A	[47], [48]
Professionalism and Ethics	13	N/A	[49], [50]

Because of the variability of the general education curriculum, with every student choosing which combination of courses match their interests to fulfill the requirements of the curriculum, assessment of its impact is difficult. To this effect, Petrosko [16] developed an instrument designed to measure student attitudes to general education. This instrument was developed specifically for students entering their first year of university, so they had little, if any, experience with the general education curriculum. The instrument was developed by analyzing the rationale for the general education curriculum at the University of Louisville to extract statements related to the core curriculum that could be rated by students. Those statements were then rated by the students along two scales, one measuring their importance ("how important these outcomes are to your college education") and one measuring students' confidence in those areas ("how confident you are of your ability in those areas"). To assess the effectiveness of instruction, surveys gauging the perception of general education to the civil engineering curriculum were administered to students before and after instruction in the course. Because the duration of this study was capped at one semester to match the duration of the introductory course, the students in this study were only asked to rate those statements on importance, as a semester was judged too short a time to meaningfully impact student confidence in those statements having only completed a small portion of their general education requirements. This approach was recommended by Petrosko when data collection time was limited and was deemed to be an acceptable use of the instrument. Following his recommendations, the students were surveyed upon their entry and their exit to the course on the first and last week of instruction.

Results

The survey the students responded to is an adapted version of Petrosko's instrument and is presented in Figure A1 in the appendix. In addition to the 23 statements from the instrument designed by Petrosko, the students were also asked to rank the importance of the 4 disciplinary groups (humanities, social sciences, fine arts, and natural sciences) that comprise the general education curriculum at their institution for their importance to their career as civil engineers. These disciplinary groups overlap with the foundational disciplines identified by ASCE (2019) in the Civil Engineering Body of Knowledge (CEBOK3) with one exception, fine arts are not recognized in the Body of Knowledge and are instead replaced by mathematics. Examples of disciplines were provided in order to clarify which courses fit into each disciplinary group.

The course had an enrollment of 24 students, 21 of which were civil engineering majors. The students were surveyed during the first and last week of instruction, and 18 civil engineering majors completed both the pre and post instruction survey and were used to build the data set used in this study. None of the 3 students in non-civil engineering majors completed both the pre and post instruction survey, due to a mix of late enrollment and student absences. The list of questions that students answered, as well as the average class rating for each question in the first and last week of instruction, the percent change in the average rating, and the p-value from a two-tailed T-test are presented in Table 3. The percent change was calculated as the difference between post-instruction and pre-instruction scores over the original score. The survey questions in which the change was statistically significant ($p \leq 0.05$) are highlighted in grey, while the questions which registered a decrease in perceived importance are highlighted in red.

The survey results are mostly positive. Students ranked 23 of the 27 survey items higher at the end of the course than at the beginning, with 4 of those increases being statistically significant. Pre-instruction results show that students perceived the arts as only medium importance to engineering practice, with the only 3 survey questions (6, 11, 15) being rated less than a 3 on average in the pre-instruction survey, all relating to the arts and their importance to a career in civil engineering. This indicates that students coming into the major are at least moderately aware of the impact of the natural and social sciences as well as the humanities to a civil engineer but are less aware of the impact the arts might have.

Table 3 – Average class rating for each question in the first and last week of instruction, the percent change in the average rating $\left({(S_{post} - S_{pre})}/{S_{pre}}\right)$, and the p-value from a two-tailed T-test. Grey highlighted rows signal statements that had a statistically significant change and red highlighted rows signal statements that had a negative change (decrease) after the course.

	For each of the following skills, please rate how important you think they are for a Civil Engineer in their career and practice	First Week	Last Week	% Change	P-Value
1	Being able to write well	3.78	4.25	9.4%	0.0406
2	Understanding fundamental principles of social behaviour (e.g. sociology)	3.56	4.40	16.9%	0.0006
3	Being able to make effective oral presentations	4.17	4.60	8.7%	0.0915
4	Logically analysing arguments using statistical or mathematical reasoning	4.61	4.45	-3.2%	0.4187
5	Understanding the world from a variety of viewpoints	4.28	4.45	3.4%	0.4101
6	Enjoying the arts	2.94	3.45	10.1%	0.0748
7	Understanding mathematical presentations of information from the natural and social sciences	4.17	4.30	2.7%	0.6084
8	Valuing cultural diversity in our society	3.72	4.05	6.6%	0.3100
9	Understanding how historical evidence is interpreted	3.83	4.35	10.3%	0.0646
10	Understanding theories in the sciences (e.g. biology, chemistry, physics)	4.17	3.85	-6.3%	0.3674
11	Understanding how the arts reveal human experience	2.94	3.60	13.1%	0.0385
12	Understanding strengths and limitations of social and behavioural sciences (e.g. psychology, sociology)	3.39	3.50	2.2%	0.7453
13	Having moral and intellectual sensitivity	4.11	4.05	-1.2%	0.8056
14	Being able to write well in a specific area (e.g. in your major area)	4.28	4.55	5.4%	0.2247
15	Being able to perform in an artistic field	2.94	3.40	9.1%	0.1190
16	Understanding of history (i.e. history of nations)	3.33	4.25	18.3%	0.0091
17	Understanding of the history of some specific field (e.g. history of music, history of science)	3.11	3.75	12.8%	0.0821
18	Understanding of methods of reasoning in the natural sciences (e.g. biology, chemistry, physics)	4.11	4.15	0.8%	0.8850
19	Knowing about nations or cultures other than the United States	3.94	4.20	5.1%	0.3621
20	Understanding how individual arts can be integrated into a single artistic product (e.g. in film, in architecture)	3.39	3.60	4.2%	0.4888
21	Realising how past events can affect the present	4.33	4.70	7.3%	0.1593
22	Understanding fundamental principles of individual human behaviour (e.g. psychology)	3.17	3.75	11.7%	0.0739
23	Understanding how different arts respond to cultural, political, or moral issues	3.56	3.70	2.9%	0.6212
24	Humanities (e.g. English, History, Philosophy)	3.56	3.65	1.9%	0.7390
25	Social Sciences (e.g. Sociology, Psychology, Political Science)	3.00	3.55	11.0%	0.1034
26	Natural Sciences (e.g. Biology, Chemistry, Physics)	4.44	4.15	-5.9%	0.4328
27	Fine Arts (e.g. Art History, Theatre, art studio classes)	3.22	3.25	0.6%	0.9331

While artistic factors rarely place design constraints on civil engineering projects, artistic factors can often impact design due to aesthetic considerations. Aesthetically pleasing or symbolic infrastructure can often be one of the largest and most visible contributions of civil engineering to a society and culture (e.g. The Statue of Liberty or the Colosseum), and while only one of those 3 questions registered a statistically significant increase in perceived importance, it is encouraging to see that average ratings post instruction had healthy increases.

Four questions (1, 2, 11, 16) registered a statistically significant change in their average ratings post-instruction, with all 4 having an increase in their perceived importance. The first question related to the importance of writing in civil engineering. The increase in perceived importance is likely due to the central role of writing in this course. All major units are assessed through a literature review of the sources and a small writing exercise about the subfield of civil engineering studied representing 30 % of the total course grade. There is a two-part team project with two written deliverables representing 25 % of the total course grade, and a written reflection on the interaction between civil engineering and other disciplines representing 10 % of the total course grade. Class participation (worth 10 % of the total course grade) was assessed through informal in-class writing activities meant to act as writing scaffolding for the larger deliverables. As three quarters of the total course points are allotted through written deliverables, it is not surprising that students perceive writing as more important after instruction.

Question 2 relates to the importance of understanding the principles of social behavior, question 11 relates to understanding the human experience through the arts, and question 16 related to understanding the history of nations. The increase in their perceived importance is likely due to the focus in this class on studying the forces driving engineering activity and innovation. Through instruction, the focus was not on the technical aspects of engineering but rather on how societal forces provide the incentives and opportunities for engineering work and innovation. Social behavior played a crucial role when discussing the structural engineering unit. The arts played a large role in the introductory unit in driving engineering innovation, and interactions between nations or proto nations played a large role in both the water resources and geotechnical units. The variable temporal context, ranging from the 2nd century to the present, might have also been responsible for the increased perceived in importance of history to civil engineering. The significant increase in question 1 aligns well with one of the course learning outcomes of the course ("demonstrate professional communication skills") and with the ABET outcome curriculum mapping which identifies this course as one where outcome 3 ("an ability to communicate effectively with a range of audiences") is assessed. The other 3 questions with increases are not as easily linked to specific course learning outcomes (e.g. "discuss the societal and historical forces that shape the development and practice of construction", "summarise the interaction between civil engineering and other disciplinary fields") or ABET outcomes (e.g. "An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts"), but are likely to have positively impacted meeting those learning objectives.

Only four survey questions (4, 10, 13, 26) registered a decrease in their perceived importance after instruction. Although these decreases were not statistically significant, it is still useful to think of possible reasons for their decrease. Question 4 relates to mathematical and statistical reasoning, which is one of the essential skills of an engineer. I believe the decrease in its perceived importance is due to the increase in the perceived importance of other disciplines in the career of a civil engineer. This would also explain the decrease in questions 10 and 26 which deal with the importance of natural sciences in engineering. Because students are aware of the central nature of mathematics and natural sciences to the practice of engineering, when they are made aware of the impact of other disciplines this may dilute the importance of mathematics and the sciences. Lastly, question 13 which relates to having a moral and intellectual sensitivity also registered a decrease. This was the smallest negative change in average rankings and is not statistically significant, however it may point to a change in how the ethics material, currently supported by the ASCE and NSPE Codes of Ethics, should be presented to the students.

Conclusions

Integrating the goals of general education into major course work in engineering is feasible, and in many cases not an onerous process. The skills that general education values: lifelong learning, information literacy, leadership, teamwork are in many cases also goals in the major that must be deliberately evaluated (in fact, teamwork and continued learning are the primary objectives of ABET outcomes 5 and 7). In an engineering curriculum that is packed tightly in order to meet accreditation goals and standards, better integration of the general and major education is a win-win proposition. This integration furthers the goals of general education and reveals its true value to the students as skills learned in the humanities and social sciences are practiced within the context of a student's profession and are appreciated as foundational skills which are transferable to their chosen career context. Through participation in the general education curriculum, engineering faculty can dedicate serious efforts towards meeting some goals, like ethics, communication, or teamwork that they recognize as essential for their practice but that are often crowded out due to the necessary focus on technical skills. Additionally, the students are able to engage in metacognition about their general education, seeing its usefulness and value in the context of their major rather than a hurdle to their undergraduate education. This allows them to better extract value from their general education, if students believe these courses teach important and relevant skills they will be more likely to engage with them. The results of this study indicate that this approach can be effective in increasing the perceived importance of general education for incoming civil engineering students, which may then increase their engagement with the general education curriculum. As the sample size in the current study is small, the author plans to gather more data in subsequent offerings of the course before attempting to assess whether this increased engagement with the general education curriculum is happening.

While this iteration of the course did not yield data on students outside of civil engineering, the author hopes that subsequent offerings attract more of these students to the course, and that the change in their perception of civil engineering's place and importance in society can be measured if it exists. Additional enrollment outside of engineering would likely increase the pedagogical effectiveness of the course, as students from other fields could describe and share how their own careers are impacted by civil engineering.

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Appendix

Appendix A1 – Survey instrument administered to students, adapted from [16]

	For each of the following skills, please rate how important you think they are for a Civil Engineer in their career and practice	(not important)				(extremely important)
1	Being able to write well	1	2	3	4	5
2	Understanding fundamental principles of social behaviour (e.g. sociology)	1	2	3	4	5
3	Being able to make effective oral presentations	1	2	3	4	5
4	Logically analysing arguments using statistical or mathematical reasoning	1	2	3	4	5
5	Understanding the world from a variety of viewpoints	1	2	3	4	5
6	Enjoying the arts	1	2	3	4	5
7	Understanding mathematical presentations of information from the natural and social sciences	1	2	3	4	5
8	Valuing cultural diversity in our society	1	2	3	4	5
9	Understanding how historical evidence is interpreted	1	2	3	4	5
10	Understanding theories in the sciences (e.g. biology, chemistry, physics)	1	2	3	4	5
11	Understanding how the arts reveal human experience	1	2	3	4	5
12	Understanding strengths and limitations of social and behavioural sciences (e.g. psychology, sociology)	1	2	3	4	5
13	Having moral and intellectual sensitivity	1	2	3	4	5
14	Being able to write well in a specific area (e.g. in your major area)	1	2	3	4	5
15	Being able to perform in an artistic field	1	2	3	4	5
16	Understanding of history (i.e. history of nations)	1	2	3	4	5
17	Understanding of the history of some specific field (e.g. history of music, history of science)	1	2	3	4	5
18	Understanding of methods of reasoning in the natural sciences (e.g. biology, chemistry, physics)	1	2	3	4	5
19	Knowing about nations or cultures other than the United States	1	2	3	4	5
20	Understanding how individual arts can be integrated into a single artistic product (e.g. in film, in architecture)	1	2	3	4	5
21	Realising how past events can affect the present	1	2	3	4	5
22	Understanding fundamental principles of individual human behaviour (e.g. psychology)	1	2	3	4	5
23	Understanding how different arts respond to cultural, political, or moral issues	1	2	3	4	5
	Please rate the importance of the following disciplinary groups for your career:	(not important)				(extremely important)
24	Humanities (e.g. English, History, Philosophy)	1	2	3	4	5
25	Social Sciences (e.g. Sociology, Psychology, Political Science)	1	2	3	4	5
26	Natural Sciences (e.g. Biology, Chemistry, Physics)	1	2	3	4	5
27	Fine Arts (e.g. Art History, Theatre, art studio classes)	1	2	3	4	5