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WIP: Sociotechnical Integration through Assignments that Position the Engineer as ”Problem Definer who Listens” in a Required Civil Engineering Course

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WIP: Sociotechnical Integration through Assignments that Position the Engineer as "Problem Definer who Listens" in a Required Civil Engineering Course

In this WIP paper, the author describes an attempt to incorporate a sociotechnical lens of analysis into a sophomore-level course called "Civil Engineering Materials." This course, which is required for all civil engineering majors, is the study of the properties and uses of materials, such as steel, concrete, asphalt, and others, that are widely used in the architecture, engineering, and construction (AEC) industry. The primary sociotechnical interventions in this course will be 1) life cycle assessments (LCAs) and 2) written reflection assignments.

For the LCAs, students will be asked to quantify the impacts of the covered materials according to conventional metrics, such as carbon footprint. For the written reflection assignments, students will be asked to comment on materials' properties and effects related to their production and use from the perspectives of different parties that work in and are affected by the AEC industry. Such parties will include trades workers, factory workers, end users, members of the public at-large, and practicing engineers. Students will be encouraged to use a variety of sources, including interviews, if possible, to inform their reflections, and to consider the connections between and contradictions raised by their LCAs and reflections.

These assignments by themselves do not necessarily represent "sociotechnical interventions." The author's intent is to promote sociotechnical integration by presenting the two tools—LCA and written reflection—as frameworks, rather than rote processes, through which to understand civil engineering materials. In other words, students will be asked not simply to memorize physical properties, but to use examination of a particular material to explore how the AEC industry and the people it comprises "work."

While more explicit attempts to dismantle engineering's "culture of disengagement" deserve recognition as essential to engineering education, there is, as others have noted, strategic value in targeting for sociotechnical intervention content that is already widely recognized as "real" engineering. This course and these interventions would be recognized as such for three reasons: 1) the course itself is required for all civil engineering majors at the author's institution, 2) LCAs are established tools in industry that require the "hard" skill of quantitative analysis, and 3) communication with "diverse stakeholders" in the AEC industry is understood as an important part of professional development.

This work is in part inspired by Gary Downey's examination of how to position engineers as not only *problem solvers*, but also *problem definers who listen*. With this in mind, the author will present the planned interventions and a two-part survey designed to assess whether the interventions have an impact on 1) students' ability to understand engineers' role within larger constructs and processes, such as the AEC industry or infrastructure development, and 2) students' ability to understand or empathize with other actors in those constructs and processes. The author would like to build on this initial effort at formal sociotechnical integration in the curriculum and hopes that the WIP format will provide the opportunity for refinement of both the interventions and the means of assessing their impact.

Introduction

Addressing the Culture of Disengagement with Sociotechnical Integration

Erin Cech argues that engineering education fosters a culture that treats concerns related to public welfare as falling outside of what counts as engineering work. She refers to this culture as the culture of disengagement [1]. In Cech's view, and my own, this culture needs to be dismantled. Engineers make up a considerable portion of the workforce tasked with designing and maintaining increasingly complex sociotechnical systems that are often inscrutable to the general public [1]. If these systems are truly to serve rather than harm the public, then engineers cannot absolve themselves of responsibility to engage critically with nontechnical concerns.

Sociotechnical integration is an approach to engineering education that, as Reddy et al. describe, "acknowledges how the bounds of technical and nontechnical knowledge are blurred and makes space for generative work at their intersection" [2]. Examples of sociotechnical integration in engineering education abound [2]-[5]. As an insistence that technical professionals like engineers are not insulated from nontechnical concerns, sociotechnical integration represents one way to start dismantling the culture of disengagement.

The problem definer who listens

Like Cech, Gary Downey identifies in dominant practices of engineering education "an absence of attention to collaboration with others, especially non-engineers, who [understand] their work differently" [6]. He attributes this absence to the conventional curricular focus on mathematical problem solving. This focus fosters a mode of thinking under which the problems posed are clearly defined and deterministic—proposed solutions can be categorized unambiguously as correct or incorrect. Those who might take issue with the problem definition or with the proposed solutions are simply understood to be incorrect and their input illegitimate. For Downey, the problem solver identity carries with it this dismissal of outside input.

As a means to confront this dismissive and disengaged mode of thinking and introduce "critical self-analysis" into the practice of engineering, Downey proposes emphasizing the role of the *problem definer who listens* as one that is core to engineering identity. His strategy, rather than to lengthen the list of engineering responsibilities or reject outright the conventional identity, is to emphasize that engineers, in addition to being problem solvers, are *already* problem definers who listen. Most practitioners would agree that engagement with non-engineers is an unavoidable part of engineering work, and most would admit that the problems they work with others to address are rarely as clearly defined as the problems they were trained to solve in school. The task is not to add new roles, but rather to refine an existing core identity to ensure that engineering students are prepared for the roles that practitioners already serve. Sociotechnical integration in education can be understood as part of this preparation because it is the illustration of the full context in which engineering work is done and in which listening skills are necessary. Instruction that targets listening skills specifically is also required for engineers to flourish in this context.

Listening in engineering education

What models exist for engineering educators interested in teaching their students how to listen and why listening is important? "An ability to communicate effectively with a range of audiences" is one of the seven student outcomes ABET lists as part of its criteria for accreditation of engineering programs [7]. Surely, listening skills contribute to the ability to communicate effectively. Since accreditation depends on students achieving this outcome, one would think that models for teaching listening and other communication skills to engineers would be easy to find. However, Downey and Leydens [8] and Bielefeldt [9] find very few examples of listening instruction in engineering education.

In fact, Leydens and Lucena cite evidence that traditional engineering education might actually make engineering students more likely to devalue the perspectives of others [8]. Like Downey, they assert that the emphasis on what they call engineering problem solving (EPS) in the curriculum fosters patterns of thought that privilege domain-specific skills and expertise over the input of outsiders. In their analysis of several listening instruction interventions in an elective seminar that is co-taught by engineering and liberal arts faculty, Leydens and Lucena acknowledge the potential of liberal arts courses that are designed with engineering students in mind, but they caution again concentrating listening instruction exclusively in courses that are outside the core courses of engineering degree programs. "Doing so may send engineering students the message that listening content is not important enough to be included within the context of an engineering course, making students relegate its importance below that of EPS and other 'engineering' content. Such an outcome would only exacerbate the marginalization of listening" [8].

Furthermore, the relative dearth of sociotechnical content in core courses can make the inclusion of "broader impacts" discussions in cornerstone and capstone courses feel superfluous, begrudgingly included at the margins of a curriculum focused primarily on problem-solving techniques. The second- and third-year engineering courses that are core to the degree program, and perhaps also to the traditional engineering identity, are the courses in which EPS dominates and in which the imagined boundaries between social and technical are most diligently policed. So what sort of "pro-listening" assignments could be incorporated into core engineering courses?

Assignments that promote listening

Actual listening, whereby students engage in meaningful dialogue with people who might be affected by their work, is ideal but not always achievable in the educational environment, especially on short time scales. Universities can be quite isolated as communities and students do not usually design and construct things that have appreciable impacts on large numbers of people: the buildings and bridges that are the focus of civil engineering capstone projects do not *actually* get built. However, writing assignments that promote perspective taking [10][11] and research assignments that highlight the interconnectedness and even interdependence of systems conventionally understood to be separate (i.e., social systems and technical systems) can promote the development of listening skills. Because such assignments can be incorporated relatively easily into core engineering courses, they can promote the image of an engineer as a problem definer who listens during the time when core engineering identity formation takes place. The interventions that are the subject of this work—life cycle assessments and writing reflections in a required, that is, core civil engineering course—are intended to be exactly such assignments. In the Methods section, I provide more specific details about these interventions. First, I will explain the institutional and curricular context in which I am attempting to intervene.

Institutional Context

Background

The author is faculty in the Department of Civil Engineering at the Wentworth Institute of Technology in Boston, MA. Wentworth is an undergraduate-focused university with 5 schools: Engineering, Architecture and Design, Computing and Data Sciences, Management, and Sciences and Humanities. The university offers 26 bachelor's degrees, 13 master's degrees, and 6 professional undergraduate certificates, and 1 associate's degree. Most of the bachelor's degrees are offered by the schools of Engineering, Architecture and Design, Computing and Data Sciences, and Management; the School of Sciences and Humanities offer only four bachelor's degrees. The university is teaching-focused, with a full-time course load of 12 credits per semester for full-time faculty and 16 credits per semester for lecturers.

The Civil Engineering Degree Program

The civil engineering program is a four-year ABET accredited bachelor's degree program. The curriculum is fairly typical for a civil engineering degree program: students complete their fundamental math and science courses in their first and second years in the program. Students start taking courses specific to the civil engineering degree program in the second year of the program. In their third and fourth years, students take analysis and design courses related to sub-disciplines of civil engineering, like structural analysis, environmental engineering, soil mechanics, and highway engineering. Students complete the program with a two-semester capstone project during their final year. The complete civil engineering degree program is shown in Appendix A.

Civil Engineering Materials
Civil Engineering Materials is a sophomore-level course. The course is the study of the uses, effects, and elemental and behavioral properties of materials conventionally used in civil engineering and construction. This course is among the first courses in the degree program that are specific to civil engineering. In other words, these courses play a large part in defining for entrants into the industry what it is that counts as civil engineering (and what does not).

Methods

Positionality Statement
I am a straight, white, able-bodied cis man who had the means to attend elite institutions of higher education in the United States. I studied civil engineering as an undergraduate, worked as a structural engineer for several years, and then returned to school for a doctorate in structural engineering. My interest in engineering education research stemmed from my involvement in a graduate student unionization campaign. Graduate students in STEM subjects were persistently more difficult to organize—scientists and engineers were in general far less likely to see any value in forming a union or have historical or political context for what a union might achieve. There were material reasons—STEM students generally had higher stipends—but it seemed to me that there were also cultural reasons. In trying to understand these cultural reasons, I came across engineering education research, which I had not heard of previously. Engineering education was the field of research that helped me begin to think about why engineers are "like that."

I want to work towards building a more politically and socially attuned and activist culture in engineering. I engage in engineering education research so that I can think through my own attempts and receive guidance and critique from those who have more experience doing so. I think much of the work of building this culture must come from organizing with colleagues. I also believe that it is crucial to introduce students—future shapers of the profession—to different ways of understanding their roles as engineers, and to encourage students who already carry such understandings and who are already attentive to the types of systemic harms engineering can cause to continue insisting on the importance of the perspectives they bring. I want to make it clear to all students that concerns of justice and ongoing inequity are not "special interests" only to be considered by those directly affected, but rather a responsibility for all engineers. My own experience makes me feel strongly that consciousness is not fixed, but change is unlikely if alternate visions are hidden or dismissed.

This paper has pushed me to reflect on my own listening practices, in the classroom and otherwise. I find it can be easy to fall back on the mode of instruction in which I was educated—more banking model than liberatory, to be sure. This tendency is also facilitated by my own clear in-group status and my position as the "authority" in the classroom, which come with self-confidence I am socialized to display and the deference others are socialized to give.

Intervention 1: Life Cycle Assessments
Over the course of the semester, I will assign students two technical reports, each focused on a different civil engineering material. The project assignment sheet is included in Appendix B. For the first report, students will be assigned a material; for the second report, students will select their own material. The technical report consists of two parts: a "material information" part, described in the following section, and an LCA of the subject material. Performing LCAs in industry requires specialized training in LCA methods, and many universities with civil engineering degree programs offer courses in LCA methods. Because the course considered in this work is only a sophomore-level course, it is likely that the concept of tracking the "life" of a material will be new to many or even most students, so the tasks required to complete the LCA projects will be basic and require no specialized software.

As I have described, my goal in this work is to target for sociotechnical interventions those courses which are conventionally understood as "real" engineering courses. To me, an LCA project seems like an appropriate tool to achieve this goal because 1) practicing engineers conduct LCAs, 2) the civil engineering profession recognizes LCA assessment as part of an engineer's responsibility in sustainable development (ASCE Policy Statement 418) [12], and 3) completing even a basic LCA requires that engineers understand their work in a broader context. For instance, teaching students about the behavioral properties of concrete might be sufficient to prepare them to appropriately size a concrete beam in future courses. Asking students to consider where concrete comes from and what happens to it when a structure is demolished necessarily draws students into a more complex problem which is not "solvable" in the way a more conventional engineering homework problem is. More importantly for this work, the exercise is intended to demonstrate to students that engineers need to draw on both their own domain-specific technical expertise and to turn to other stakeholders for guidance.

Intervention 2: Writing Reflection Assignments
The material information part of each technical report asks students to report on the material's chemical properties, behavioral properties, manufacturing process, uses, and so on. Students can draw most of this information from class material: lecture notes, provided slides, the textbook, and links to external resources that I provide. Students must also include a "current events" section in their report, wherein they find their own resources—news articles, technical reports, and so on—that they think most clearly demonstrate why the material they have selected is important. On the day the reports are due, students will share their "current events" findings with the rest of the class. I then ask all students to prepare a sticky note on the online platform Mural containing three things: 1) one person or group that is affected by the material, 2) how the material affects them and how they might feel about it, and 3) how things might be different. The sticky notes, available to all students on Mural, will then provide the starting point for group discussion. This is a stakeholder identification exercise and a perspective-taking exercise. I will

also encourage them to draw on what they learned from their LCAs to inform their reflections. In particular, I will encourage them to consider whether new information they have received from other students' "current events" work might have changed their assessment of whether their own LCAs were "thorough" or "complete" or "accurate," and how they define those descriptors.

As I mentioned previously, communication skills are widely understood to be an important part of engineering education. Usually, this importance is attributed to the necessity for engineers to engage with stakeholders. Even first- and second-year students understand that, in the "real" world, they will have to interact with non-engineers. My goal with this intervention is to ask my students to engage in what is understood to be a reality of engineering, but to shift the focus from communicating ideas *to* stakeholders and onto attempting to actually *understand* stakeholders, even to the point of evaluating their own technical work in light of stakeholders' opinions.

The Interventions as Frameworks

I sometimes assess a school's engineering program by considering where the curriculum lies on a spectrum: on one end, the engineering program is a liberal arts education with a special focus on applications of science and math; on the other, it is a pure job training program. If a program's focus is closer to the job training end of the spectrum, engineers are presented to students as technicians who can deliver engineering products. An LCA is one such engineering product. In this model of the engineering curriculum, the goal for an educator would be to train students to complete a process that yields a quality product, which is to say, a product that a client would be satisfied with.

The goal I have for my students is not for them to produce a "correct" LCA—I will emphasize to students that I do not intend to rigorously fact check their numbers. My goal is for students to go through the exercise of tracking the "life" of a product in a way that they might not have done before. All students have "interacted" with steel insofar as they have crossed a bridge or walked up a flight of stairs, but most have not thought of where the steel has come from, what processes created it, or what effects those processes had on people and the environment. This exercise can lead them to recognize an interconnectivity between all sorts of people and places that might previously have been hidden to them. The exercise—that of identifying all the phases of the life of a material and its various impacts—becomes a framework if I ask students to perform the same exercise on something that is not a material or product. For instance, "how might I think about the 'life' of my own work as an engineer and the impacts it might have during different phases in different locations on different people? How might I think about the 'life' of the institution that employs me and all its impacts? What interconnectivities become apparent when I apply this sort of analysis, usually reserved for a product or material, to activities or institutions?"

Similarly, stakeholder identification and outreach can, in many professional contexts, become a box-checking exercise: in the most cynical version of engagement, the attitude is that as long as an engineer was present at a town hall meeting about a future project, then engineers have successfully engaged stakeholders. Presenting stakeholder engagement as a job responsibility that students will eventually take on perhaps emphasizes the activity as a rote process. My intent with the writing reflection assignments is to use the notion of stakeholder engagement, a common feature of engineering work, as the basis for an activity in which students have to try to understand and adopt the perspectives of people other than themselves.

I believe that the rote versions of the interventions and the framework versions coexist—I do not think it is possible or even necessarily desirable to make the interventions be entirely one thing or the other. But I believe that the way I present the interventions, describe my expectations for student work, and assess that work can help highlight the ways in which parts of the engineering curriculum represent opportunities for reflection rather than simply opportunities for acquisition of "marketable" skills.

Additional Materials

To supplement the assignments, I will also regularly post additional materials on Brightspace, our institution's learning management system. Such materials include videos, articles, websites, and so on that call attention to the sociotechnical nature of engineering work. I will also occasionally post optional discussion boards prompting students to write about some of the resources in exchange for a small prize, like a bonus point on a quiz. I have used this method in other technical courses I have taught as an initial means of incorporating sociotechnical material. These additional materials are not included in any primary assessments for the course, and students' engagement with them is optional, but I make a point to introduce and explain each resource as I post it, to ensure students know it is there, and I sometimes end class by hosting brief discussions about the optional resources. Samples of previous discussion assignments and additional materials I have used in other courses are included in Appendix C.

Surveys and evaluation questions

To understand the effects of these sociotechnical interventions, I have designed and will administer two short Qualtrics surveys for students to complete. The surveys and the study have been approved by Wentworth's Institutional Review Board. Potential participants consist of all students enrolled in CIVE 2400: Civil Engineering Materials. In the Spring 2026 semester, there are about 81 students currently enrolled across three sections, all taught by the author. My expectation is that the sample size will be comparable in future semesters. All students enrolled in the course will be invited by the instructor to participate. In my attempt to ensure no students feel coerced into participation, I will emphasize to students verbally and over the invitation email that their participation is entirely optional: there will be no reward for participating or penalty for not participating. In fact, because the survey results are de-identified, there will be no way for me to know whether they have participated or not.

Participation consists of the completion of two surveys, which consist of the same core questions. Survey 1 is administered towards the beginning of the semester; Survey 2 is administered towards the end of the semester. In between Surveys 1 and 2, students will have completed the sociotechnical interventions described above twice. Students' responses to Survey 1 will be linked to their responses to Survey 2, so I can track changes in student responses, but the results are de-identified.

Survey 1 is meant to measure baseline levels for students' ability to understand the complexity of engineers' roles and their ability to emphasize with other stakeholders. Survey 2 is meant to assess whether there is any change to those baseline levels over the course of the semester. The two primary questions asked in Surveys 1 and 2 are the following:

1. In the space below, included a numbered list of the different stakeholders that either affect engineers' work or are affected by engineers' work.
2. For at least two (2) of the stakeholders you listed above, explain how they might feel about civil engineering projects and why.

In addition, Survey 2 asks students other open-ended questions about the role of civil engineers and asks them to identity assignments, in CIVE 2400 or in other courses, that they believe have had some impact on their ability to identify, listen to, and understand different stakeholders. The complete list of survey questions is included in Appendix D.

Question 1 is my attempt to measure "students' ability to understand engineers' role within larger constructs and processes" by using "students' ability to imagine how many different stakeholders are affected by civil engineering work" as a proxy. My reasoning is that if a student can produce a longer list of stakeholders, then the student has a better sense for the interconnectedness of the engineering profession with those outside its ranks. If the student-generated stakeholder lists are in general longer in Survey 2 than they were in Survey 1, then I will take that to mean that the sociotechnical interventions described in this paper might have encouraged students to think more deeply about how broad the impacts of civil engineering work can be.

The length of a student-generated stakeholder list as a variable to measure "ability to understand engineers' role within larger constructs and processes" is admittedly reductive and crude, and I am wary of the problem highlighted in Walther et al. [10], whereby consideration of multiple perspectives on a problem becomes a purely intellectual exercise. However, the more easily quantifiable results are 1) an easier point of entry for a novice education researcher and 2) a simpler way to show changes in student thinking. I do not yet have a rubric for what should count as sufficiently unique stakeholders—my thinking is that such a rubric will emerge as I read responses.

Question 2 is my attempt to measure "students' ability to understand or empathize with other actors" in the constructs and processes within which engineers work. The responses to this question are open-ended, so my intent is to assess whether students' descriptions of their interpretations of other people's thoughts and feelings become any "richer" between Survey 1 and Survey 2, or whether there is a noticeable shift in students' attitudes towards their perceptions of others' opinions—for instance, a shift from a more dismissive attitude to a more understanding one. Question 2 is not quantifiable in the way that Question 1 is, but I want students to have some opportunity to explain their thinking in an open-ended way, as well as a qualitative data set that I might use to practice interview coding.

Because the students complete the sociotechnical interventions between completing Surveys 1 and 2, I am assuming that changes in results from Survey 1 to Survey 2 are at least partially attributable to the sociotechnical interventions, though of course changes in student responses can be attributable to other factors, such as the other courses they are taking. I try to account for this by specifying, in my Survey 2 question about what assignments they feel have affected their ability to identify, listen to, and understand stakeholders, that they can also cite assignments from other courses. This does not account for other experiences, personal or extracurricular, that could also have had an impact on these abilities.

The concept of "engineer as problem definer who listens" is, again, a key inspiration for this work. Some of the additional questions in Survey 2 ask students directly about listening, but Questions 1 and 2 do not use the word listening at all. My reasoning is that Questions 1 and 2 might be thought of as some measure of students' "predisposition" to listening—you can't listen to people if you can't identify them. I also wanted to avoid obvious signals in Survey 1 that I am interested in assessing students' abilities to listen. I want to assess baseline levels for students' listening ability for the definition of "listening" I have employed without activating in the students their own definitions of listening.

Conclusions

In this section, I will discuss the difficulties I encountered in my initial attempt to carry out the work described in an earlier version of the abstract and explain the lessons I learned that should help me to complete this work in the future. The difficulties stemmed from 1) delays to my course schedule, 2) lack of familiarity with using Qualtrics, and 3) insufficient scaffolding for the LCA project assignment. The first two are self-explanatory; the third deserves more discussion.

Through informal conversations with students as they asked for details about the first LCA project and through classroom discussions about their experience with completing the project, I drew some initial conclusions about how best to alter this work for a completed paper next year. Many students felt that the LCA project was difficult to start in part because it was so different from assignments in their other classes, in which they simply have to practice techniques that were demonstrated to them. I think additional scaffolding for this assignment will help. The need for scaffolding is twofold: 1) to increase students' comfort level with the new concept of an LCA and the associated technical practices and 2) to increase their comfort level with open-ended problems. To increase their comfort level with the concept of an LCA, I want to design simple in-class technical problems that we can complete in advance of the LCA project to supplement the lecture. My hope is that a more structured demonstration of the technical skills associated with LCA will lessen the uncertainty that they feel when they are asked to employ those skills in the context of an open-ended problem. To increase their comfort level with open-ended problems, I need to design exercises in which students have more discretion over what their completed work should be.

However, I do not want to fully eliminate the tension students are identifying between this open-ended LCA project and typical assignments in their other engineering courses. Student responses in classroom discussion indicate to me that, once they overcame some initial uncertainty, they found the latitude they were afforded challenging but also satisfying. I think encouraging them to reflect further on that tension could be very generative. These are just general impressions, but I find them encouraging—it seems like sophomore year is not "too late" in the engineering education process for students to incorporate a mode of thinking other than the "traditional" engineering mindset. Their thoughtful responses to a relatively simple intervention also make me wonder whether I am too cautious or even condescending in my assumptions regarding how willing engineering students are to engage in something different.

Lastly, I think that the interventions above could provide a good springboard for a discussion, informed by case studies, of the sociopolitical function of "expert status" and how that affects engineers' ability or willingness to listen to non-engineers. The expert's decision to dismiss outside input functions to maintain oppressive structures. Expertise can serve to justify work that achieves ends that are racist, sexist, classist, and so on, even if the agents of such work understand themselves as progressive. Yanna Lambrinidou's work on the relationship between technical experts and those that technical experts define as non-experts is a model of the kind of interrogation I hope to guide students towards [13]. Lambrinidou examines this relationship in the context of the Flint water crisis, a preventable crisis marked by the failure and refusal to listen of many technical experts. She also highlights how the hero narrative that positions professional researchers from outside Flint as the saviors of the people of Flint disempowers those who were both the most acutely affected and in fact the first to establish that their water was actually poisoned. Lambrinidou's "Learning to Listen" pedagogy [14] and work by Elisa Bravo and Clay Walker [15] will be instructive for me in designing assignments to engage students in the interrogation of expertise and how it relates to meaningful listening.

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Appendix A. Civil Engineering Curriculum at Wentworth Institute of Technology

FIRST YEAR		
Fall Semester		Credits
ENGR1100	Introduction to Engineering Experience	2
ENGR1206	Engineering Laboratory - BSEN	2
MATH1776	Calculus 1A	2
MATH1777	Calculus 1B	2
CHEM1100	General Chemistry I	4
English Sequence		
	Credits	16
Spring Semester		
ENGR1300	First-year Engineering Design	2
ENGR1406	Applied Engineering Analysis-BSEN	2
MATH1876	Calculus 2A	2
MATH1877	Calculus 2B	2
PHYS1250	Engineering Physics I	4
English Sequence		4
	Credits	16
SECOND YEAR		
Fall Semester		
CIVE2000	Statics and Mechanics of Materials I	3
CIVE2205	Introduction to Geomatics	4
CHEM1600 or PHYS 1750	Gen Chem II or Eng Phys II	4
MATH2025	Multivariable Calculus	4
	Credits	15
Spring Semester		
CIVE2300	CAD in Civil Engineering	3
CIVE2400	Civil Engineering Materials	3
CIVE2500	Statics and Mechanics of Materials II	4
MATH2600	Diff Eq and Linear Systems	4
MGMT3200	Engineering Economy	3
COOP2500	Introduction to Cooperative Education	0
	Credits	17

THIRD YEAR		
Fall Semester		
CIVE3000	Fluid Mechanics	4
CIVE3100	Environmental Engineering	4
CIVE3200	Structural Analysis	4
CIVE3300	Soil Mechanics	4
Civil Engineering Elective		3
	Credits	19
Spring Semester		
COOP3500	COOP Education 1	
	Credits	0
Summer Semester		
CIVE3700	Highway Engineering	4
CIVE3900	Hydraulic Engineering	4
Civil Engineering Elective		3
HSS Elective		4
	Credits	15
FOURTH YEAR		
Fall Semester		
COOP4500	COOP Education 2	
	Credits	0
Spring Semester		
CIVE4000	Civil Engineering Design Projects	4
ENGR2100	Programming for Engineers	4
Civil Engineering Elective		3
HSS Elective		4
	Credits	15
Summer Semester		
CIVE5500	Civil Engineering Capstone Design	4
MATH2100	Probability and Statistics for Engineers	4
Free Elective		3
HSS Elective		4
	Credits	15
	Total Credits	128

Appendix B: Material Information and Life Cycle Assessment Project Assignment

Steel Project: Assignment Overview

With your group, prepare a report on steel consisting of two parts: Material Information and Life Cycle Analysis. You should organize your report into the following sections, but feel free to rearrange them or add sections or subsections. The prompt questions are meant to be a guide for what each section should be about, but you do not have to limit yourself to answering these questions. Your contributions should be in paragraph form and my question prompts should **not** be included in your report. List the names of the group members who worked on each part.

Steel Project Part 1: Material Information

Sections

Composition

- What elements does the material consist of?
- What is the molecular structure of the material? For instance, what sort of atomic bond type does it have?

Physical Properties

- What are the defining mechanical and non-mechanical properties of the material? What makes this material distinct?
- What sort of control do humans have over these properties? In other words, what sorts of processes can we use to alter the material properties of the material?
- How are the material's makeup and its properties connected?

Uses

- What is the history of this material? In particular, how long has it been in use and what has it been used for in the past?
- What are the modern uses of this material in civil engineering applications?
- What are some uses of this material outside of civil engineering?
- Why do the material properties make it well suited for these applications?

Current Events

- Can you find research into new uses for the material or methods of producing it?
- Can you find news articles explaining problems or opportunities for the industries that produce or use this material?

Required:

Your report should include the following elements.

1. At least one figure showing numerical data (in any of the above sections)
2. At least one table showing numerical data (in any of the above sections)

Appendix B: Material Information and Life Cycle Assessment Project Assignment

Steel Project Part 2: LCA

Background

A typical life cycle assessment (LCA) of a material or product can be prepared by following these four steps:

1. Scoping: Define the scope and goal of your LCA
2. Life cycle inventory: Gather the data and sources of data you will need
3. Impact assessment: Quantify the impacts according to chosen metrics
4. Discussion: Summary and interpretation of results

We can think of most products and materials as following this cycle:

1. Raw materials extraction
2. Manufacturing and processing
3. Transportation
4. Use, including maintenance and repair
5. End-of-life—demolition and waste

A typical LCA might focus on quantifying the following impacts:

1. GHG emissions, like CO2 and methane
2. Energy and water consumption
3. Negative impacts on water supply, including acidification and eutrophication
4. Solid waste production
5. Raw materials extraction
6. Chemical runoff or by-products

Sections

Stages of the Material's Life Cycle

- State the scope of your LCA: what phases will you include? Which particular applications of steel will you consider?
- State the goal of your LCA: how would you want someone to act on the results of your LCA?
- Provide a short description of each of the stages of the product life cycle. Include a labeled diagram showing the life cycle of the material.

Inventory and Impact Assessment

- Pick two of the impacts from the list above. Explain why you have selected these impacts and provide a description of what these impacts capture.
- Quantify those two impacts for each of the stages of the product life cycle. Provide links to the sources where you found this information and descriptions of your procedure if you had to perform any analysis. **You must provide sources for this section.**
- Present your findings in a figure or table.

Appendix B: Material Information and Life Cycle Assessment Project Assignment

Discussion

Summarize and interpret your findings. Consider some of the following questions:

- How might civil engineers use the results of your study? How might people outside of civil engineering use the results of your study?
- Which stage of the product life cycle had the greatest impact, according to your chosen metrics? Why? Did this surprise you?
- In your research, did you come across other impacts you think are missing from your own analysis or from the list above?
- How do you feel about reducing the life cycle impacts of a product to a single number? What benefits and harms might result from this simplification?

Required:

Your report should include the following elements.

1. A labeled diagram showing the life cycle of the material
2. A figure or table showing the numerical results of your investigation

Note on Use of AI

If you use AI to aid in your preparation of this report, you must include a reflection explaining what you used it for, what steps you took to verify any information it provided you with, and why you found it preferable to your own writing.

Appendix C: Samples of Additional Materials

C.1 Discussion assignment for Mechanics of Materials course

Background

Part of being an engineer is recognizing when it is most appropriate to use different engineering materials. Throughout the semester, we have been investigating the behaviors of different materials under different types of loading. We have primarily focused on the mechanical properties of these materials--for instance, calculating the modulus of elasticity using the results of compression tests. There are, of course, other considerations that might affect what materials are the best to use in a particular scenario.

At the start of the semester, we performed compression testing of steel, aluminum, and timber. My motivation for including timber is that timber is often listed as a material that is "sustainable." In this discussion, I want you to consider why some materials are considered sustainable while others are not.

Discussion Questions

Answer the following questions:

- What are common civil engineering materials?
- What might be your reasons for choosing them?
- What benefits might steel have over timber? Timber over steel?
- What does it mean for a material to be "sustainable"?

Reading

Watch the video linked below and read the following two articles. Explain whether they change your answers to the discussion questions.

Belinda Carr. (2023, May 16) Understanding the Basics of Mass Timber Construction. https://www.youtube.com/watch?v=4jtU9Jtc7IQ

Ove Arup and Partners Limited. (2023, June 5). Report on Embodied Carbon: Steel. Buildings and Infrastructure Priority Actions for Sustainability. https://www.istructe.org/IStructE/media/Public/Resources/ARUP-Embodied-carbon-steel_1.pdf

Robbins, J. (2019, April 31). As Mass Timber Takes Off, How Green Is This New Building Material? Yale Environment 360. https://e360.yale.edu/features/as-mass-timber-takes-off-how-green-is-this-new-building-material

****This discussion assignment would be a good one to adapt for use in CIVE 2400: Civil Engineering Materials. A resource recommended by a reviewer would complement this assignment nicely: Whyte, K., Caldwell, C., & Schaefer, M. (2018). Indigenous lessons about sustainability are not just for "all humanity.". Sustainability: Approaches to environmental justice and social power, 149.**

C.2 Discussion assignment for Structural Analysis

If you complete a short discussion post (5-8 sentences) by Sunday, November 9 at 11:59pm ET, I will give you 1 bonus point* on Exam 3.

Look through the links I provided about Urban Renewal in the Extra Information section on Brightspace. Use these resources as a starting point for a reflection on the period of urban renewal in the United States. You can focus on as many or as few of the resources as you would like. Feel free to look for additional resources to complement these ones. Questions you might consider in writing your discussion are:

- What role did engineers play in urban renewal? What could they have done differently? What were the factors influencing their actions?
- Are there places you are familiar with (your home, where you went to school, etc.) where you can see the evidence of urban renewal?
- The demolition and replacement of neighborhoods is easy to recognize in photographs and accounts of the time period. What are some of the lasting impacts of urban renewal that are not so obvious?
- How can we avoid doing something similar in the future? Is there anything happening currently that you think resembles urban renewal?
- How do you think about the relationship between your role as an engineer and your role as a citizen and community member?

These questions are simply prompts--you don't have to answer them specifically. Feel free to discuss whatever you would like.

Links:

1. Urban Renewal in NYC
2. Robert Moses and Jane Jacobs
3. People Before Highways – Interview with Karilyn Crockett
4. Segregation by Design

Appendix D: Project Information Statement and Qualtrics Survey

1) Project Information Statement

The following will be included in the Qualtrics survey and any email communication with the students inviting their participation. In addition, I will explain this content to them verbally during class time when I invite their participation.

"I am working on a conference paper about civil engineering students' understanding of 1) the role that civil engineers have in industry and, more broadly, in society and 2) the relationships that civil engineers have with different stakeholders that participate in and are affected by civil engineering work. My plan is to assess this understanding using two surveys: one to be completed during the Spring 2026 semester and one to be completed at the end of the Spring 2026 semester. The responses to the survey questions will be used as part of a research project to be published and presented at the American Society of Engineering Education 2025 Annual Conference. Your responses to the survey questions will be anonymous. Participation is entirely optional—there is no reward for choosing to participate and there is no penalty for choosing not to participate. If you do not want to participate, you can disregard the emails about the surveys. Also, if you are under the age of 18, you cannot participate in the study.

Whether you choose to participate or not, I'd be happy to answer any questions you might have and to share the work with you once it is complete, if you are interested."

2) Qualtrics Survey

Survey 1: Early/Mid Spring 2026 Semester

1. In the space below, included a numbered list of the different stakeholders that either affect engineers' work or are affected by engineers' work.
2. For at least two (2) of the stakeholders you listed above, explain how they might feel about civil engineering projects and why.

Survey 2: End of Spring 2026 Semester

1. In the space below, included a numbered list of the different stakeholders that either affect engineers' work or are affected by engineers' work.
2. For at least two (2) of the stakeholders you listed above, explain how they might feel about civil engineering projects and why.
3. Do you think your engineering education has provided you with the means to understand different stakeholders? List the lessons or assignments (in this class or any other class) that you feel have affected your ability identify, listen to, and understand different stakeholders.
4. Rank the importance of the ability to listen to the opinions of stakeholders relative to technical skills:
    a. The ability to listen is much more important than possessing technical skills.
    b. The ability to listen is just as important as possessing technical skills.
    c. The ability to listen is much less important than possessing technical skills.
5. Please explain your answer to the question about the relationship between listening skills and technical skills.
6. What does it mean to be a civil engineer?
7. How do you think a civil engineer should act on the input from stakeholders? In other words, how should listening affect an engineer's technical work?