Competency-based Engineering Leadership Development using a Bookend Approach

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Introduction and Background

The National Academy of Engineering (NAE) and the Accreditation Board of Engineering and Technology (ABET) established a set of attributes that engineering graduates should possess upon graduation, including both technical and non-technical competencies [1], [2]. The current pace of technological advancement makes lifelong learning vital for engineering graduates. Focusing on competency development helps engineering students gain familiarity with the language and process, thereby preparing students to identify and intentionally develop necessary competencies in the future [3]. Additionally, industry expectations for graduates with leadership competencies, incorporating both technical and professional skills [4],[5] continue to increase, driving the need for engineering-specific leadership development models, frameworks and programs [6].

Despite the need for engineering leadership competency development, several barriers to implementing these types of frameworks exist. First, many engineers continue to hold a traditional, hierarchical view of leadership and thereby may resist the notion that engineering is a leadership profession [7], [8]. Additionally, while many opportunities to gain experience exist, support is needed to provide students with more meaningful development through intentional engagement and reflection [9]. Providing a comprehensive framework for competency development faces many challenges, including lack of shared curriculum across engineering majors, lack of faculty expertise or commitment to leadership development [10], difficulty implementing efforts at scale, and misconceptions that leadership is a field best suited for students in other disciplines, such as business or liberal arts. While the majority of engineering students at our institution reported involvement with at least one type of engagement experience, such as research, civic engagement, creative work, international experience, entrepreneurship, client projects, or internships, previous institutional studies found that the intentionality of development and measurement of professional competencies were limited in these efforts [9], [11].

The College of Engineering at the University of Michigan (U-M) implemented two elective, bookend courses that introduce undergraduate students to engineering leadership competencies, provide opportunities to intentionally seek development of these competencies, and guide students to integrate growth in these competencies into future experiences. Due to the lack of shared curricular requirements across the eighteen engineering majors offered at U-M, incorporating a bookend approach seemed to be a potentially effective strategy. Updating an existing course in the first year, where some shared curriculum does exist, and implementing a new course in the senior year when most students are completing their senior design experience and preparing to enter the workforce, proved to be the most feasible.

This practice paper primarily provides information regarding the design of these two courses, including explanation of the motivations for implementing these courses and the research basis that informs the course design. Additionally, we analyze how utilizing coursework during the first year and during the final year to introduce engineering leadership competencies supports students' understanding of the value of those competencies. Drawing on data from a survey and focus groups, we consider the following questions:

- Upon completion of either course, are students better able to identify and communicate the value of specific leadership competencies necessary for success in an engineering career?
- Upon completion of both courses, are students able to identify and make meaning of the connection between the courses?
- What barriers do students perceive in developing professional competencies?

Competency Development & Alignment with Leadership Development

In 2019, the College of Engineering at the University of Michigan engaged in an multi-year experiential learning initiative to develop a framework to support students to intentionally explore learning opportunities, engage meaningfully in experiences, reflect on what they have learned, and communicate the value of the core competencies they have developed [9]. Experiential learning has been identified as a high-impact educational practice [12], and provides the opportunity for the student to develop and practice competencies in authentic settings [13]. To support experiential learning, the College of Engineering developed a set of key professional competencies (Table 1) through a strategic vision process involving faculty, staff, students, alumni, and industry professionals as well as from national sources including the National Academy of Engineering (NAE) [2], the American Society for Engineering Education (ASEE) [14], and the Accreditation Board for Engineering and Technology (ABET) [1] (See Appendix A for competency definitions and dimensions). Each competency can be assessed on one of three performance levels designated as: Exploring, Engaging, and Explaining (Table 2) [15].

Table 1: Key Professional Competencies [15]

● Communication ● Creativity ● Empathy ● Entrepreneurial Mindset	● Ethics ● Global/Cultural Awareness ● Grit/Persistence/Resilience ● Leadership	● Lifelong Learning ● Risk Management ● Systems Thinking ● Teamwork

Table 2: Competency Development Performance Levels [15]

Exploring (1)	Engaging (2)	Explaining (3)
Students might engage at this level in a 100/200-level course or in the first semester of a co-curricular	Students might engage at this level in a 200/300-level course or in the first year of a co-curricular	Students might engage at this level in a 300/400-level course or in extended co-curricular participation

An examination of existing competency-based leadership models shows close alignment between these key professional competencies and leadership competencies. For example, the Hogan Competency Model includes “risk management”, “teamwork” and various communication-related competencies [16]. The National Education Association (NEA) Leadership Competency Framework includes “communication” [17]. The Relational Leadership Model includes “communication”, “ethics” and “collaboration” (which incorporates teamwork) [18]. The Michigan Model of Leadership incorporates “teamwork” and “empathy” [19]. Even though not explicitly defined as a leadership model, the Department of Labor Engineering Competency Model includes “communication”, “lifelong learning” and “professional ethics”, further supporting the alignment between engineering competencies and leadership competencies [20].

The Student Leadership Competencies model [3] is closely aligned with the competencies identified by our institution, including “systems thinking”, “empathy”, “ethics”, “resiliency”, “collaboration” (which incorporates teamwork) and several communication-related competencies. Furthermore, each of the sixty competencies included in the Student Leadership Competencies model include four elements to demonstrate proficiency, including “Knowledge”, “Value”, “Ability” and “Behavior” [3]. These align particularly well with the “Exploring”, “Engaging” and “Explaining” development performance levels used at our institution [15]. Seemiller incorporates these competencies into the Leadership Competency Development Taxonomy, using a scaffolded approach that includes “tiers” to demonstrate the complexity of each competency, “categories” to group related competencies and “domains” to indicate level of development. These areas of existing alignment with the Student Leadership Competencies and the Leadership Competency Development Taxonomy provide a foundation for leveraging these competencies to create leadership development curriculum and measure student leadership learning and development [3]. In this paper, we focus on the “Knowledge” and “Value” elements of the Student Leadership Competencies to describe an effort to implement two bookend courses that incorporate leadership competency development. Initially, focusing on the “Knowledge” and “Value” elements allows us to emphasize students’ ability to identify and define valuable competencies, which is a foundational step toward later engaging students in developing mastery within those competencies.

Course Descriptions

Engineering 110: Design your Engineering Experience (ENGR 110), an elective course for first-year engineering students, exposes students to the competencies within the context of defining engineering as a field, guides students through identifying opportunities available at the University of Michigan, and aims to develop self-authorship [21], [22]. The competencies provide a framework for intentionally exploring learning opportunities available at the University of Michigan as students create a plan for their future educational experiences.

Engineering 499: Design Your Engineering Future (ENGR 499), an elective course for senior-level engineering students, helps students leverage their experiences through reflective observation to better understand and explain their leadership development [23]. These reflections occur through meetings with professional engineers who serve as mentors, as well as through storytelling activities in class that enable students to articulate both their technical and professional skills [9].

Through both courses, students are exposed to a competency-based approach to leadership development that will prepare them to identify and develop competencies deemed necessary in future careers [3].

Competency Introduction through Engineering 110 (First-Year Elective Course)

Engineering 110: Design Your Engineering Experience is an introductory course in which students explore the breadth of opportunities available to engineers in both their education and their career. The course is structured around three key themes: What is Engineering?, Exploring Michigan and Michigan Engineering, and Self-Understanding. Students explore these themes through self-directed, online modules accompanied by a weekly, in-class discussion (18-20 students per discussion section). In Fall 2023, 50% of the first-year undergraduate engineering students (775 students) at our institution enrolled in this elective course. Students are directed to this course by first-year advisors during orientation. Students are most commonly recommended to take ENGR 110 if they need support in determining a specific engineering major, are interested in connecting with other first-year students or would benefit from peer and alumni mentorship. In 2019, ENGR 110 underwent a redesign through a three-year partnership with U-M's Center for Learning on Research and Teaching's Foundational Course Initiative, in order to provide students with multiple tailored opportunities to explore their academic interests and professional goals. This redesign effort also supported the incorporation of competency development into the course and enabled the course to scale in size from enrolling 25% to 50% of the first-year engineering students each year.

Course Learning Goals and Structure

Upon completion of this course, students will be able to:

- Explain the role of engineering in society, articulating the importance of a mindset that values diverse perspectives and experiences, and ensures equitable access and participation in all aspects of engineering education, design and practice.
- Apply design thinking principles and decision-making skills to evaluate personal, academic, and professional interests; make decisions; and create a planned academic path in the College of Engineering.
- Describe different career opportunities associated with a variety of the engineering disciplines offered within the College of Engineering.
- Begin to develop an engineering identity by identifying personal strengths and learning about the opportunities available during the undergraduate experience.
- Speak in an intentional way about their academic plan, including selection of major and plans for engagement with experiential learning opportunities.

The course utilizes a hybrid model, through which students engage in synchronous, weekly, small group discussion sections and asynchronous online modules. The weekly discussion sections are led by upper-level engineering students (junior and senior-level engineering undergraduate students), while the online modules include faculty perspectives provided by the lead faculty instructor and selected engineering faculty. The weekly discussion sections provide students the opportunity to explore their strengths and values in support of the development of self-authorship [22], and enable students to explore their interests among a community of peers. See Appendix B for course vision, mission and themes.

The weekly discussions course topics include:

- Introduction to Educational Planning
- Common Reading Experience
- Peer Mentor Stories & “Navigating” Campus
- Personal Strengths
- Design Thinking & Decision Making: Socially Engaged Design
- Foundation Module Review and Engagement Module Planning
- Social Identity: Understanding Difference and Perspectives
- Exploring the Technical, Social and Global Dimensions of Engineering
- Department/Majors Exploration Day
- Values, Priorities, and Responsibilities
- Engineering Identity and Statement; Forward Look at Personal Action Plan
- Ethics
- Professional Development
- Personal Action Plan

The discussion also includes a reflection assignment each week to ensure that students are integrating concepts from both the modules and the discussion into their educational plans.

The online modules establish the foundations for the course (Foundation Modules), provide an opportunity to explore the field of engineering (Exploration Modules) and support engagement with advisors, alumni and mentors (Engagement Modules). A complete list of online modules is provided in Appendix B. The modules require students to complete a pre- and post-reflection, asking them to access prior knowledge, describe a personal learning goal for the module, consider any questions they have before engaging with the materials and ultimately reflect on their learning upon completion of the module [23]. While all students are required to complete the five Foundation Modules to ensure students develop a foundational understanding of the course themes, students begin to develop a sense of autonomy and personal agency in their learning experience by choosing their own path through the remaining modules [24]. Students select five from a total of 23 Exploration modules and five from a total of 15 Engagement modules.

The final element of the course is the creation of a Personal Action Plan through which students reflect on the choices they made in navigating the course, create a personal engineering vision statement and identify experiential learning opportunities they plan to engage in throughout their educational experience.

Competency Introduction

The competencies are initially introduced to students through the Immersed (Experiential Learning) Foundation Module, which focuses on co-curricular engagement and experiential learning. This module is a required element of the course and typically completed during the first few weeks of enrollment. The module consists of multiple elements intended to familiarize students with the process of experiential learning, emphasize the importance of engaging in experiential learning and prepare students to explore the various experiential learning opportunities available at our institution. The competencies are first introduced to students through a faculty perspective video. As the faculty member shares their story and experiences, the competencies are mentioned as valuable concepts that are best gained through immersive activities outside of the classroom. Subsequently, students are provided with basic definitions of each competency, followed by a low stakes quiz to test their retention.

Upon completion of the Immersed module, students complete a reflection assignment that asks them to identify their top three competencies from the full set of twelve, select one competency they would like to strengthen and describe how they plan to develop this particular competency during their educational experience. Although there is considerable alignment with leadership development competencies, students are not currently introduced to the competencies in the context of leadership in this course. This could be attributed to preconceived notions within our

College of Engineering that previously defined leadership in a narrow way, rendering the connection between leadership development and the course content less clear in the past.

Spire - Experiential Learning Tool

Beginning in Fall 2021, the University of Michigan introduced a web-based learning platform called Spire to guide students through the process of prioritizing which competencies they want to work on and identifying learning opportunities to develop specific professional competencies. This tool enhances the "Experiential Learning" module and Personal Action Plan assignment by providing a guided process for selecting competencies, a mechanism for finding experiences to develop those selected competencies, and a place to indicate goals for future experiential learning engagement in a format that continues with them beyond completion of the course [15]. As students engage with these experiential learning opportunities, they can use Spire to reflect on how they have grown in the related competencies and how these competencies (and experiences) play a role in their future success as engineers. Progressing through Spire, students can earn a badge that can be pushed to LinkedIn as a credential. This tool is now available to students who enroll in ENGR 110, but was not yet available to the students who took the course in Fall 2020, who provided the survey and focus group responses detailed in this paper.

Competency Introduction through Engineering 499 (Senior-Level Elective Course)

Engineering 499: Design Your Engineering Future is an elective course for upper-level engineering students, which focuses on reflective learning of undergraduate experiences through storytelling. Alongside professional engineering mentors, this course helps students articulate the value of their unique experiences through a leadership lens to external audiences.

Students are expected to have completed at least one experiential learning experience (active, concrete, and contextual) prior to enrolling in the course [26], such as study abroad, involvement in student organizations and design teams, undergraduate research, internships, or presentations at conferences. It is the goal throughout the course that students will be able to describe their growth in and mastery of competencies in the context of their undergraduate engineering experience. As more students engage with and reflect in Spire from their first year onward, they will have a collection of experiences they can use to describe their development and mastery of these competencies.

Students are recruited for this course through a variety of methods. This course was approved as an alternate route to fulfill the requirement of an existing professionalism course, required for all Computer Science Engineering, Computer Engineering, Electrical Engineering, and Data Science Engineering students. Due to this equivalency, the course is heavily populated by students in these fields. This course is advertised through emails to students in the targeted majors, digital display

advertisements around campus, and by working with academic advisors in the four previously specified areas to make students aware of this option to complete the professionalism requirement. This course was first offered in Fall 2020 as a special topics course. It was approved to serve as an alternate course for the four majors' professionalism requirement in Fall 2022 and approved by the curriculum committee as a permanent course in Winter 2023.

While the College of Engineering offers 18 undergraduate majors, this course typically enrolls 47% from Computer Science, 17% from Computer Engineering, 15% from Electrical Engineering, and 5% from Data Science. In Fall 2023, the course consisted of 42 total students, of which 23 were from Computer Science, 10 were from Computer Engineering, 6 were from Electrical Engineering, 1 was from Data Science, 1 was a double major between Electrical Engineering and Computer Science, and 1 was a double major between Electrical Engineering and Biomedical Engineering.

Course Learning Goals and Structure

This course offers two sections of different lengths. One section meets for only the first seven weeks of the semester (1 student in Fall 2023) and one section meets for the entirety of the semester (41 students in Fall 2023). In order to earn credit for the professionalism requirement, students must be enrolled in the section that meets over the entirety of the semester.

This course originated as a seven-week course, focused on providing students who had earned an experiential learning grant the opportunity to use that experience to consider their personal leadership development and speak about their experience(s) externally. The course was extended to the full semester, with additional topics added, in order to meet the professionalism requirement for four majors. The first seven weeks of the course give students the opportunity to reflect on their experiences through a leadership lens and prepare to tell their story. The full term course provides students additional opportunities to build mentorship relationships, look at their experience through additional competencies, and develop a project that showcases and summarizes their experiences to external facing audiences.

It is expected that by the end of the course, students will be able to:

- Describe their growth in and mastery of competencies in the context of their undergraduate experiences
- Develop their social capital by working with a professional mentor to ask salient questions, receive meaningful feedback, and discuss [or evaluate] challenging decisions about their personal and professional future
- Design a set of guiding principles and values for their personal and professional futures and use their guiding principles and values to:

    - Describe what being an engineer means to them and their responsibility in serving the common good
    - Support personal and professional decisions using their guiding principles and values
    - Inform the creation of professional documents
- Apply a project (such as a LinkedIn profile) to meet personal and professional goals*
- Use strategies and philosophies to reason through ethical challenges*
- Examine experience and examples using intellectual property law*

* indicates course outcomes only applicable to students enrolled in the full semester section of the course

This course meets once per week for two hours. The course is 14 weeks long, and covers a variety of leadership topics including:

1. Networking, Social Capital, and Mentoring
2. Professional Competencies & Storytelling
3. Leadership
4. Constructive Feedback
5. Values & Creativity
6. Communication
7. Diversity, Equity, and Inclusion
8. Ethical Reasoning
9. Risk Management & Systems Thinking
10. Creating Professional Documents
11. Entrepreneurial Mindset & Intellectual Property
12. Lifelong Learning & Personal Finance
13. Storytelling & Generative Listening (covered for two weeks)

Students work in small groups of 6 to 7 students, referred to as “pods”. These remain the same throughout the semester and help build community and provide a space for constructive feedback within the larger class. See Appendix C for the full course description.

Competency Introduction

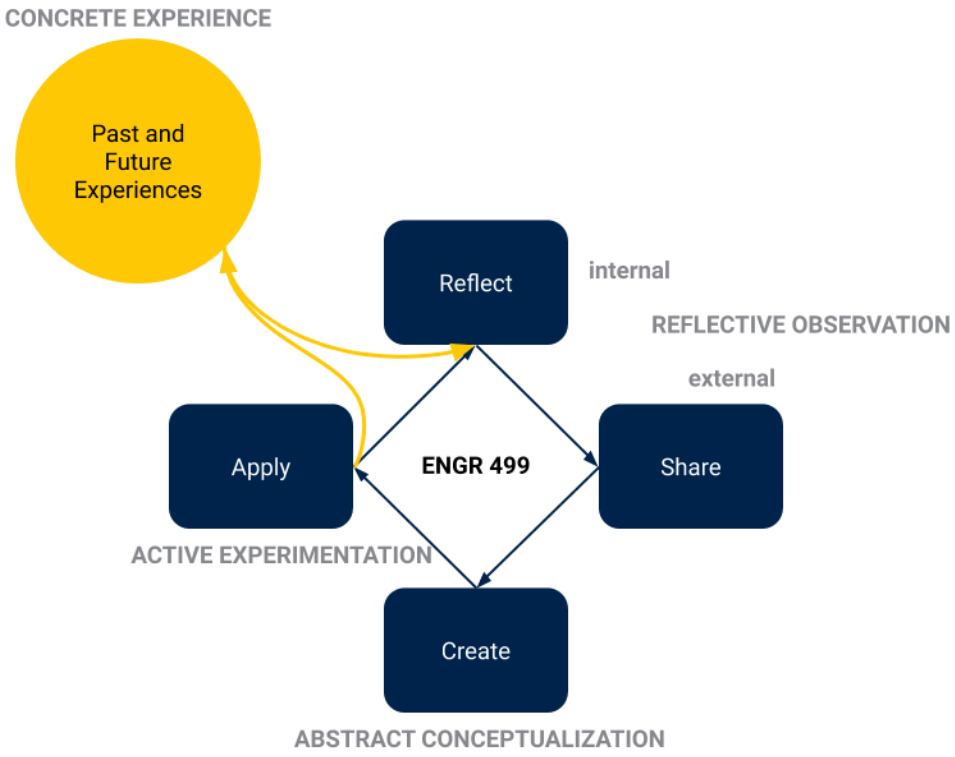
The competencies provide a framework for this course, beginning with an introduction to the twelve key professional competencies during the first class session. The initial introduction is followed by context related to development of the key professional competencies, along with a discussion of the importance of being able to develop and articulate these skills as engineers. Subsequently, one competency is covered in depth each week throughout the semester.
During the third week of the semester, “leadership” is the focal point. Students are provided with a comparison of our College of Engineering’s professional competencies and Seemiller’s

taxonomy of leadership competencies [3] to demonstrate that students are being challenged to learn leadership by the College of Engineering.

Each competency is introduced in the course using a consistent structure. Students are asked to work in their pods to provide a definition of the selected competency. Students are then shown a video created by U-M's College of Engineering showing a collection of alumni discussing what the term means for them and how they use it in the field of engineering. Students are then shown a rubric that the College compiled for that competency - giving the definition, and showing the dimensions of that competency [27]. Activities are generally built into the class to give students an opportunity to engage with the competency and intentionally reflect on how they have used this in their past experiences. Students are given a prompt at the end of class to help them reflect on how they could outwardly express their use of that competency. These prompts are shared with the student's mentor at their monthly check-ins, edited based on feedback from the mentor, and submitted to the instructors.

This course utilizes Kolb's Experiential Learning theory as a process model for the course design (Figure 2) [28].

Figure 2. Kolb's Experience Learning Model, as used in ENGR 499 [28]



In-class activities to introduce topics are generally interactive and engage students in their pods. For example, to introduce the concept of leadership, students are asked to work in their pods to draw a stick figure of a leader, and add to the stick figure items that help describe the qualities of a leader. Students then build from this to create a definition of leadership. Subsequently, students compare their own definition of leadership to the College's rubric on leadership and video responses provided by alumni.

Methods

Data Collection

In Fall 2023, current College of Engineering senior level students were invited to participate in a focus group and survey. All participants responded to the same survey, but students were directed into one of four separate focus groups, depending on which course(s) they had completed: ENGR 110 only, ENGR 499 only, both courses or neither course. Students who were enrolled in ENGR 499 were invited to participate in the optional survey and focus group during class time, but course instructors were not present and did not have access to focus group recordings or transcripts until after the completion of the semester. Focus groups centered on discussion of competencies required for success as an engineer, value placed on the competencies, existing experiences that provided opportunity to develop the competencies and barriers to developing the competencies (see Appendix D). A total of sixty-eight students participated in focus groups and responded to the accompanying survey.

Data Analysis

The data resulting from the survey was iteratively and emergently coded [29] in order to identify competency alignment and common trends among student answers. First, the responses were grouped and quantified (i.e. all of the responses of "communication" were collapsed into one response, assigned a value of N=8, since "communication" appeared eight times, and then categorized as the "communication" competency). Next, words that were part of the competency definition or dimensions, as indicated in the competency rubrics [15] were counted in the category for that competency. Finally, similar words or synonyms were counted in the category for the related competency. In a few cases, responses included multiple competencies, such as "communication/teamwork", and were counted in multiple categories.

This analysis is limited due to focus group capacity impacting sample sizes. The population of senior-level engineering students who took neither course was 611, with 12 students responding to the survey and focus group. The population of senior-level engineering students who took only ENGR 110 was 697, with 25 students responding. The population of senior-level engineering

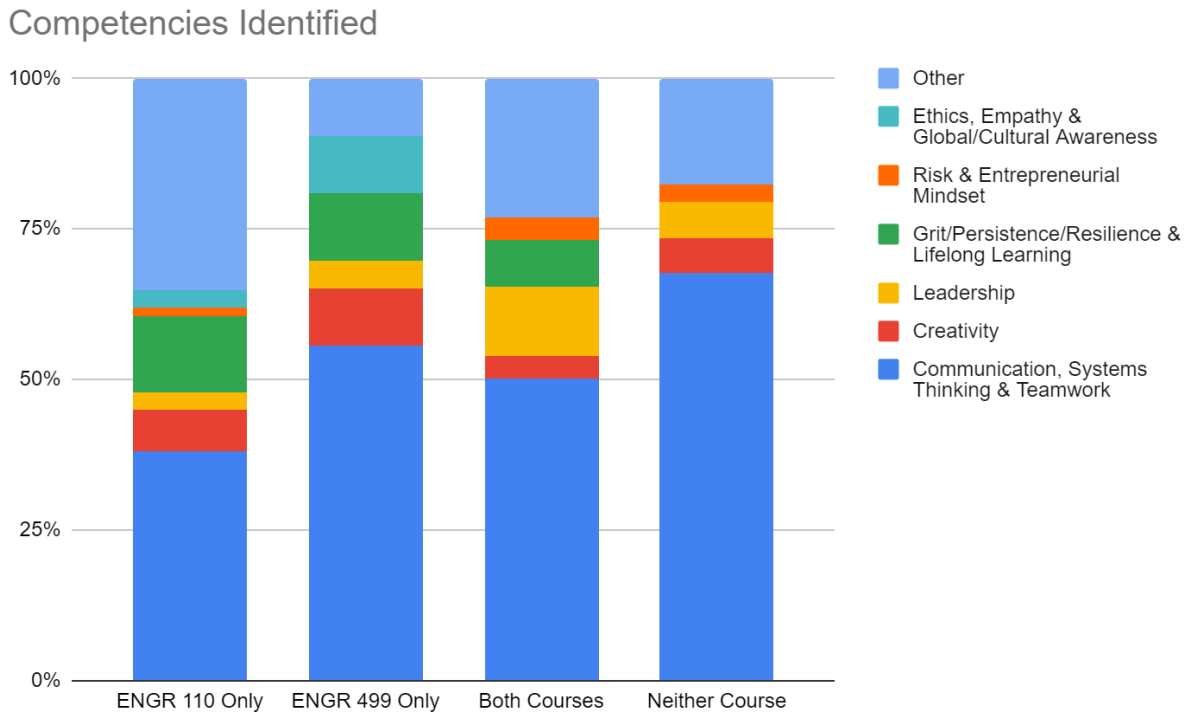
students who took only ENGR 499 was 24, with 22 students responding and the population of senior-level engineering students who took both courses was 9 with 9 students responding. Given the small sample sizes, drawing statistically significant conclusions is limited. The results from the survey data are included in this paper for informational purposes and to provide context for the focus groups. Recordings of focus groups were transcribed, and transcripts were analyzed using thematic coding and analysis to identify specific understanding of the competencies and themes among the barriers to development.

Results & Discussion

The survey asked students to indicate three skills needed in order to be successful as an engineer. We analyzed these responses to determine if students who took one or both courses were more likely to identify leadership competencies than students who took neither class (Figure 1). While unsurprising, it is worth noting that students in all groups identified technical skills as important for success as an engineer, however, for the purposes of this analysis, we will focus specifically on leadership competencies. Students identified three specific competencies with similar frequency, regardless of their course enrollment: communication, teamwork, and systems-thinking. Creativity and leadership also appeared among responses from all groups, although at a much lower frequency. There were some competencies that were only identified by students who had taken either or both courses, including: empathy, ethics, global & cultural awareness, grit/persistence/resilience, and lifelong learning. While students in all four categories identified leadership, it appeared with the highest frequency among students who took both courses.

Students who enrolled in ENGR 499 tended to use language consistent with the twelve competencies, rather than supplying an alternate word or phrase that described the competency. For example, students who took ENGR 499 used the terms “communication”, “creativity”, “grit”, “persistence”, “resilience”, “systems-thinking” and “teamwork” directly, as opposed to providing words describing them, such as “perseverance” or “presenting skills”, as seen in other groups. This could be attributed to stronger familiarity with the College’s set of competencies, recency bias, or a combination of factors.

Figure 1: Competencies Identified by Students who took ENGR 110 (n=79), who took ENGR 499 (n=66), who took Both courses (n=27) and who took Neither course (n=39). N represents the number of responses, which was typically three responses per student.



Students who were enrolled in ENGR 110 provided the largest list of "other" competencies of any of the groups (Table 3). Although not direct dimensions or synonyms of any of the competencies, several of the responses were noticeably similar concepts or could be considered competency subskills, such as "relationships skills", "decision making", "open to new ideas", and "adaptability". This might suggest that students who took ENGR 110 were able to identify a wider array of non-technical competencies than those students who took neither course. While students who took ENGR 110 demonstrated understanding of the concepts broadly, the variable terminology in their responses may suggest lack of exposure to those competencies during the subsequent years of their education.

Table 3: Additional Competencies Provided by Students in Each of the Four Groups. These responses were categorized as "Other" (shown previously in Figure 1).

ENGR 110 Only	ENGR 499 only	Both courses	Neither course
• "A little bit crazy" • "Ability to learn" • "Ability to socialize"	• "Dedication" • "Efficiency" • "Fast learner"	• "Forethought" • "Hardworking" • "Open minded"	• "Adaptability"* • "Open-mindedness" • "People skills"

● "Adaptability" ● "Analytical thinking" ● "Clever" ● "Confidence" ● "Decision making" ● "Finding Data" ● "Foresight" ● "Hardworking" ● "Human skills" ● "Insight" ● "Interest in engineering" ● "Interpersonal Skills" ● "Logic" ● "Networking" ● "Open to new ideas" ● "Relationship/people skills" ● "Sticking up for yourself" ● "The ability to bullshit" ● "Time management"* ● "Utilizing resources" ● "Work ethic"	● "Foresight" ● "Hard work" ● "Personability"	● "Organization"* ● "Organized"	● "Project management"*

* Denotes a response that appeared twice within the specific group.

Beyond the survey asking students to identify competencies for success in an engineering career, focus groups were also conducted to better contextualize the responses. Several key themes were identified through the analysis.

Value of Communication & Existing Gaps

The value of engineers developing communication skills was articulated by multiple students in all four groups, however, students felt there was a gap between technical communication coursework and the type of communication skills needed. Students commented:

> *"In terms of communication I would say honestly, most of my learning communication happened in my internships. I honestly don't think that mechanical engineering really emphasizes it as much as they should because… it's one of the*

last classes you take. That's the only time that you really do big presentations, so a lot of people don't really have those skills yet, which is crazy to me."

"The way academia teaches technical communication is very different than the real world. Every company that I have gone to has said, "Forget what you learn and this is how you should do it…"

"I think, also, the fact that the communication side, yes, we have a lot of technical communication, but we don't talk about just interacting with people on Slack or email or basic conversations within your team at work or with your boss, but not on the assignment. How do you communicate professionally, but also in a slightly informal way?"

"I think one of my biggest takeaways was (that in ENGR 499) we talked a lot about storytelling. I just never thought about framing communication as storytelling. Just thinking about that makes a lot of sense to me."

Importance of Teamwork & Existing Gaps

Students described gaining teamwork skills through experiences outside of the classroom, such as internships, student organizations and athletic teams, but offered criticism regarding teamwork in engineering classes.

One student commented:

" I don't think they really teach you how to work with your team. You just end up doing it. I think people who have good experiences and say they learned relationship-building and communication skills probably just had a better team."

Some students expressed concerned about the siloed approach to teamwork:

"It teaches really how to form a collaboration in which people end up—like one person will do all of the CAD, which just teaches you to silo things."

"I think the inherent issue is that the classes that do teach those skills don't force everyone to learn those skills. That goes back to the collaboration aspect of it where if you think you have the best skills at something and you're just going to take it for the team, and people will let you do that."

Existing Gaps in Leadership Development

Students raised concern about the lack of leadership development in their coursework:

"I don't think any of my courses really helped me learn how to be a leader."

> *"I think that the classes, where leadership skills are needed, like the team classes do almost a bad job of teaching leadership because what ends up happening is the person who already is a leader, already has those skills, is going to be the one to step up, and the people that need to learn more about it are just going to let that person do it."*
>
> *"I think some of your team leadership courses built into the curriculum (would be beneficial). I think that's an area that a lot of Michigan engineers are going to step into, into leadership roles and whatnot. I know there are—depending on student project teams—that there are experiences you can gain, but I think some kind of curriculum focusing on that would be beneficial."*

One student offered a contrasting viewpoint:

> *"This is kinda contrasting. I feel like a lot of the skills are not very well taught in a classroom. Even if there is a class dedicated to it, and you go to class, at least in my mind, it ends up being a filler class. It's not directly something that I can only learn at school. It's like I'm buried in work, right? When you're considering workload, it's like, 'Oh, am I gonna to take another upper-level EE class, or am I gonna take a class that does this?' I feel like a lot of times when classes purport to teach something that's a bit more abstract like this, it doesn't always stick as well."*

Internship experiences helped students identify gaps in their own competency development

> *"I think that a little bit more of project management and a lot of higher-level teaching would be better because I know a lot of the capstone classes aim to try to help students develop their own project from scratch and go through that whole, entire design development phase. I think a lot of the stuff I learned during internships, or even in outside classes and stuff… is not really touched upon in classes."*
>
> *"When I went to my internship after sophomore year it was very—like I'm mechanical, and it was also very electrical-focused because I think these days a lot of things encompass electrical engineering as well. I was like, "Wow. I just don't know anything at all. Like any of this."*

Curricular constraints and workload were the primary barriers students expressed regarding why they didn't engage in courses and experiences that would help develop leadership competencies

> *"I didn't seek it out because it's not really built into my requirements, and a lot of the time, I'm just trying to keep my head above the water, so if it's something that is optional to take, then I'm probably not going to take it because I don't need more work on my plate"*

"I think it's easy to say, 'Oh. You can just go and join a project team to get that experience,' but that means that you have to go out of your way and actually join something and be like, 'I'm not going to take the easy way out and just let someone else deal with it.' That's not to say that we're not all high-achieving people. It's just like sometimes the easier way is just to get through the classes because they are so challenging and time-consuming."

"Like one solution would be to go join the design team where you could learn those skills and maybe you'd start to collaborate with others, except for the fact that that requires you to give up, in addition to all of the hours you spent on homework in class, you now to have to go to a design team and give up those hours as well in your free time for something that, you know, that you might learn to collaborate"

Students expressed a perceived value of embedding competency development and experiential learning into the curriculum

"At one of my internships, there was a lot of on-the-job training… I felt like that was really helpful. I mean, there was a lot of teamwork stuff. There's some things that come close to that in the classroom, but I feel like it's really hard to recreate that environment in a classroom. Then I have friends at other schools, and some engineering programs they require an internship. I mean, I know most people already do it, but I think it'd be interesting to actually incorporate it into the curriculum."

"It's not about one specific skill, but just about the hoops that you have to jump through in order to access the extra opportunities. Like so many of the things people have listed—like you can do the design teams and whatever—but most of those, you still need to apply into, so there is no guarantee you'll get into it."

"That just goes with all of the classes and the clubs. Like it's really hard to jump through those hoops when these skills aren't being offered in classes (we) are already required to take. "

Students who took both courses had difficulty drawing connections between the two experiences

"Well, for me, they were pretty separate in my mind. There was not too much of an overlap. They both focus on engineering skills I need. I think 499, having come in at this stage (was) better than 110. They're just at two very different points in my college career."

"I guess, for better or worse, I didn't ever really think of them as linked until this focus group. Maybe that's just 'cause it's a distant memory. I'm not sure. Yeah, I never really thought of those as linked."

One student recalled:

> *"I remember in Engineering 110, there was some module about describing your journey to U of M. I think that's what we were talking about so it was kinda like I refer back to that document while we work through Engineering 499, which it's interesting to see."*

Students emphasized the value of the bookend approach, but discussed the importance of what happens during the sophomore and junior year

One student who had only taken ENGR 499 and wasn't aware of ENGR 110 suggested:

> *"If we were given (499) earlier—this is really for a senior starting in the workforce. If there's a different version that's trying to prep you for working in teams in college, I think that would be helpful to take it as a freshmen…You don't need one every year, but where you take one early, and then you take one later as a senior, I think that could be a good addition."*

Another students emphasized the value of taking a leadership development course in the junior or senior-year:

> *"Engineering 499 is the only course that really focuses on professional development. As was previously mentioned, the storytelling element is the missing link between technical knowledge and being able to actually prove to an interviewer that you have that high-level knowledge. To me, it filled in a lot of gaps in terms of going from a student to engineer."*

Some students commented on the lack of leadership competency development in the sophomore and junior year. One student noted:

> *"Our curriculum sophomore year and early junior year, it's just purely physiology and physics and stuff like that. It's not actually helping you build certain skills you need to actually go into an internship, which is important."*

Several key themes arose in the focus groups, including the acknowledgement that leadership development, including communication and teamwork are important for engineering but are not currently taught effectively in the engineering curriculum. Students placed considerable value on internship experience, both indicating that internships were a learning experience for them and that internships helped students identify gaps in their own development. Students later identified that curriculum constraints and heavy academic course loads were the primary barriers to leadership competency development. Students also indicated that embedding leadership competency development into the curriculum would be valuable. Students who took both courses were mainly unable to draw connections between the two courses, but indicated that the bookend approach, with some additional touchpoints in the sophomore and junior year would be beneficial.

The focus group findings indicate that further expansion of ENGR 110 and ENGR 499 to reach a wider audience of students could be worthwhile. Additionally, framing the competencies as leadership competencies by using a shared leadership framework could help strengthen the

connection between the two courses. This could be supplemented with the Spire tool or additional touch points through coursework in the sophomore or junior year. It may be important to reference the same framework for all points of contact, as students seem unable to form connections between the coursework, when those connections are more abstract.

It is important to note limitations to these survey and focus group findings. As discussed previously, a relatively small number of students participated in the survey and focus groups, meaning comparison between some of the groups is not statistically significant. Because of the number of respondents, we are unable to disaggregate the data demographically, which could provide insight into the specific experiences of female and underrepresented minority students with leadership competency development at our institution, as one example. Additionally, ENGR 110 was impacted by the Covid-19 pandemic during Fall 2020. The weekly in-person discussions took place online, instead of using the hybrid course model, which impacted the experience of students who took ENGR 110 and participated in the survey and focus groups. Finally, because four engineering majors allow ENGR 499 to fulfill a degree requirement, the course enrollment is predominantly students from only four majors out of the 18 majors offered at our institution.

Conclusion

Regardless of enrollment in ENGR 110 or ENGR 499, students were able to identify some competencies with similar frequency, while others were only identified by students who had taken one or both courses. Despite being able to identify the specific competencies of communication and teamwork, students expressed a gap between what they gained through their curriculum and what they deem necessary for success in an engineering career. Students who took the senior-level course were more likely to name the competencies directly than students who took only the first-year course or neither course. Students who took only the first-year course described competencies that were similar in concept but did not use institution-specific language as frequently as students who took ENGR 499. This indicates a general understanding of the value of leadership competencies, but a lack of retention after three years, which could be attributed to lack of reinforcement and repetition in the sophomore and junior years.

Students described barriers to developing these competencies, some of which these courses may address, if expanded. Students described curricular constraints and heavy technical course loads as barriers to competency development and expressed a need for embedding experiential learning and competency development into the curriculum, through both the bookend approach illustrated here and additional efforts in the sophomore and junior year.

Students who took both courses indicated leadership as important to success in an engineering career with more frequency than other students, but were unable to make direct connections between the two courses. Introducing the competencies as leadership competencies and using a

shared model in both courses could help students draw better connections between the two courses and could deepen their understanding of engineering leadership development. A redesign of the instructional model for ENGR 499 to improve scalability could be beneficial. The creation of additional points of contact embedded in the sophomore and junior year curriculum could also be considered. Future studies should focus on a more comprehensive survey with larger sample sizes to determine the impacts of these two courses as compared to the control group (students who took neither course). Future work should also include an exploration of survey response differences, based on demographics. Additionally, future work could include a longitudinal study of students' capacity for lifelong learning after being exposed to the language and process for engineering leadership competency development to determine if the approach students encountered in these two courses impacted learning in their future careers. Finally, an examination of the impact of these courses on the development of engineering identity upon College entry and prior to career entry could be beneficial.

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References

[1] Accreditation Criteria and Support Documents, https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2023-2024/ Accessed on February 7, 2024

[2] National Academy of Engineering. Engineering the Future 2018. https://www.nae.edu/215419/NAE-Annual-Report-2018 Accessed on March 1, 2021.

[3] Seemiller, C. (2013). The Student Leadership Competencies Guidebook: Designing Intentional Leadership Learning and Development. San Francisco, CA: Jossey-Bass.

[4] Hartmann, Beth & Jahren, Charles. (2016). Leadership: Industry needs for entry-level engineering positions. IEEE Engineering Management Review. 44. 76-85.

[5] Bielefeldt, Angela. (2018). Perceived Importance of Leadership in their Future Careers Relative to Other Foundational, Technical and Professional Skills among Senior Civil Engineering Students. 10

[6] Kendall, M. R. & Rottmann, C. (2022). Student leadership development in engineering. New Directions for Student Leadership. Issue 173. 1-155

[7] Rottmann, C., Sacks, R., & Reeve, D. (2015). Engineering leadership: Grounding leadership theory in engineers' professional identities. Leadership, 11(3), 351-373.

[8] Schell, W. J., & Kauffmann, P. J. (2016, June). Engineering leadership: Faculty perceptions and profiles. In 2016 ASEE Annual Conference & Exposition.

[9] Callewaert, J. H., & Millunchick, J. M., & Woodcock, C. S. E., & Jiang, K. C., & Edington, S. (2020, June), Developing a Framework for Experiential Learning Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2--34414

[10] Klassen, M., Reeve, D., Evans, G.J., Rottmann, C., Sheridan, P.K. and Simpson, A. (2020), Engineering: Moving Leadership From the Periphery to the Core of an Intensely Technical Curriculum. New Directions for Student Leadership, 2020: 113-124.

[11] Woodcock, C. S. E., Callewaert, J., and Millunchick, J., "Synthesizing Definitions of Professional Competencies Linked to Experiential Learning in Engineering Education: A Literature Review," J. High. Educ. Theory Pract., vol. 21, no. 4, 2021.

[12] Kuh, George D. (2008). "High-impact educational practices: What they are, who has access to them, and why they matter." AAC&U, Washington, D.C. 34 pp.

[13] National Society for Experiential Education. (1998). Eight principles of good practice for all experiential learning activities. Paper presented at the 1998 Annual Meeting, Norfolk, VA.

[14] American Society for Engineering Education, "Transforming Undergraduate Education in Engineering," 2013.

[15] Callewaert, J. H., Millunchick, J. M., Woodcock, C. S. E., & Jiang, K. C. (2021). Assessing and Communicating Professional Competency Development Through Experiential Learning. ASEE Annual Conference and Exposition, Conference Proceedings.

[16] Hogan Assessment Systems Inc. (n.d). The Hogan competency Model. https://info.hoganassessments.com/hubfs/EL_Hogan_Comp_Model.pdf Accessed on January 31, 2024

[17] National Education Association. (n.d.). NEA Leadership Competency Framework. https://www.nea.org/professional-excellence/leadership-development/leadership-competencies Accessed February 2, 2024.

[18] Komives, S, Lucas, N., & McMahon, T. (1998). Exploring Leadership for College Students Who Want to Make A Difference. San Francisco: Jossey-Bass.

[19] DeRue, D. S., Spreitzer, G., Flanagan, B., & Allen, B. (2013). Developing adaptive leaders for turbulent times: The Michigan model of leadership. The European Business Review May - June 2013

[20] U.S. Department of Labor, Employment, and Training Administration. (n.d). Engineering Competency Model. Retrieved [insert date], from [insert URL here]

[21] R. Kegan, "In Over Our Heads, The Mental Demands of Modern Life, Bulletin of Science, Technology & Society, vol. 16, no. 1, p. 92, 1996.

[22] M. Baxter Magolda and P. King (eds.), "Learning Partnerships: Theory and Models of Practice to Educate for Self-Authorship. Sterling, Va.: Stylus, 2004.

[23] Kolb, D. A. (1984). Experiential Learning: Experiences as the Source of Learning and Development. Prentice Hall.

[24] Marsik, F. J., & Cameratti-Baeza, C. G., & Levesque, E. M., & Edington, S. (2021, July), Acknowledging Unique Needs: Empowering Student Choice in the Creation of Their Pathway Through a First-year Experience Course Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2--36641

[25] Callewaert, J. H., & Jamison, C. S. E. (2023, June), Supporting the Development of Professional Competencies and Engineering Identity at Scale Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore , Maryland. 10.18260/1-2--44372

[26] Kolb, David A., Boyatzis, R. E., & Mainemelis, C. Experiential Learning Theory: Previous Research and New Directions. In Perspectives on Thinking, Learning, and Cognitive Styles, 2011. https://doi.org/10.4324/9781410605986-9

[26] Kolb, David A., Boyatzis, R. E., & Mainemelis, C. Experiential Learning Theory: Previous Research and New Directions. In Perspectives on Thinking, Learning, and Cognitive Styles, 2011. https://doi.org/10.4324/9781410605986-9

[27] Woodcock, C. S. E., Callewaert, J., & Millunchick, J. (2021). Synthesizing definitions of professional competencies linked to experiential learning in engineering education: a literature review. Journal of Higher Education Theory and Practice, 21(4), 123-146.

[28] D. A. Kolb, Experiential Learning Experience as the Source of Learning and Development, Second. Upper Saddle River, New Jersey: Pearson Education Inc., 2015.

[29] J. W. Creswell, Research Design: Qualitative, Quantitative and Mixed-Methods Approaches, 3rd ed. Thousand Oaks, CA: SAGE Publications, Inc., 2009.

Appendix

Appendix A: Competency Definitions and Dimensions

COMMUNICATION: *Ability to critically read, listen, reflect, and convey information effectively in a variety of media with diverse audiences with different needs and perspectives across a variety of settings and contexts.*

Dimensions: Listening, Presenting - Oral and Visual, Speaking - Small Group or Informal Settings, Writing

CREATIVITY: *Ability to generate ideas, processes, products that are both novel (unique, original, atypical, cutting-edge) and appropriate (relevant, practical, useful, applicable, fitting, effective).*

Dimensions: Applying Divergent and Convergent Thinking Processes, Innovation, Production of Novel Ideas, Production of Useful Ideas

EMPATHY: *Ability to understand, appreciate, value the perspective of someone else by reasoning from their premises, assumptions, or ideas.*

Dimensions: Cognitive Empathy, Emotional Empathy, Empathic Response

ENTREPRENEURIAL MINDSET: *Ability and intent to engage proactive, innovative strategies in various contexts to solve ambiguous problems.*

Dimensions: Entrepreneurial Intent, Entrepreneurial Skills, Intrapreneurship

ETHICS: *Fully engage stakeholders to recognize that actions and choices have consequences, and that one must act with integrity and trustworthiness.*

Dimensions: Ethical Behavior, Ethical Reasoning, Knowledge of Ethics

GLOBAL/CULTURAL AWARENESS: *Ability to acknowledge, practice, and articulate one's own cultural identity to better appreciate, adapt to, and interact with individuals from differing backgrounds, values, and cultures.*

Dimensions: Cultural Competence or Awareness, Diverse Workplace Competence or Awareness, Global Competence or Awareness

GRIT/PERSISTENCE/RESILIENCE: *Ability to persevere and maintain passion/commitment for achievement of long-term goals, despite setbacks, failure, and/or adversity.*

Dimensions: Navigating Hostile Workplace, Overcoming Setbacks, Perseverance for Long-Term Goals, Pivoting When Appropriate

LEADERSHIP: *Cultivating an environment that collectively develops a shared purpose and inspiring others to work toward it.*

Dimensions: Organizational Leadership, Societal Leadership, Team Leadership

LIFELONG LEARNING: *Ongoing desire and fundamental ability to recognize personal skills/knowledge deficits; seek out and acquire needed skills and knowledge; and continue to grow new interests, talents, and passions.*

Dimensions: Ability to Seek out Appropriate Sources to Learn on One's Own, Knowing When to Ask for Help, Self-Agency in Educational Choices

RISK (Ability to Accept and Manage Risk): *Ability to critically assess available information, take action despite uncertainty, manage outcomes, and learn from failure as well as from success.*

Dimensions: Being Proactive About Risk Associated with Engineering Work, Consideration of Risk v. Reward in Decision Making, Recognizing the Need to Take Risks

SYSTEMS THINKING (Authentic Problem Solving): *Ability to recognize and appreciate the complex structures and their interconnectedness which are embedded in a system while maintaining a view of the highest -level objective to be achieved.*

Dimensions: Ability to Break Down a System into Discrete Pieces and Put it Back Together in a Coherent Solution, Ability to Make Appropriate Estimates when Problem Solving, Consideration of the Multi-level Goals of the Project

TEAMWORK: *Working to define and achieve a shared goal by leveraging individuals with different perspectives, roles, responsibilities, and aptitudes to overcome and use conflict to their advantage to create a more robust solution.*

Dimensions: Ability to Work Across Disciplinary Differences, Recognition of and Commitment to a Common Purpose/Goal, Valuing the Development of Shared Rules, Norms, Structure

Appendix B1: Engineering 110 Vision, Mission and Course Themes

Vision

Every Michigan Engineering undergraduate student feels empowered to intentionally pursue academic, professional, and personal experiences that leverage their strengths and ignite their passions. Students become engineers, scientists, and citizens who are committed to serving the common good and improving the human condition.

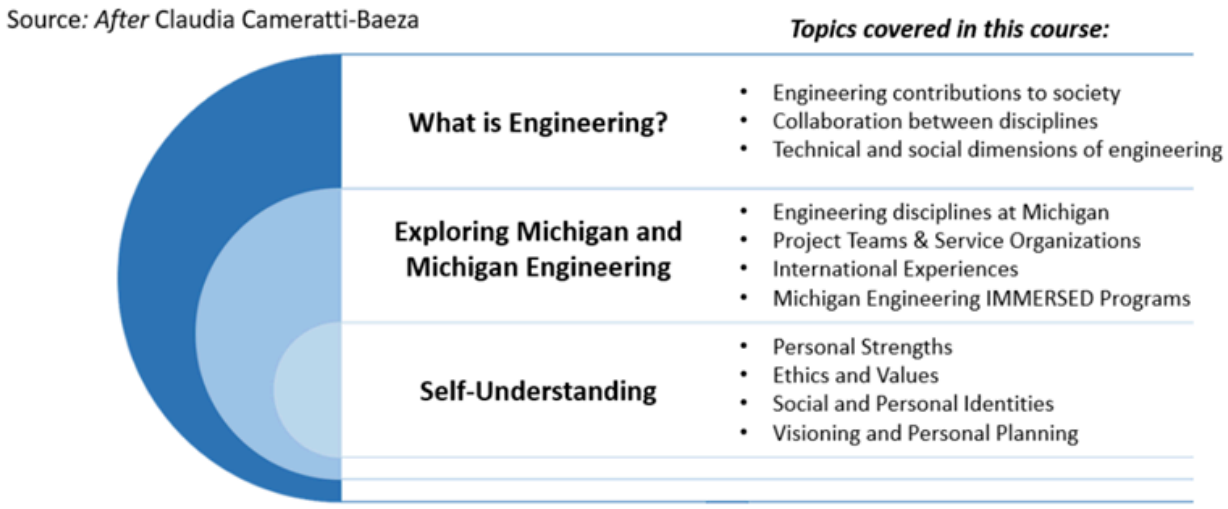
Mission

Through Engineering 110, we develop engineering students who have the knowledge, skills, and self-understanding to make academic, professional, and personal decisions for themselves.

We do this by creating:

- An inclusive community that synergizes with our students' strengths, styles, values, and identities;
- A supportive environment that fosters our students' confidence;
- Diverse opportunities that pique our students' curiosities and passions;
- Engaging experiences that energize our students' actions; and
- Meaningful reflections that promote our students' growth

Course Themes



Appendix B2: Engineering 110 Modules

FOUNDATION MODULES: These modules cover core course content, and give an overview of the course and Engineering at Michigan. All five of these modules are required. Each Foundation module includes one pre-survey assignment ("Access Prior Knowledge"), a selection of Canvas module content, and one reflection assignment.

- Welcome to Engineering 110
- Introduction to Engineering Design and Decision-Making
- What is Engineering?
- Michigan Engineering: The Disciplines
- Michigan Engineering: Immersed

EXPLORATION MODULES: These modules allow students to explore what Michigan Engineering has to offer and how it aligns with their goals and interests. There are three types of exploration opportunities: Departments, Michigan Engineering Immersed programs, and Academic and Professional topics. Students must complete five of these modules. At least two of them must be departments. There is one pre-survey to complete before starting any Exploration modules, and one reflection assignment to complete after finishing five.

Exploring Departments (students must complete at least two of these)

- Aerospace Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil & Environmental Engineering
- Climate & Space Sciences & Engineering
- Electrical Engineering & Computer Science
- Industrial & Operations Engineering
- Materials Science & Engineering
- Mechanical Engineering
- Naval Architecture & Marine Engineering
- Nuclear Engineering & Radiological Sciences
- Robotics

Exploring Michigan Engineering Immersed

- Arts & Engineering
- Engineering Abroad
- Leadership Development
- Human-centered Design
- Orgs and Teams
- Research & Teaching

- Work Experience

Exploring Academic and Professional Topics

- Student Resources
- Unconscious Bias
- Growth Mindset
- Introduction to Sustainability

ENGAGEMENT MODULES: These modules provide opportunities for students to get out and engage with faculty, organizations, events, and other real-world experiences. Students must complete five of these modules. The "Attend ENGR 110 Office Hours" Module is mandatory. In addition, students must complete at least one Perspectives on Engineering and one Mentorship module. Each Engagement module includes one pre-survey assignment ("Access Prior Knowledge"), some Canvas Module content ("Find & Prepare for Engagement Opportunity"), an experience portion, and one reflection assignment.

Perspectives on Engineering

- Attend CoE Speaker Event - PERSPECTIVES
- Attend Alumni Panel - PERSPECTIVES
- Attend DA Student Panel - PERSPECTIVES

Co-Curricular

- Informational Interview with Student Organization Leader
- Participate in a Student Organization Event
- Meet with an Advisor for an Immersed Program

Academic

- Attend ENGR 110 Office Hours - OFFICE HOURS
- Informational Interview with Faculty to Discuss their Research - MENTORSHIP
- Observe an Upper Level Course
- Attend Department Presentation or Speaker Event
- Attend Department Open House

Career

- Informational Interview with Faculty to Discuss Career Trajectory - MENTORSHIP
- Informational Interview with an Alumnus or other Engineering Professional on a Particular Career Path - MENTORSHIP
- Attend an Appointment with a Career Center Advisor

Additional: Instructor Approved Engagement Experience

Appendix C: ENGR 499 Full Course Description

ENGR 499.001 and 499.002 meet together for the first seven weeks of the semester. Then, ENGR 499.002 continues to the end of the semester. **Indicates information specific to ENGR 499.002.*

As graduation approaches, you have engaged in a wealth of experiences and collected a bounty of stories. As you move forward to new experiences, you may have many questions about your future: What career do I want? What lifestyle? What jobs should I apply for? Accept? Should I attend graduate school? Am I an effective engineer?

This course will help you leverage your past experiences to create and use tools that will help you answer questions about your personal and professional futures. You'll create a set of guiding principles and a professional statement and begin a vision for your future. You'll then apply your principles and vision to make challenging decisions and create professional documents that will be useful in your near future. Throughout this course, you'll use a set of competencies and collaborate with a group of peers and mentors from academia and industry alike.

*Then, you'll develop and apply a project to meet your personal and professional goals. Examples of projects include a website, a LinkedIn profile, a vision, or a portfolio. You'll further examine competencies, such as ethical reasoning, and apply them to examples that engineers often experience at work.

Appendix D1: Survey Questions

1. What are three skills that you think you will need in order to be successful as an engineer?
2. Did you receive classroom or practical experience developing/learning (in this competency) during your time in the College of Engineering?*
3. How do you define (this competency)?*
4. What specific classes or practical experiences helped you develop/learn (this competency)?**
5. What could Michigan Engineering have done to help facilitate you developing/learning (this competency)?***
6. Did you take ENGR 110?
7. Did you take ENGR 499?
8. If you have taken ENGR 499 (Design Your Engineering Future), what semester did you take it?

*Questions 2 & 3 were repeated for each competency.
**Question 4 was shown for each competency where question 2 was responded with "yes" or "somewhat"
***Question 5 was shown for each competency where question 2 was responded with "no"

Appendix D2: Focus Group Questions

1. Imagine yourself 5 to 10 years from now, working as a successful engineer, what skills do you think you will need to be successful?
    a. Why did you select these skills?
    b. Did you develop these skills during your time at the University of Michigan?
        i. If so, how did you develop a particular skill?
        ii. If you don't feel like you fully developed the skills through the University of Michigan, are you aware of experiences or classes that would have helped you develop one of the particular skills you named?
            1. If yes, what was a barrier that prevented you from participating in that experience or taking that class?
            2. If no, what types of experiences or classes do you wish you had been offered to develop those skills?

2. If you took Engineering 110:
    a. What do you recall about Engineering 110?
    b. Did your experience in Engineering 110 impact your time at the University of Michigan? If yes, how so?
    c. In what ways, did that course impact your perceptions of engineering?
    d. How would you be different today, if you had not taken ENGR 110?
    e. Did taking ENGR 110 impact your experience in ENGR 499, and if so, how so? (Only for the group that took both courses)
    f. Would you recommend Engineering 110 to future students? Why or why not?

3. Additional questions
    a. Would you recommend Engineering 499 to future students? Why or why not? (only for group that took ENGR 499)
    b. What attracted you to the University of Michigan?
    c. This is a two part question: Do you consider yourself a leader? Do you think you will be a leader in the future?
    d. What experiences or courses during your time at the University of Michigan helped you develop leadership skills?
    e. In what way are leadership skills the same or different from the skills we discussed previously?