Undergraduate Civil Engineering Students' Perspectives on Skills for Future Success

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***Abstract*— This full research paper explores undergraduate construction and civil engineering (CCE) students' perspectives on the skills they need to be successful in their future careers. Previous research has identified important outcomes and attributes for engineering students to inform curriculum development. However, discrepancies between skills emphasized in the curriculum and those valued in industry have been reported. This potential disconnection raises questions regarding what students are trained to prioritize through their formal education and professional socialization, which has implications for their workforce development. This study explores what skills students believe they need and how/where they learned the importance of these skills. This work aims to connect these perspectives with those expressed by industry. The theoretical framework underpinning this research is a set of competencies that recent graduates need when entering the workforce, as identified by experienced professionals in CCE.**

This study employed a qualitative approach to explore student perceptions through semi-structured interviews. In 2019, 13 undergraduate CCE students at four U.S.A. institutions completed an interview. The transcripts were analyzed with a combination of inductive and deductive coding.

At least one participant described 15 of the 19 competencies included in the guiding framework. The greatest number of students identified Communication, Humility, and Teamwork as important for success in their future field. Emergent competencies were Personal Persistence and Passion for Work. Students expressed that they primarily learned the importance of these skills and practiced them in internships and out-of-class activities. Although a few participants mentioned the classroom, the results indicate an opportunity for engineering educators to better emphasize these competencies in their courses and provide opportunities to foster their development. This research contributes an understanding of where expectations of students already align with industry perspectives, what gaps still need to be closed, and how engineering educators can help prepare students for the realties of the workforce.

Keywords—civil engineering; professional competencies; workforce preparation

I. INTRODUCTION

Civil engineering is a dynamic profession shaped by evolving challenges and emergent opportunities. Engineers need a broad skillset to address factors such as climate change, population growth, infrastructure failure, and technological advancement that are driving the industry [1]. To continue serving society, civil engineers must fulfill their roles as master builders, risk managers, innovators, environmental stewards, and civic leaders [2]. Achieving these aims requires a "broad union of civil engineering technical and non-technical knowledge" [2, p. 17]. To span the technical and non-technical domains, civil engineers need a range of competencies, defined as the knowledge, skills, and attitudes/values of the profession [3], [4]. In this research, competencies and outcomes are used interchangeably since outcomes are also defined as knowledge, skills, and attitudes [5]. Technical competencies have historically served as the foundation of engineering curricula. However, the importance of non-technical, or professional, competencies continues to be realized and integrated into civil engineering education.

Although engineering professional societies (e.g., [5]) and accrediting agencies (e.g., [6]) explicate the role of professional competencies in engineering education, there is less awareness of how industry stakeholders and undergraduate students conceptualize the importance of these skills. This study was designed to bridge that gap. The research employed a qualitative approach to understand the competencies that CCE undergraduate students consider important to their future careers and how those perceptions aligned with expectations of industry. Understanding and aligning the expectations of students and employers will support students' preparation for the workforce and their ability to meet the responsibilities of the civil engineering profession.

II. BACKGROUND

ABET EC2000 formalized the outcomes (i.e., competencies) that graduates of accredited engineering

programs are expected to attain. The criteria also introduced professional skills that reflect the importance of educating engineers for a globally competitive and technology dependent workforce [7]. Over the past two decades, there has been growing emphasis on the inclusion of these competencies and their application to engineering practice. Across engineering disciplines, recent graduates rated teamwork, data analysis, problem solving, and communication as the most important competencies to their professional experience [4]. These perspectives of recent graduates reflected the competencies that are emphasized in the literature; a meta-synthesis indicated that problem solving, communication, and teamwork are most important in engineering [8]. These generic competencies are key for all engineering disciplines [9]. However, each engineering discipline addresses different problems and fills different roles. As a result, it is worth focusing on civil engineering and considering the competencies needed to succeed in that field.

A. Competencies in Civil Engineering

The Civil Engineering Body of Knowledge Third Edition (BOK3) defines 21 outcomes that the future civil engineer needs for entry into the profession [5]. These outcomes span foundational (e.g., math and science), technical (e.g., design and project management), engineering fundamental (e.g., experimental methods and problem solving), and professional (e.g., ethical responsibilities and leadership) categories. Industry stakeholders have echoed the need for a broad set of skills. Recruiters for construction companies located in the eastern U.S.A. rated ethical issues, problem solving, interpersonal skills, and leadership as the most important for new hires [10]. Text mining of construction job postings reflected the need for interpersonal, computer, and communication skills [11].

However, there appears to be some disconnection between what is valued by professionals versus students. Employers and undergraduates agreed on the importance of construction knowledge but disagreed on the weight of interpersonal skills; employers considered trust and honesty most important and ranked communication highly while students deemed management more essential [12]. In engineering there has been a competency gap between education and industry [13]. As part of this gap, the university focused education and assessment on technical skills while employers hired for a broader range of traits and attitudes and expected a certain degree of performance for job-specific skills. Recent efforts have sought to bring the classroom and industry experience into closer alignment by emphasizing professional competencies through, for example, engineering service [14], capstone design [15], and role-play with working engineers [16]. It is thus worth investigating if the gap is beginning to close and if efforts to integrate broader competencies in education are leading to students' increased understanding of the skills that are expected of them in industry.

B. Bridging the Gap: Guiding Framework and Research Questions

This study aimed to understand student perceptions of competencies that are important for their future career and compare them against industry expectations. The framework underpinning this research is a set of competencies that were identified by CCE industry experts as necessary for individuals entering the professional workforce [3]. The framework of 19 competencies was developed with the Delphi method, which uses strategically designed surveys to gain consensus from subject matter experts. Criteria to serve as a panelist included (1) being employed in construction, (2) having at least 10 years of industry experience, (3) holding a management positions, and (4) serving as an advisor for a college of engineering. A total of 21 experts (all were White and 95% were male) participated in the three-round Delphi process. While the lack of diversity among the experts is a limitation, it is representative of industry management. Table 1 lists the 19 competencies and notes if each competency is included in the BOK3 [5] and the outcome category (foundational, technical, engineering fundamentals, and professional) to which it belongs. The authors coded the BOK3 for whole matches (e.g., communication is verbatim included as a standalone outcome) and partial matches (e.g., time management is part of the leadership outcome under Professionalism and quality solutions are part of the design outcome under Technical).

Table 1: COMPETENCIES IDENTIFIED BY CCE INDUSTRY EXPERTS

Competency	**Definition**	**CE BOK3**
Communications Skills	The ability to listen to others and convey ideas effectively.	Professional[1]
Ethics/ Responsibility	Performs duties in good faith maintaining the best interests of all parties involved. Understands the impact that his/her actions have on others.	Professional[1]
Professionalism	Maintains an appearance and demeanor that are professional and contributes positively to the work environment.	Professional[1]
Critical Thinking/ Problem Solving	Responds to daily tasks, especially adversity or unexpected events, with clear analysis, good decision-making, and successful improvement.	Engineering fundamentals[1]
"Big Picture" Thinking	Understands how the whole system works. Recognizes the impact that all elements of the system can have on whole and keeps the end goal in mind.	Engineering fundamentals[2]
Ambition/ Drive	Motivated to get better, succeed, rise in the organization, and do more.	
Self-awareness	Understands his/her role and capabilities, manages emotions well, and is aware of his/her impact on others and the company.	
Humility	Receives feedback well, recognizes own personal limitations.	
Teamwork/ Collaboration/ Networking	The ability to work well with others, even those who one may find difficult. Recognition that shared ideation generally creates solutions	Professional[1]

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	that are more effective. Invests time in appropriate connection with colleagues/clients.	
People Focus	The ability to maximize human relationships and get the most out of every member of the team.	Professional[2]
Time Management	Prioritizes tasks, manages multiple projects, meets deadlines, etc.	Professional[2]
Management	Manages processes and resources well; in general and within project teams.	Technical[1]
Adaptability	Applies his or her skills and resources to new contexts well.	Professional[2]
Quality Control	Detailed eye for and capability to manage systems that maintain high quality products and solutions.	Technical[2]
Computer Skills	Is capable with relevant software and hardware.	Foundational[2]
Safety and Risk Management	Maintains protocols and procedures to maintain a safe work environment.	Technical[1]
Assertiveness	The ability to assert one' own opinion in a firm, but professional, non-aggressive way.	
Legal Knowledge	Understand legal concepts as related to the industry (mostly contracts).	Professional[2]
Economic Principals/ Trends	General understanding of economic and political ties to company mission and performance.	Technical[1]

[1] Whole match; [2] Partial match

This study addressed the following research questions:

1. What are the competencies that CCE students think they need to be successful in their future career? How do these competencies compare to those identified by industry leaders as important for graduates entering the profession?
2. Through what experiences did students form these perspectives and where did they learn the importance of these competencies?

III. METHODS

A. Data Collection

This study was embedded in a larger project that explores leadership development and professional preparation in engineering from industry, student, and faculty perspectives. The mixed-methods project uses quantitative surveys and qualitative interviews to investigate how leadership is defined to help bridge the gap between academic perceptions and industry expectations to ensure engineering graduates are sufficiently prepared to enter the workforce. In a previous phase of the study (described above), 19 competencies of CCE professionals were identified from the industry perspective. After establishing the competencies that industry experts deemed essential, the study shifted to the student viewpoint, which is the focus of this paper.

1) Participants

In 2017, undergraduate students in science, technology, engineering, and math (STEM) majors at eight U.S.A. institutions were invited to take an online survey via Qualtrics. The survey included questions on their involvement in leadership related programs, their perception of leadership in industry, and their understanding of competencies important in their field. At the end of the survey, respondents could indicate if they were willing to be contacted for a follow-up interview. Of those who were willing, the first selection criterion was major. Only those who were majoring in CCE were retained for the interview due to the disciplinary focus of the research. Of the 2,268 total survey respondents, 71 CCE students provided their contact information for a follow-up interview. Another criterion was that students must have indicated on the survey that they are knowledgeable about the field they plan to enter after graduation. Since the research is based on perceptions of competencies important for their field, students needed a baseline understanding of that field for validity purposes. Lastly, first-year students were not included because it was desired that students would have more academic experience on which to reflect.

In 2019, 13 CCE undergraduate students completed an interview. Participant information is displayed in Table 2.

Table 2: INTERVIEW PARTICIPANTS

Pseudonym	Year	Gender	Future Desired Career
Albert	4th	M	Industry: structural
Alex	3rd	F	Master's, Industry: structural
Beca	5th	F	Industry: general CE
Charles	3rd	M	Industry: CE consulting
John	4th	M	Industry: eng, non-CE
Kaitlyn	3rd	F	Industry: general CE
Kim	4th	F	Industry: construction
Lily	5th	F	Industry: general CE
Max	2nd	M	Industry: general CE
Mike	6th	M	Industry: general CE
Phil	5th	M	Industry: non-eng
Shelby	4th	F	Master's, Industry: structural
Tobias	5th	M	Industry: construction

2) Interviews

The semi-structured interviews were completed in-person or via videoconference and lasted approximately an hour. An undergraduate researcher majoring in civil engineering conducted the interviews.

In previous research (e.g., [10], [12]), participants were given lists of competencies and asked to rate their importance. As a result, they were prompted to consider certain skills that the researchers preemptively valued. This research aimed to elicit students' authentic perception of competencies important to their future career in civil engineering by using open-ended prompts in the interview. The interviewer began the interview by asking students about their pathways into the major. The next set of questions asked students "What do you see yourself doing after graduation?" and "Keeping this future goal in mind, what do you need to be successful in your field?" Students were then asked when and where they learned what is needed to be successful in their future career.

3) Data Analysis

The interviews were transcribed verbatim and imported into Dedoose [17] for analysis. For the first research question,

the interview transcripts were analyzed with a combination of deductive and inductive coding [18]. Each of the competencies in the guiding framework served as an *a priori* code. Competencies that students mentioned that were not included in the framework were noted as emergent codes. For the second research question, the transcripts were analyzed inductively. Due to the range of potential settings and experiences that could inform students' understanding of professional competencies, there were no preset codes; therefore, where and when participants learned about these competencies were labeled with emergent codes.

IV. FINDINGS

A. *RQ1: Students' perspectives on competencies needed for career success and comparison with industry perspective*

The participants were asked to describe their desired future career to contextualize the skills they need for that field. The students noted industry: general civil engineering (n=5), construction (n=2), structural engineering (n=3, 2 who want to pursue a Master's), civil engineering consulting (n=1), engineering but not civil (n=1), and non-engineering (n=1). As indicated, all of the students plan to pursue jobs in industry after graduation and only one student wanted to work outside of engineering.

The competencies identified by the industry experts are shown in Table 3 with the number of students (out of 13) and number of female students (out of six) who mentioned each competency as important to their future career. An example quote from the interviews mapped to each competency is also displayed. The *a priori* competencies are arranged in descending order of prevalence. Emergent competencies are displayed in italics in the last two rows of the table.

Competency	**N students (female)**	**Example quote**
Communications Skills	9 (6)	"You do need very strong communication skills… because we did work alongside different departments, and being able to just talk to them as a human being, rather than just an objective, I guess, seemed to help a lot." -Phil
Humility	6 (2)	"Accepting when I'm wrong even though that hurts, you know putting your pride aside that's always a hard one. Taking criticism is a big part of that too." –Max
Teamwork/ Collaboration/ Networking	6 (2)	"I think you need to be able to work in a team environment." –Lily
Adaptability	5 (4)	"I guess now that I've gotten a little more experience in the industry, I'd say definitely yes, the willingness to learn, but also adaptability is something that you really need to focus on… In the construction industry and the whole design industry, yes, you do have to follow somewhat of a set schedule, but as with everything, it's going to shift around, so you kind of have to prepare for doing this on this day instead of this day. Just being adaptable to the surroundings that you're given." –Kim
People Focus	5 (3)	"Learn everyone's strengths and weaknesses, how to exploit those strengths, how to improve on those weaknesses. That mentality is something I was able to pick up and use… I know what somebody is really, really good at or maybe they're kind weak on and use that to our advantage in a way." –Alex
Management	5 (3)	"Definitely strong people or management skills where I can talk with others and tell them exactly what I need and how I want it done and how I want the end result to be." -Kaitlyn
Professionalism	4 (3)	"You want to establish the relations but at the end of the day they need to finish their work on time. So knowing how to balance that kind of professionalism I think is a skill." -Kaitlyn
Ambition/ Drive	4 (2)	"I guess really putting myself out there. Instead of not doing something, asking to go on a site visit or something, or asking to do more or asking for more projects…" -Shelby
Critical Thinking/ Problem Solving	4 (1)	"In order to be successful, I feel like you need to know how to put out fires and amend problems. As a project manager, nothing is going to be perfect. Some small stuff is going to come up or there's going to be some complaint or someone is going to be suing you and you have to be able to put out fires and actually stay level headed the entire time but you've got to be a leader." -Tobias
Self-awareness	3 (2)	"The need to branch out, to accept that you really are going to need a lot of other people. Because there's so many other ideas come into play that I think that's an encompassment of leadership in a sense of like knowing that you're not always going to be right. You're not always going to have the full part to everything. I think one of the biggest roles to that is understanding that you need to rely on others." –Max
Time Management	3 (2)	"Even like concrete materials, you have plan 28 things, all that type of thing, so I think organization and scheduling is probably one of the most important." –Beca
Assertiveness	2 (2)	"Professionalism… It's not really asking, it's telling them in a relaxed manner way, 'Oh the deadlines coming up, what are you doing?' Checking in on those dates that are required for them by their contract to fulfill but not in an aggressive way because sometimes they can get pretty heated but in that I'm still your boss, we're discussing what needs to be done because we're working." –Kaitlyn
Quality Control	2 (2)	"I think it goes back to submitting things that you're proud of… When it comes to something that your name is on, and being judged on it, or just something that's representing something larger than you… So, I think in the future, it really is, if I turn this in, have I tried my hardest on that or not? And if the answer's or not, then keep working, you have to keep working, there's no, it's not really a solution. Or not really an excuse for it to be the way it is. But, yeah, that's definitely my biggest thing, did you try your best at it?" -Beca
Computer Skills	1	"So, in our engineering program… they tell you how to use AutoCAD, Revit, MathCAD, different softwares. I'm not

		going to be using them in the future but, being able to pick up how to learn software, like what should I look up online, or to see a tutorial, or should I ask a specific question how to use this function?" -Phil
"Big Picture" Thinking	1	"I don't think you really can just figure something out and do it by yourself, because there's so many things that you have to coordinate, it's not just you… [in] structural, you have to consider so many disciplines and I would say yeah with that, being multidisciplinary, not just thinking of building, construction, concrete you know? You have to think like, electrical, plumbing, mechanical, HVAC, so just being open-minded." -Albert
Personal persistence	2 (1)	"I think that what stands out to me is being personable, being resilient in your effort because there's definitely those times with construction where it's like hurry up to go slow type of things and you just have to stick it through, and definitely the aspect of no matter what, being true to who you are and that'll get you through it." –John
Passion for Work	2	"… the biggest thing I've taken away from being wherever I am, just like whatever you do, make sure you care for it. And so like some people are passionate about 3D printing, some people are passionate about trying to raise a number of minorities in STEM fields. Some people are passionate about making the world a more cleaner place". –Charles

Of the 19 competencies in the guiding framework, at least one student identified 15 of them as important to their future career. Communication, humility, and teamwork/ collaboration/ networking were the most prevalent competencies described by participants. None of the students mentioned safety/risk management, ethics/responsibility, legal knowledge, and economic principles/trends.

Two students identified competencies that were coded as personal persistence. This competency was similar to critical thinking/ problem solving, responding to adverse or unexpected events with clear decision-making, but was more related to personal, as opposed to professional, responses. Personal persistence captured students' value on staying authentically grounded in who you are despite any external challenges.

The second emergent code was passion for work. Two students described that to be successful in their future career, they needed to care deeply about what they are doing. This intrinsic passion and care for their work was not captured by the industry experts in the guiding framework.

B. RQ2: Experiences that taught students the importance of these competencies

The interviews also probed how students came to understand the competencies they need to be successful in their desired career. By soliciting reflection on where and when students learned about the importance of these competencies, the research sought to examine the experiences that are influential in students' perceptions of professional preparation. The most commonly cited factor was internship, followed by family, networking, out-of-class activities, trial and error, and academic. These experiences are presented in greater detail in the following sections.

1) Internship

Internship was cited by 10 of the 13 participants when asked when and where they learned the importance of the competencies they previously described as important. Internships were influential because they provided exposure to industry and enabled students to observe and model the skills and behaviors that practicing engineers embodied on the job. For example, after noting the importance of professionalism and communication in civil engineering, Kaitlyn described the role of her internship in forming her perspective.

"And then with the internship that I worked this last summer, I saw a lot of that on the construction site, the communication, I saw that with how the general contractor would talk to the other sub-contractors… You want to establish the relations but at the end of the day they need to finish their work on time. So knowing how to balance that kind of professionalism I think is a skill. Definitely takes a while to pick up."

Albert described a similar experience in the role that his internship played in emphasizing the importance of communication in engineering practice. When prompted to reflect on where he learned about this competency, he cited his construction experience.

"The internships, seeing subcontractor meetings where people are piled in a 20 by 20 room and they're just getting yelled at because they're behind… On top of that, communication, like hearing people trying to speak about issues… Seeing those communications skills and seeing times where people didn't have them, and seeing how it delayed the process in trying to figure out a problem really made me understand that communications definitely number one for me."

Internships enabled students to learn from both positive and poor examples of professional practice. In the situation that Albert described, he understood how a lack of communication across the many stakeholder involved in a construction project could stall its success. Alex similarly learned about what it takes to be successful in civil engineering by observing that a lack of particular competencies could adversely affect the work. She cited time management and management as important competencies and expressed how her internship experience cultivated this perspective.

"I think because I saw it on my internship a lot, I think that's kinda what made me open my eyes... I was part of project meetings, I was part of all this hustle and bustle thing going on within the project and I just noticed a lot of room for improvement that they were doing. In terms of time management and being organized, I'm just like, 'You can totally do this and this will increase the efficiency by so much,' but like something that the project engineer and project manager didn't think were important."

Internships were also valuable because for many students, they provided the first exposure to engineering practice and thus the most practical preparation for a career. Kim described

the humbling experience of her first internship and how it taught her the importance of accepting her own limitations (humility and self-awareness) and demonstrating a willingness to learn.

"In my internship, I was responsible for all of our daily sight walks and stuff like that throughout this massive construction site, and nothing really prepares you for that. I would say, kind of going back to one of my last answers, just like a willingness to learn, I guess, is something that I wish I could've told my younger self, so that's definitely something that upcoming graduates or even people going into internships should really take into account… You're not going to know everything ahead of time."

Mentorship was another commonly cited facet of internship that informed students' understanding of key professional competencies. The two students who described the emergent code of passion for work cited their industry mentors as formative in teaching the importance of this competency to being successful. Charles had participated in several engineering and non-engineering internships throughout college and the thread that tied together all of these experiences was the importance of passion.

"And each of those different internships, they're not all related. One was a mechanical engineering one, one was like a product design, one was urban planning, and now I'm like sustainability consulting. And each of those, my managers and the people that I've met at my jobs… they all kind of care about what they do, and I think that's the biggest thing I've taken away from being wherever I am, just like whatever you do, make sure you care for it… I've learned that they really do love what they do, and so that's one of the biggest takeaways I've gotten."

Max similarly cited his internship mentor as the most significant contributor to his understanding of his future career. He learned from his mentor that to successfully navigate the challenges of the profession, you have to care about your work.

"I think the most impactful person towards my career would probably have to be [name redacted] because she's really showed me like it's not all rainbows and sunshine... She was really the one that showed me like this is what you're getting into, you have to really love this to do it."

2) Family

Six students cited their family and upbringing as the sources for understanding what it takes to be successful in the future. For some participants, their parents were able to offer insight into the workforce and advice on how to be successful. Tobias emphasized the need for management and critical thinking/problem solving skills in industry, which stemmed from his father's experience. He noted,

"My dad, he got a chemical engineering degree and he's a manager... he's taught a lot about managing… He kind of taught me how to deal with certain situations, how to deal with like, I guess how to live a very high stress life whilst staying level headed. So he gave me some advice throughout the years and I applied it throughout my work experiences."

Kaitlyn also benefitted from having a parent in industry who passed lessons to her. When asked about how she came to learn the role of the competencies she described in her future career, she responded, "My dad knows a lot more about the industry so I feel like he's been able to give me a lot of inside helpful hints."

This code also extended broadly to the ways in which students were raised. John described drive/ambition as key in his future career, which was a competency he acquired and appreciated while working on his family farm.

"I think that it's a balance between home life, just the way I was brought up being from a farm and you gotta work hard always, even when people aren't looking, that type of thing."

3) Networking

Six students cited networking as a professional development opportunity that taught them which competencies they need to be successful in their future career. When asked how she figured out what her future career might look like and require, Kaitlyn responded,

"I guess knowing that comes from talking with professionals and asking what their day-to-day kind of life is. Or what is a day of work like. So I think it mostly comes from that."

As another example of networking, Mike described an on-campus career fair as the most influential factor in conveying what it takes to be successful in engineering practice. After speaking to employers, he said, "I feel like that really prepared me for what I need to know specifically entering the civilian workforce. It was a big eye-opener, how to talk to people, what they expect." Networking could also be less formal and more self directed; for example, Tobias reached out to construction professionals through online discussion boards to solicit comments on the skills he needs to develop to be successful and pose questions.

4) Out-of-class Activities

Five students cited their involvement in out-of-class activities when asked how they learned about the competencies needed for their future career. Some participants described that leadership positions in co-curricular and extracurricular activities helped them understand what skills they need to be successful and provided the opportunities to cultivate them. As an example, Lily commented on the importance of communication and assertiveness and described positions in her sorority as demonstrating the importance of these competencies:

"I think, three roles in my sorority. Like director roles and then I've held a couple different roles for [philanthropy], which is like an organization, philanthropic organization at the [university]. And then all of those roles I had to communicate timing of things, planning large events, just doing various things where I interacted with a lot of different people so I had to like figure out ways to relate information back to them without being too pushy or not pushy enough. And your just like how do you work with people without upsetting them and how do you get things done without disregarding other peoples feelings."

Being in the sorority and taking on a leadership role provided an applied context for Lily to understand which approaches worked with her peers and how to develop strategies for communicating and getting results.

Out-of-class activities also provided exposure to opportunities and perspectives that might not be represented in the classroom. Alex was involved in an engineering organization that offers outreach to prospective and accepted students and acts as a liaison between the college and student body. She described this activity as where she learned the importance of various competencies through interactions and presentations.

"I really learned a lot from other people I would say. In my organization, people give leadership presentations all the time and they talk about their experiences, how they handle certain situations and I've been able to pick up from people like that… it's my favorite part about the meeting just because everyone is a leader in their own way."

Learning from others could also take the form of peer mentoring. For example, Albert noted the older fraternity member to whom he was assigned when he joined a fraternity as the biggest influence on helping him prepare for his future career.

"My big [brother] in my fraternity… He's also a civil engineering student, and I remember he got me as a freshman, and he was graduating, and he was thinking about Master's and stuff, so that enlightened me a lot in what to expect for the future, seeing him and what he was going through. And then any situation that arose, and whatever I was going through, I would call him."

5) Trial and Error

When asked how and where they learned about competencies needed for success in their field, five students responded through trial and error. This code indicated that students described an iterative process of understanding the skills and strategies that do or do not lead to success. When asked about future skills and the settings in which she learned them, Alex responded,

"For sure time management. That is something I learned a lot in college. I'm really overly involved and I still manage to get everything done cause of time management… I would say I learned... I would say a lot of trial and error. I've always been a busy-body, so in high school I was really overly involved, had a part-time job and then it was really stressful. I would be so stressed and my health would just be totally affected. So when I came into college, I kept doing trial and error of things that I can do. I slowly started getting better and better."

Beca also explained the importance of making mistakes and learning from them. She said management, self-awareness, and assertiveness are key competencies in civil engineering and learned the value of those skills in ASCE's Concrete Canoe design competition.

"There were a lot of hard conversations that were like tears... I mean sometimes people cry, but if people start getting worked up, I think that's your first signal, but you don't really know. Like sophomore year, I didn't know, I was like, 'I don't understand why you're getting worked up, I don't be mean to be harsh,' But certain people just get worked up easy, which is fine, like sometimes I do. But yeah, definitely it was trial and error."

6) Academic

Four students described academic settings and mentors as helping construct their perspectives on competencies required in their field. As an example, the classroom illustrated the importance of problem solving to Kaitlyn.

Interviewer: "When did you learn that that is something that you would need for the future?"

Kaitlyn: "In a lot of my classes, they've always talked about problem solving skills, like looking at the problem it's not very obvious but it's necessary and I can see that happening because this problem's arisen, nobody's fixed it, nobody knows how to do it. It's looking at what can you do to solve this on your own without help."

The degree to which problem solving was emphasized in her engineering courses demonstrated its value to engineering practice. In addition to setting the course content, engineering faculty helped shape students' perspectives by serving as mentors. This was particularly salient for professors with industry experience, which Kim described as a benefit to her professional preparation.

"Honestly, it makes up for the experience that I currently lack. It's nice to have somebody there that's been there, done that, seen it, experienced it… Like a different insight on how my classes relate to the industry and stuff… It was nice to hear like, 'Oh, these classes are worth it,' like, 'I've benefited from these classes.' That was kind of like a 'light at the end of the tunnel' moment for me."

The civil engineering professor, who returned to teaching after working in industry, helped Kim connect the engineering curriculum to its practical application and shared her experiences to help Kim understand what was coming in her future career.

V. DISCUSSION

Economic competitiveness and technological innovation require a STEM- capable workforce [19]. Within the STEM workforce, there are a number of sub-workforces with unique challenges and needs that necessitate examining workers' preparation on a finer scale [20]. An important step in preparing civil engineers is to understand and align the expectations of students and employers.

Findings from this study indicated that undergraduate CCE students consider a range of professional competencies important to success in their future field. Students, like the industry experts whose perspectives informed the guiding framework, indicated that communication and teamwork are critical. These competencies are included in the accreditation [6] and BOK3 [5] outcomes.

Students also echoed the importance of humility, an intrapersonal skill that has gained attention in different engineering contexts such as service learning [21] and engineering design [22]. By being aware of their own

limitations and being open to feedback, individuals are able to engage in lifelong learning, which is paramount in a dynamic profession. Another intrapersonal competency that participants described as important was adaptability. Non-linear pathways in which engineering degree holders take different journeys between their fields of study and work increasingly define the engineering workforce [20]. As a result, CCE professionals need to be able to apply their skills in different contexts.

People focus and management, which were described by five interview participants, are interpersonal competencies that enable leadership [3]. Learning how to optimize individuals' skills and manage processes on teams allow engineers to function as leaders. There are growing calls to improve leadership integration in engineering education to meet the demands of the civil engineering profession (e.g., [23], [24]).

There were four competencies that none of the participants discussed when prompted to broadly consider the skills they will need to be successful in their desired career. Safety and ethical responsibilities are included as student outcomes in accredited engineering programs [6], indicating that students have exposure to these competencies and the opportunity to develop them during undergraduate education. The participants not mentioning these competencies could suggest that they have not internalized their importance or that, relative to other skills, they did not come to mind when considering what is most critical to their career. This finding aligns with the lack of students' engagement with, and value of, ethical issues [25], [26] despite the high importance that employers place on ethical issues [10]. Furthermore, a survey of practicing engineers and engineering students indicated a "substantial mismatch between engineering student expectation and practicing engineering experience regarding ethics", which was compounded by a lack of exposure and training in the undergraduate curriculum [27, p. 538]. The finding in this paper suggests that this mismatch persists.

The other two competencies that were not identified in the interview data were legal knowledge and economic principals/trends. ABET [6] specifies that undergraduate students must attain an ability to consider economic factors in engineering design and account for economic contexts in their professional judgments. Engineering economics is also included in the BOK3 and reflects the importance of business/financial acumen in project management and engineering practice [5]. Within the BOK3, legal issues are embedded in professional responsibilities and emphasized for the need to comply with laws, codes, and regulations [5]. Despite these imperatives, there appears to be a lack of appreciation for the value of these topics by students. The finding matches with the low importance that engineering students assigned to business practices in a survey of generic skills [28].

In addition to exploring what students deemed important, this study examined how and where they developed those viewpoints. Engineering students' professional formation is shaped by a host of factors within and outside formal instruction. Their competence is informed by varied, sometimes unintentional and non-traditional factors in engineering education that form the Contextual Model of Competence Formation [29]. This model posits that learning activities, learning environment, student disposition, extracurricular elements, and meta-influences inform competence development. Through this lens, our findings indicated that extracurricular elements (i.e., internships and out-of-class activities), student disposition (i.e., family background) were impactful; learning activities (i.e., course instruction) and learning environment (i.e., curriculum) were to a lesser degree. Internships offer a number of benefits to students with an opportunity to work on real problems with practicing engineers in professional settings [30]. Internships can also help fill the "knowledge-application gap" by having students learn how academic theory applies to engineering practice [31]. Out-of-class activities are associated with positive outcomes for civil engineering students such as personal development, communication skills, leadership skills, and professional development [32]. However, not all engineering students have the opportunity to participate in internships and out-of-class activities. As a result, the onus is on engineering programs and educators to ensure students understand the competencies they will need after graduation and have the chance to develop them.

VI. CONCLUSION

The success of individual civil engineers and the profession at large depends on broad skillsets that enable individuals to adapt and thrive in an ever-changing industry. One critical component of workforce preparation is aligning academic and industry expectations. This study used a qualitative approach to explore undergraduate student perspectives on important skills and mapped them to a competency framework informed by CCE industry experts. The findings indicated some degree of alignment for 15 of the 19 competencies with the greatest number of students describing communication, teamwork, and humility as important. There was a disconnection in the apparent value students placed on safety, ethics, economic factors, and legal knowledge.

Across these competencies, students most often cited internships, family, professional development, out-of-class activities, and trial and error as shaping their perspectives. Although a few students mentioned course content and academic mentors, there is an opportunity in the classroom to better emphasize the skills that students need in practice.

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