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Identifying the potential gap between graduates' preparation and the Professional Civil Engineering Consultant's needs

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Work-in-Progress: Identifying the potential gap between graduates' preparation and the Professional Civil Engineering Consultant's needs

Abstract

There is a gap between the preparation of Civil Engineering (CE) students at graduation and the needs and expectations of the professional Civil Engineering Consultant industry. With the American Society of Civil Engineers rating our nation's infrastructure a C-, and the federal government enacting an infrastructure plan to address the needed improvements, the success of infrastructure initiatives depends on a skilled workforce to design, build, construct, and maintain critical infrastructure. This gap between engineering consultant requirements and student preparation impacts companies' productivity and exposes issues within engineering education programs.

The paper will identify the needs and expectations of Professional Engineering Consultant firms with regard to new civil engineering graduates, particularly on the graduates' readiness to enter the workforce and create value for their employers. Data was collected from seven interviews of Civil Engineering transportation infrastructure leaders and evaluated to uncover three overarching themes that provided an answer to the research question of identifying the current skill gaps.

Introduction

The purpose of this paper is to identify the needs and expectations of Professional Engineering Consultant firms with regard to new civil engineering graduates, particularly on the graduates' readiness to enter the workforce and create value for their employers. We want to better understand industry expectations to better equip them with the skills needed to meet industry demands and enter the workforce with a solid foundation for future growth. The importance of the paper lies in identifying the current gap, as defined by today's CE leaders. This is a topic that has been studied many times; however, the industry is continuing to evolve, and this important topic needs to be kept current.

The American Society of Civil Engineers has scored our nation's infrastructure a C- [2] and it is more important than ever to advance engineering education research in Civil Engineering. In November 2021, the President of the United States signed the unprecedented Infrastructure Investment and Jobs Act (IIJA) to allocate funding to address the backlog of US infrastructure projects [6]. Yet, its success depends on having a skilled workforce to design, build, and maintain critical infrastructure. The Bureau of Labor Statistics denoted Civil Engineering will grow at 6% between 2023 and 2033. This is faster than the 4% average of all occupations [11]. In February 2024, 51% percent of engineering firms continued to turn down work due to workforce shortages [1]. This suggests that Industry needs a skilled and ready workforce. As one interviewer clearly responded that their firm is "looking for recent graduates to hit the ground running."

The gap between industry requirements and student preparation impacts companies' productivity. Despite significant work to prepare students to enter the workforce, there are still deficiencies with new graduate engineers having knowledge and skills required to be effective in the workforce [5]. In 2016, an article was published that shared the forecasted shortfall in civil engineering workforce would be caused by the strong growth in the private sector and increased volume of public infrastructure projects over five years from 2016. This dearth will eventually drive a salary rise for workers, which may have a detrimental impact on the future delivery of infrastructure projects [10]. Based on our interview responses, this sentiment still holds true in 2024. As one respondent said, "currently the [civil engineering] industry is struggling to find talented Engineers".

According to the American Council of Engineering Companies (ACEC), 73% of engineering firms say the biggest concern is continued upward pressure on wages for new hires [1]. With this upward pressure, firms expect new graduates to immediately contribute to remain competitive.

We interviewed CE leaders in the transportation infrastructure field about the current state of readiness of new graduate hires. They explained their expectations to be effective in the profession and build a career that propels solutions to infrastructure challenges. The needs of today may not be the same needs of the past as the civil engineering consultant industry may be changing more rapidly than academia. It is conceivable that the core elements have not changed but there may have been a change in relative importance. This adds to the notion that civil engineering educators face continuing challenges to prepare the workforce under the rapid changes [8].

Background

To frame this study, we are using the framework of Skill Gap Theory [7]: This theory focuses on the discrepancy between the skills graduates possess and the skills employers require. It's rooted in workforce development and educational alignment. We are investigating gaps in the knowledge, skills, and attributes demanded by the civil engineering consultant industry.

By keeping our understanding of the current skill set required in civil engineering as defined by transportation infrastructure industry leaders and comparing to what others have said, our results will provide a framework that we can utilize to plan a future that will bridge the gap and provide for more effective new graduates as they enter the workforce. We expect that our results help academia prepare students to better meet expectations of future employers.

Methods

Data Collection:

This exploratory study identifies key skills, from the industry perspective, for civil engineering graduates to develop a solid foundation to build upon based on interviews with seven consulting engineering firm professionals at the levels of Owner/President, Executive, and Division Managers from firms with a background in transportation infrastructure. The

interviewee firms ranged from international, publicly traded firms to regional firms doing significant transportation infrastructure projects that are primarily located in the Mid-Atlantic United States. These leaders, with over twenty years of experience, have experience in hiring, onboarding, and training recent graduates. The interviewees were selected and recruited through the industry organization of American Council of Engineering Companies NJ. This organization acted as the gatekeeper to expand the breadth of potential interviewees to broaden the sample of potential interviewees. The interviewees have experience within the engineering profession and shared their perspective on the current industry needs.

Data was collected in the Fall of 2024. We conducted two semi-structured, forty-five-minute virtual interviews to pilot our questions and then collected data from seven structured written interview responses, submitted via email, to written interview questions. The written response format was utilized due to the availability of the interviewees. All interviewees provided thoughtful and detailed responses with word counts ranging from 1,013 to 1,665 with an average word count of 1,294.

We focused on eleven key questions that all interviewees provided responses and optional questions for interviewees to provide more nuanced answers in an effort to elicit what skills are important to industry as they hire new graduates. The following are some sample questions:

What is important to industry professionals as you hire new graduates?
What types of professional skills are most beneficial?
What types of technical skills are most beneficial?
What knowledge and skills would you like to see from new graduates that you believe are missing?
What do new graduates need to know to be an effective team member?
What should students be able to do upon entering the workforce?

Data Analysis:

This exploratory study is a work in progress. The findings will help identify gaps in current student preparedness. This will ensure graduates are better prepared for the demands of the field.

The data was in vivo coded to nine key areas. Communication; Teamwork; Professional attitude (Attitude, Work Ethic; Growth & Development; Confidence; Willingness / Drive, Asking Questions); Internships; Project Management; Problem Solving; Basic Technical skills; Time management; Software / Technology proficiency. The data from the industry professionals had recurring themes throughout the question responses. We coded 233 statements within the above codes, with some statements included in more than one code.

Results

The interview responses described three overarching themes as the most critical skills for new graduates entering the civil engineering profession: communication, teamwork, and professional attitudes. These skills are not new developments to civil engineering as ABET and

ASCE BOK3 [3] identify the importance of these skills. However, they continue to be identified by leaders as highly important skills and gaps in these skills at the new graduate level are currently a concern for industry.

Communication

Seven of the seven interviewees mentioned effective “communication” as an important skill. These references to communication were stated as: “written”, "verbal", “communicating with a team”, “asking questions”, “listening”, “communicating with clients”, "communication with others to solve problems”, and “reporting to the team or supervisor”.

Communication enhances the effectiveness of the team, allows new graduates to learn from others with more experience, and provides for sharing of information. As explained in Simmons [9], civil engineering professions demand team practice and problem solving as a part of complex and unique projects that rely on effective teaming and collaboration.

Communication skills are a cornerstone of professional success encompassing a range of abilities that allow professionals to interact effectively with diverse stakeholders. These skills are demonstrated in various ways, including verbal, non-verbal, and written communication, all of which are essential for building rapport with clients and developing relationships. When communicating with clients, civil engineers must not only articulate complex project issues but also present solutions in line with the client's understanding and expectations. Writing skills enable consultants to document project findings, develop reports, and develop proposals that meet both technical and professional standards.

Effective communication is also about ensuring that the intended message is understood and actionable. As one Senior Vice President shared, “Someone that can easily communicate with others shows that they are outgoing and willing to learn.” Another Vice President identified that “Regular communications with project staff, so you are current on project status and can address problems quickly.”

A critical application of communication skills lies in working as a member of a project team, where collaboration and information sharing are important. Civil engineers must be able to explain their roles within the team and the contributions they bring. As a high level executive shared, “What differentiates someone is communication and the ability to collaborate. Both written and oral communication skills are important.” Team contributions occur only when employees are willing to engage. As multiple interviewees highlighted, confidence and the ability to speak up are particularly valuable, as they enable engineers to advocate for project needs and solutions effectively. This is not only about presenting what they are doing right but asking for help. As one Senior Vice President shared, “Communication is not just explaining what you’re doing right, but understanding when to speak up if you are struggling.”

Effective communication as part of a team involves not only confidence in speaking up but also active listening. As one Senior Vice President shared, “A good listener is also important.” Another Vice President Director stated, “More active listening when discussing specific problems and solutions.” This reinforces the idea that the ability to actively listen is necessary to integrate feedback and align with team objectives, articulating ideas clearly and

resolving conflicts constructively, ultimately driving project success. As a Senior Vice President added, “Report back to the team on progress and potential issues that have been encountered. Be willing to provide input, even if they are the junior person on the team.”

Communication extends beyond project teams to interactions with clients and other stakeholders. These interactions necessitate the ability to adapt messaging to suit different audiences while maintaining professionalism. This idea was highlighted by a Vice President Director, “Effective communication - should be capable of expressing thoughts, ideas and questions clearly.” Internal and external presentations are common responsibilities, requiring engineers to convey technical results to audiences with varying levels of expertise.

Whether collaborating with team members to address project challenges or explaining project issues to clients, civil engineers must demonstrate a balanced skill set that includes speaking, writing, and listening. This was emphasized by a West Point educated Vice President of a mid-sized consulting firm stating, “Communication skills and experience working as part of a team. This includes both writing skills and skills interacting with other people.”

Internship experience further enhances communication skills by exposing students to real-world interactions. One industry leader noted, “Exposure to a professional work environment is highly desirable,” underscoring the role of internships in developing graduates' confidence in team discussions and client presentations.

Civil engineering graduates can bridge any potential gaps by embracing communication skills and positioning themselves as valuable members of any project team. Complex civil engineering projects require effective teaming and learning [9]. Communication is essential for teamwork, but teamwork has many more facets than communication alone.

Teamwork

Seven of the seven interviewees discussed “teamwork” and the necessity for new graduates to: “participate in team meetings”, “work as a member of a team”, “interact with other people”, “work in cross-functional teams”, “collaborate”, “build connections” and “relationships”.

As Zaccaro [12] points out, team collective effort begins to accomplish more than the sum of its individual member contributions. Civil engineering professions demand team practice and problem solving as a part of complex and unique projects that rely on effective teaming and collaboration [9].

Teamwork is a cornerstone of the civil engineering profession, as project work is almost always completed collaboratively. As relayed by a consulting firm VP, "Being able to work as a member of a team is also very important, as that is typically how project work is completed in industry." This highlights the necessity of teamwork skills within a department, across departments, and in cross-functional teams. "Teamwork - the ability to work within the department and inter-departmentally", as shared by an engineering manager, is vital for ensuring smooth operations and effective communication. The ability to work in cross-discipline teams

allows engineers to integrate diverse perspectives, which is critical for solving complex infrastructure challenges.

As an executive leader points out, "Engineering is a team sport and each person on the team needs to be accountable for their piece of the overall product". This underscores the importance of fostering accountability and a growth mindset among new graduates. Learning to work in teams during school prepares students to adapt to the collaborative nature of the workforce. Additionally, teamwork skills involve knowing how to interact with others, resolve conflicts, and provide constructive feedback. As noted by Bae et al. [4], successful teamwork in engineering also involves knowing how to give and receive constructive criticism.

Collaboration is fundamental in the civil engineering profession. Engineers must often "work with others to be part of something bigger than yourself," as one manager pointed out. This approach requires working with interdisciplinary teams, clients, and regulatory agencies to complete projects that serve the greater good. Multiple responses from the interviewees shared that "the ability to collaborate is fundamental in civil engineering," as it enables professionals to bring projects to fruition by integrating technical expertise with effective communication. By emphasizing teamwork in educational programs, civil engineering students can be better prepared to navigate the collaborative demands of the industry and contribute to impactful projects.

Internship experience has become a key expectation for graduates entering the civil engineering consultancy industry, as firms value practical exposure to fieldwork and real-world project scenarios. Internships reinforce teamwork skills by providing practical experience in collaborative environments. One executive stated, “Internships help graduates learn how to interact with professionals, resolve conflicts, and provide constructive feedback.” These experiences also allow students to build professional connections and understand the dynamics of interdepartmental collaboration.

Professional Attitudes

Many of the other interview responses shared many characteristics that we identified as “attitudes”, rather than skills. Consistently throughout the interview process, the interviewees shared that “confidence”, “work ethic”, being “proactive”, having a “growth and development mindset”, having a “willingness to learn” and an ability to “take direction” and “feedback”.

Every interviewee mentioned some form of “basic technical skills” like CADD, critical thinking, and engineering fundamentals, however, the notations of attitudes were more prevalent. These, we believe, are characteristics that every student has inside of themselves. As one interviewee pointed out, passion, open mindedness, reliability, integrity, honesty, a growth mindset, and positive attitude enhances students' success in the civil engineering profession.

In the civil engineering consultant industry, attitudes are often valued even more than technical skills. The interviewees placed much emphasis on characteristics such as drive, willingness to learn, and work ethic. This may possibly be attributed to a generational gap of the interviewees; however, it is clear from the responses that these characteristics are keys to success in the current workplace. As an engineering firm CEO explained it, “Dedicated employees who

maintain a strong work ethic are always the ones who succeed." While recent graduates are typically well-prepared with technical abilities, such as proficiency in CADD and some engineering software, industry professionals overwhelmingly highlight gaps in areas like work ethic and perseverance. Interviewees consistently noted that graduates need to exhibit behaviors such as showing up on time, asking questions, and demonstrating a willingness to learn. As one interviewee remarked, "We rarely need graduates with more technical knowledge; what we look for is drive and the willingness to grow." These attitudes form the foundation for long-term career development and success in the field. An executive interviewee shared "new graduates should have a natural sense of curiosity and a desire to learn. They should not be afraid to ask for help or guidance".

One of the attitudes that graduates must develop is the drive to build a career, which encompasses behaviors like showing initiative, asking thoughtful questions, and maintaining passion for their work. This drive indicates to employers that a candidate is committed to continuous growth and taking responsibility for their professional development. One employer noted, "The willingness to take on challenges and show enthusiasm for learning is what sets apart candidates who thrive in the industry." Such behaviors reflect an intrinsic motivation that is essential for navigating the complex and dynamic challenges of civil engineering projects.

Another important attitude is a strong work ethic, which includes discipline, engagement, and a growth mindset. Employers value candidates who demonstrate a willingness to learn and adapt, as well as the perseverance to overcome obstacles. According to Grigg [8], "Civil engineers will have to take increased responsibility for their careers," which underscores the importance of self-motivation and accountability. As one Vice President commented, they want new hires that "have a growth mindset. We can teach them all the technical knowledge." Evidence for these qualities can be drawn from extracurricular activities, leadership roles, or academic projects that required sustained effort and collaboration.

Internship experience plays a role in shaping these attitudes. One industry professional explained, "Internships help students develop discipline, accountability, and problem-solving skills in a real-world setting." However, graduates without internships can still demonstrate their readiness through senior design projects, leadership roles, or extracurricular activities that showcase initiative and teamwork.

Graduates can demonstrate their attitudes to convey their readiness to meet the demands of the profession and stand out in a competitive job market. Multiple interviews shared that they often assess these characteristics during interviews or internships, as they are strong indicators of a candidate's potential for success in the long term.

Discussion

The results of this study provide valuable insights into the skills and attitudes necessary for civil engineering graduates to excel in their careers and highlight critical areas for improving their preparedness as they transition into the workforce. While graduates often possess strong technical knowledge, such as proficiency in engineering software and design principles, our findings suggest a greater emphasis is needed on practical skills and key professional attributes.

The U.S. construction industry increasingly requires civil engineering graduates who combine technical expertise with essential professional competencies to contribute effectively to a rapidly evolving field [9].

Communication and teamwork emerged as central themes from interviews with industry professionals. Employers consistently highlighted the significance of these competencies in civil engineering consultant careers, emphasizing the need for new graduates to collaborate effectively within multidisciplinary teams and engage in professional communication. Practical experience gained through internships or co-op programs was frequently cited as essential, reinforcing prior research advocating for hands-on learning opportunities in engineering education. The *ASCE Body of Knowledge, Third Edition (BOK3)* similarly underscores the importance of professional skills, including communication and teamwork as fundamental learning outcomes for civil engineering graduates [3].

Our interviews also revealed a persistent industry focus on attitudes and behaviors. Qualities such as perseverance, adaptability, and a willingness to learn. While these attributes may be inherently present in students, they require intentional development and reinforcement throughout their academic and early professional careers. As noted in BOK3, attributes such as professionalism, lifelong learning, and ethical practice are integral to career success in civil engineering [3]. Thus, educational strategies should not only facilitate skill acquisition but also cultivate professional mindsets that align with industry values and expectations.

The emphasis on the three skills may be interpreted that these skills are currently emerging as the most important skills and could be most impactful to new graduates. Industry leaders are sharing that mastering these skills can have great positive consequences in an early career and this is currently where the gap is greatest. Technical skills were noted as essential, but employers are not commenting that these are currently not being met. This may be due to technical skill expectations being met. We purposely were searching for what was not meeting expectations.

Interestingly, while leadership is a core competency outlined in BOK3 [3], it was rarely mentioned by our interviewees as an immediate expectation for new graduates. This suggests that industry professionals may view leadership as a quality developed over time, with entry-level engineers instead expected to build competence, take initiative, and demonstrate reliability in collaborative settings. Employers emphasized a desire for graduates who are committed to continuous learning, innovation, and delivering value to their organizations. These attributes, along with a growth mindset and strong professional foundations, were identified as critical to long-term career success in civil engineering.

Future Work

Conducting similar interviews with academic leaders, professors, and recent graduates would provide valuable perspectives on the extent and size of a skill gap.

Future work in this area can focus on fostering continual and stronger partnerships between academia and industry, extending beyond financial contributions to include

collaborative projects and the active involvement of industry professionals. Initiatives such as industry networking days could help build rapport between students and professionals, offering practical insights into the expectations of the civil engineering field. Conducting similar interviews with academic leaders and professors would provide valuable perspectives on their perceptions of industry needs to potentially enhance educational outcomes. Exploring student motivations, such as job attainment and salary expectations, could also shed light on how these factors influence the development of essential skills and attitudes.

Conclusions

The transition from academia to industry requires more than technical proficiency; communication, teamwork, and professional attitudes are critical for success. While internships provide valuable exposure to these skills, alternative experiences can also help graduates demonstrate readiness for the workforce. By developing these competencies, graduates can position themselves as valuable contributors to engineering teams and complex projects.

The demand for civil engineers continues to rise, with above-average job growth compared to other engineering disciplines [8]. This trend underscores the importance of ensuring that graduates are equipped with the knowledge, skills, and attitudes required for career success.

It is important to recognize that while the skills identified in our study are essential, they do not represent the full spectrum of competencies necessary for long-term success. Workforce development efforts should focus on both foundational skills and the continuous acquisition of new knowledge to meet evolving industry demands. As *BOK3* and prior research suggest, fostering ongoing collaboration between academia and industry will ensure that civil engineering graduates are prepared not only to meet current challenges but also to drive innovation and leadership in their field.

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