WIP: Key Technical and Professional Skills Valued by Engineering Employers for Workforce Success

Dr. Atheer Almasri, West Virginia University

Dr. Almasri is currently a teaching assistant professor in the Fundamentals of Engineering Program (FEP) at the Statler College of Engineering, West Virginia University. He has been serving in this position since 2020. Before joining West Virginia University, he worked as a teaching assistant professor of chemical engineering at Imam University for 10 years. Dr. Almasri holds a bachelor's degree in Chemical Engineering, as well as master's and Ph.D. degrees in Materials Engineering.

Dr. Lizzie Santiago, West Virginia University

Lizzie Y. Santiago, Ph.D., is a Teaching Professor and Director of the Fundamentals of Engineering Program in the Benjamin M. Statler College of Engineering and Mineral Resources. She holds a Ph.D. in Chemical Engineering and has postdoctoral training in Neural Tissue Engineering.

Dr. Todd R Hamrick, West Virginia University

Dr. Todd Hamrick, Ph.D. is aTeaching Professor in the Fundamentals of Engineering Program at West Virginia University Statler College of Engineering and Mineral Resources, a position he has held since 2011.

Dr. Robin A.M. Hensel, West Virginia University

Robin A. M. Hensel, Ed.D., is a Teaching Professor in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University and an ASEE Fellow Member. As a mathematician and computer systems analyst for the U.S. Department of Energy, she collaborated in engineering teams to support energy research before entering higher education where she has taught mathematics, statistics, computer science, and engineering courses, secured over $6.6M to support STEM education research, led program development efforts, and served in several administrative roles. She has been recognized for her teaching, advising, service, and research and as an Exemplary Faculty Member for Excellence in Diversity, Equity, and Inclusion.

Dr. Carter Hulcher, West Virginia University

Dr. Hulcher is a Teaching Assistant Professor in the Fundamentals of Engineering Program in the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University in Morgantown, WV. He has been in his current role at WVU since 2020. Dr. Hulcher holds degrees in Civil Engineering, as well as Mathematics.

Dr. Akua B. Oppong-Anane, West Virginia University

Akua Oppong-Anane is a Teaching Assistant Professor at the Fundamentals of Engineering Program at West Virginia University. She holds a Bachelor's degree in Chemical Engineering, a Master's degree in Chemistry and a Ph.D. in Environmental Engineering Sciences. Her research areas are in environmental engineering, advising and engineering education (persistence and retention of first year engineering students).

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Introduction

This "Work in Progress" paper concerns technical and non-technical skills that prepare engineers to navigate workplace challenges successfully. These skills are typically introduced in first-year engineering courses and further developed in advanced coursework. Key non-technical skills such as oral communication, teamwork, and project management are often emphasized to build a strong foundation for professional and career growth.

Professional skills are interpersonal abilities that enhance collaboration, build effective relationships, and complement technical expertise, playing a vital role in achieving success and efficiency in the work environment. These skills are generally categorized as functional and adaptive [1]. Functional skills focus on task-oriented abilities, such as problem-solving and decision-making, while adaptive skills emphasize personal conduct, emotional intelligence, and interactions with peers and the broader work environment [1]. In engineering education, professional skills include oral communication, teamwork, and project management. Technical skills refer to the specialized knowledge and expertise required to perform specific tasks. In engineering courses, technical skills often include proficiency in the engineering design process, computer programming, statistical analysis, estimation techniques, and mathematical problem-solving.

The 2013 Transforming Undergraduate Education in Engineering (TUEE) workshop report [2] states that employers value both professional and technical skills in engineers. Professional skills such as problem-solving, communication, teamwork, and adaptability are critical for success in the workplace. While technical expertise remains important, employers seek engineers who can effectively apply their knowledge in real-world scenarios and effectively communicate ideas to diverse audiences. Teamwork is particularly emphasized, with collaboration across disciplines being crucial. Employers also seek leadership potential, as managing projects and guiding teams is highly valued. The 2017 TUEE report [3] further underscores the importance of both technical and professional skills. Key technical competencies include engineering fundamentals, mathematics, and scientific principles, which are vital throughout an engineer's career. However, the report stresses the need for engineering education to also foster professional skills such as communication, leadership, teamwork, adaptability, critical thinking, problem-solving, and time management – skills often inadequately developed through traditional coursework alone. Multidisciplinary teamwork, project-based learning, and opportunities to engage in community service and leadership roles are essential for cultivating these competencies.

The list of skills examined in this study, both technical and non-technical, was carefully developed based on the curriculum and learning objectives of the courses offered within the Fundamentals of Engineering Program. The list was systematically compiled to accurately reflect the essential competencies students are expected to acquire and was validated through comparison with existing literature, ensuring alignment with key skills recognized in engineering education.

The goal of this study is to determine which professional and technical skills are seen as important by different engineering industries and workplaces. Specifically, this study focused on two main research questions: (1) what technical and professional skills do employers value, and (2) how do these skills differ by industry? The information collected in the study provides valuable data to help determine which skills should be emphasized in first-year engineering courses. Input from faculty will also be considered when making the final decision.

Project Approach

This project was conducted at an R1, land-grant public institution in the Mid-Atlantic region. Thirty-seven employers took part in a voluntary survey shared via a QR code provided at the STEM Career and Internship Fair held during the Fall 2024 semester at West Virginia University. The survey included multiple-choice and Likert-scale questions, which were the primary focus of this analysis. The study was approved by the Institutional Review Board (IRB).

At the career fair, participating companies could select their applicable industry sectors from a predefined list. This list was created based on the North American Industry Classification System (NAICS) classifications and standards [4]. The NAICS is the standard utilized by federal statistical agencies to classify business establishments for collecting, analyzing, and publishing statistical data on the U.S. business economy. The list included the following sectors: Construction, Manufacturing, Energy, Utilities, Finance and Insurance, Information Technology (IT), Transportation and Logistics, Agriculture and Agribusiness, Education, Healthcare, Chemicals, Retail, Aerospace and Defense, Media and Entertainment, Real Estate, Environmental Services, and an open category labeled "Other" for additional specifications.

Since many companies operate across multiple sectors, their responses often span several categories. Industry sectors were grouped according to the NAICS categories [4] to simplify and standardize the data for analysis. The following NAICS categories were used in the current study: "Construction," "Manufacturing," "Services," "Transportation," and "Miscellaneous." The "Miscellaneous" category included items that do not have many responses such as "Retail," "Finance and Insurance," "Public Administration," and "Other" as seen in Figure 1 below.

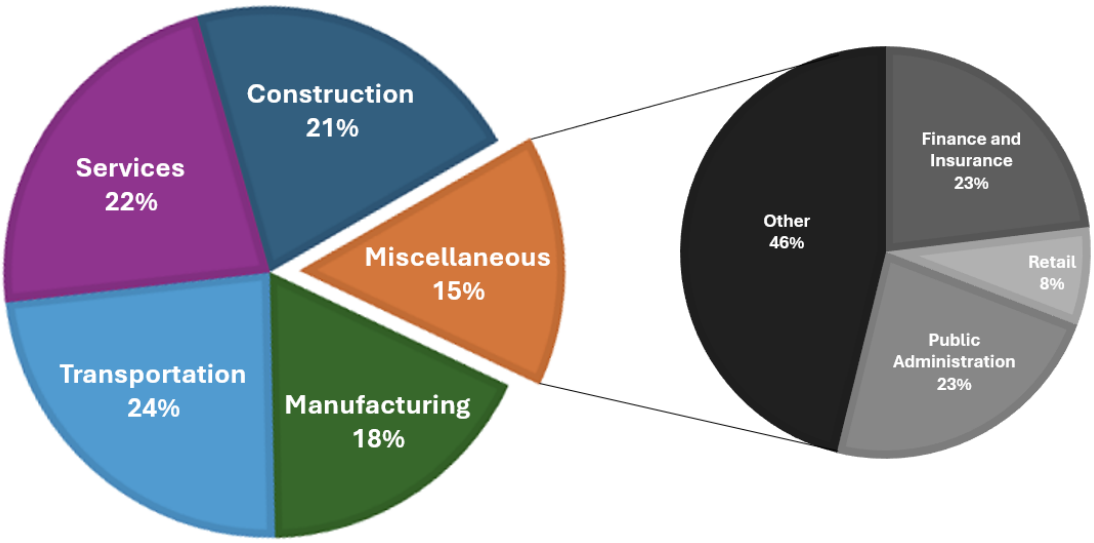

Figure 1. Representation of each industry sector among the study participants.

The Transportation category included companies operating primarily in transportation, logistics, utilities, telecommunications, and energy. The Manufacturing category included manufacturing entities, chemicals, agribusiness, and packaging/processing industries. The Services category included healthcare, media and entertainment, environmental services, IT, and education sectors. The "Miscellaneous" category included aerospace and defense, retail, finance and insurance, real estate, and other uncategorized sectors such as "Finance and Insurance," "Retail," "Public Administration," and "Other"

In cases where a company reported involvement in multiple sectors, the company's entry was duplicated to ensure representation across all relevant NAICS categories. For example, if a company lists its services under Construction and Transportation & Logistics, the entry was included two separate times: once under Construction, and once under Transportation. This approach ensured an accurate representation and analysis of each company's diverse industry engagements while maintaining consistency across the NAICS classification framework.

Results

The analysis of technical skills sought by employers across various industry sectors highlights distinct priorities seen in Figure 2. In the Construction sector, the highest-rated skills included the use of computational tools and estimation techniques, which were both rated as equally important skills. Understanding mathematical language and applying the engineering design process followed closely, while statistical data analysis was rated slightly lower.

Computational tools were most valued for the manufacturing sector, reflecting the sector's dependency on technology-driven solutions. Statistical data analysis and understanding mathematical language were also important, with slightly less emphasis placed on estimation techniques and the engineering design process.

In the Transportation sector, employers valued applying the engineering design process most, followed by understanding mathematical language and estimation techniques. Computational tools and statistical analysis were rated lower.

The Services sector emphasized applying the engineering design process as the most critical skill, with mathematical problem-solving and computational tools closely following. Statistical data analysis and estimation techniques were rated slightly lower.

Computational tools received the highest rating for companies categorized as Other, reflecting a versatile demand for technology-based skills. Both the engineering design process and mathematical problem-solving were equally valued in second place, followed by estimation techniques and statistical analysis.

Overall, across all sectors, the application of the engineering design process and the use of computational tools emerged as universally the most important technical skills as they appear to have the highest values. However, the emphasis on specific skills varied, with some industries prioritizing estimation techniques or statistical analysis based on their unique operational requirements.

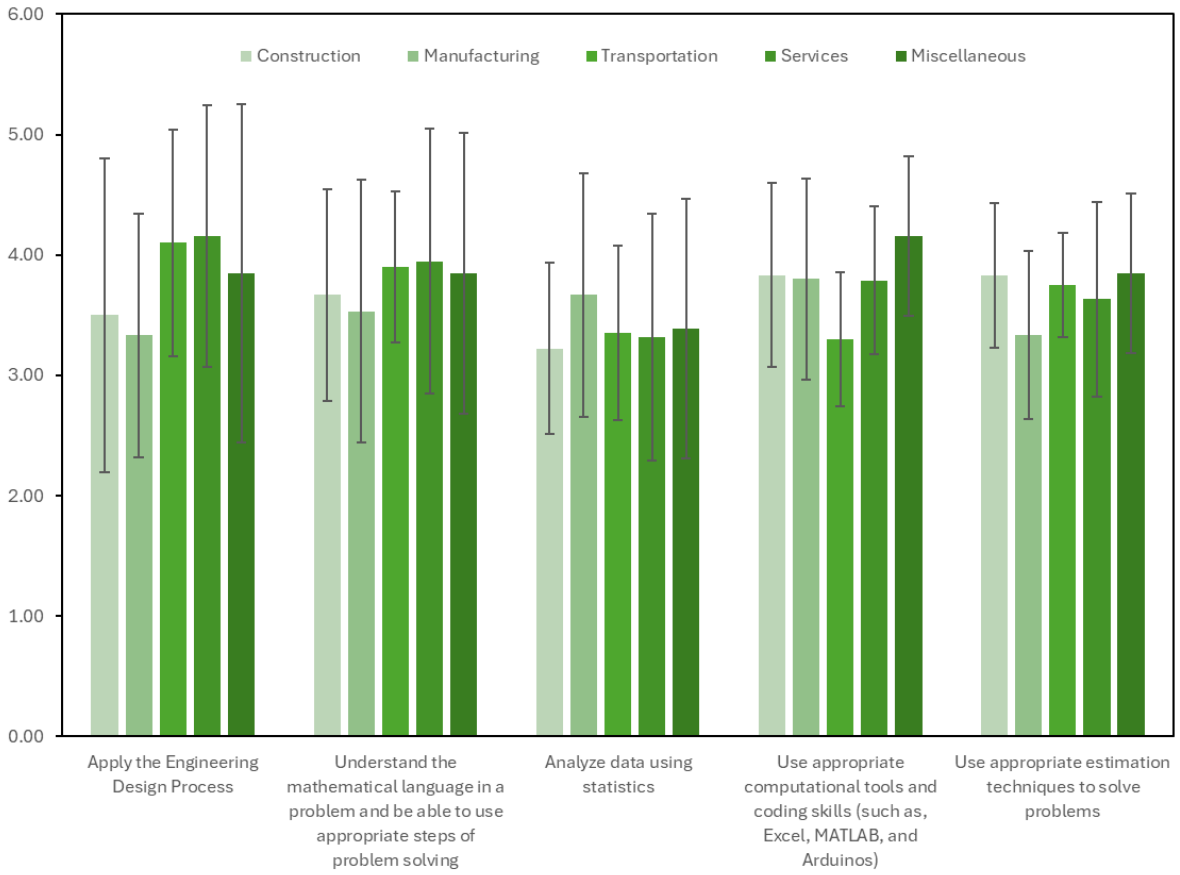

Figure 2. Technical skills versus industry sector.

The analysis of non-technical skills valued by employers across industry sectors, shown in Figure 3, reveals key workforce expectations for engineering graduates. In the Construction sector, employers prioritized teamwork skills and oral communication, reflecting the collaborative and communicative nature of construction projects. Time management and written communication were also highly valued, while skills related to career planning tools and conducting literature reviews were given less importance.

Teamwork was the top-rated skill for the Manufacturing sector, followed by oral communication and time management. These results indicate a strong emphasis on collaboration and efficiency. Career planning tools and conducting literature reviews were rated comparatively lower, suggesting less immediate relevance in the manufacturing industry.

In the Transportation sector, oral communication and teamwork were identified as essential skills, highlighting the industry's reliance on clear communication and coordinated efforts. Time management and ethical decision-making were also prioritized. However, conducting literature reviews and career planning tools received lower ratings.

Employers in the Services sector prioritize teamwork and oral communication, with written communication and time management also valued. Career planning tools and literature reviews received less emphasis.

Teamwork and oral communication received the highest ratings in the “Other” category, followed by written communication and time management. Career planning tools and literature reviews were rated lower, reflecting limited emphasis. Notably, approximately 54% of the “Other” category consists of the retail, finance and insurance, and public administration sectors.

Overall, teamwork, oral communication, and time management emerged as the most consistently valued non-technical skills across all industries. Conversely, career planning tools and conducting literature reviews were generally rated lower, suggesting that while important, they may not be as immediately relevant in day-to-day industry operations.

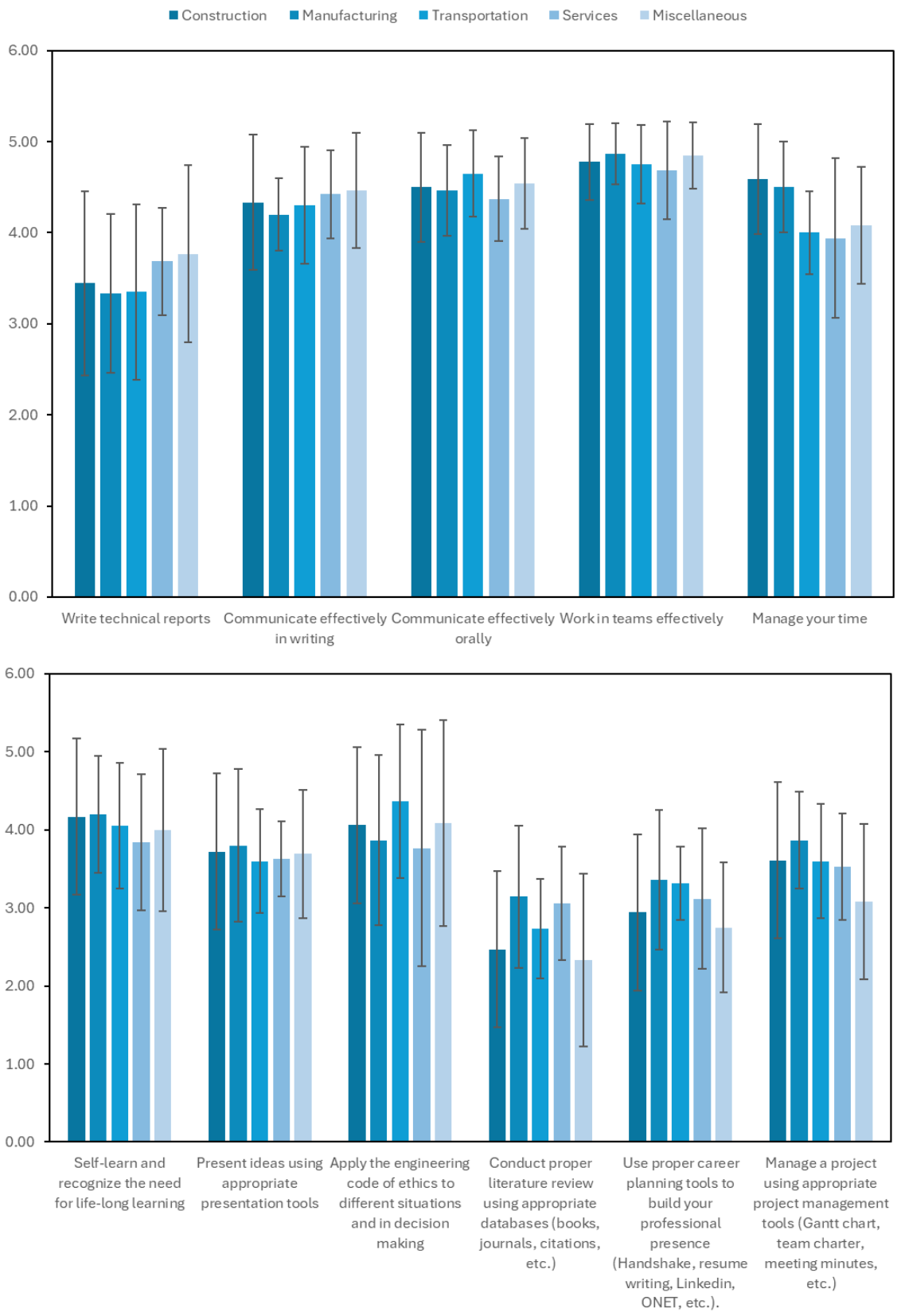

Figure 3. Non-technical skills versus industry sector.

Discussion

Employers across sectors consistently valued the application of the engineering design process and the use appropriate computational tools and coding skills [5], as shown in Figure 2, indicating the importance of problem-solving and technology-driven approaches. However, sector-specific variations emerged. For example, the Construction and Manufacturing sectors emphasized computational tools and coding, reflecting their reliance on data analysis, simulations, and design software. In contrast, the Transportation and Services sectors prioritized the engineering design process, likely due to the iterative nature of problem-solving in these industries. Interestingly, technical skills such as data analysis using statistics and estimation were rated lower across all sectors, suggesting either a lack of perceived importance or an assumption that these skills are embedded within broader problem-solving processes.

As seen in Figure 3, the data analysis revealed a stronger emphasis on teamwork, oral and written communication, and time management, aligning with existing literature [5-8] that underscores the importance of these skills for workplace efficiency and effective collaboration. Employers in construction and manufacturing place huge importance on teamwork and oral communication, reflecting the collaborative nature of these fields, as noted by McGunagle [9]. Written communication and project management skills were also highly valued, reflecting the need for engineers to document processes, manage resources, and lead teams effectively. However, career planning and literature review skills were consistently rated lower across sectors, suggesting their limited immediate applicability in most workplace contexts.

The results suggest that while technical competencies are foundational to engineering practice, non-technical skills - particularly teamwork, communication, and time management - are equally vital for professional success. Undergraduate engineering programs must balance cultivating technical expertise with opportunities for students to develop these crucial professional skills.

The data suggests that a more holistic approach to engineering education, integrating both technical and professional skills, would be beneficial. Faculty could redesign assignments and projects to incorporate more teamwork, peer feedback, and real-world problem-solving, to provide students with opportunities to develop key competencies. Input from faculty and industry professionals will be crucial to refine these recommendations, ensuring they are practical and aligned with the evolving needs of the engineering profession. The study also suggests that traditional coursework alone is insufficient for developing these professional skills. Engagement in design projects, internships, and student organizations are key for building them.

Conclusion

This study highlighted the importance of both technical and non-technical skills in preparing engineering graduates for the workforce. Technical skills such as applying the engineering design process, using the appropriate computational tools, or analyzing data remain fundamental to engineering practice. Non-technical skills such as oral and written communication, teamwork, and time management are critical for professional success. The results also suggested that industries highlight specific technical or non-technical skills more than others.

Addressing these insights in engineering education requires intentional curriculum design that integrates technical and non-technical skill development across courses. Additionally, educators should reinforce their importance through real-world applications and project-based learning.

Future work could explore the long-term impact of educational interventions on skill development. Engineering programs can better equip students to excel in an evolving professional landscape by bridging the gap between academic preparation and industry needs.

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