Understanding How Skill Development During Graduate School Can Prepare Students for Engineering Industry Career Pathways

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Abstract

This research aimed to better understand how engineering graduate students entering industry or government careers feel prepared from a skills development perspective. We sought to understand this alignment between graduate education and industry or government positions from two perspectives: 1) experienced engineering professionals who hire new engineering graduate degree holders, and 2) new engineering graduate degree holders in their new roles within the past few years. Our paper reports on findings from five interviews conducted with experienced structural engineering professionals with over 20 years of experience as well as eight interviews with recent alumni of graduate programs who reflected on how their educational experiences prepared them to enter the workforce. Results from the executives' interviews revealed that a structural engineering candidate with a thesis-based master's was preferable at some companies compared to a non-thesis master's candidate because writing a thesis helps graduate students develop critical thinking and communication skills. Structural engineering employers were more skeptical of recent doctorate applicants as compared to recent master's applicants based on the assumption that PhDs may be overqualified or have too specific expertise that could not be translated easily into industry. From the interviews conducted with recent alumni, our study found that all participants experienced some gap with respect to preparedness for the workforce when transitioning from academia to industry or government. In particular, recent alumni emphasized an opportunity for graduate programs to enhance how they help graduate students develop professional skills such as collaboration and communication.

Introduction

The skills an engineer needs to be successful in the workforce are rapidly changing. Duderstadt (2010) noted over a decade ago how the requirements of the 21st century engineer consist of someone being technically advanced, globally aware, and culturally adaptive. Engineering education curricula need to adapt to this rapidly changing world that is full of new designs and technologies. Large restructuring initiatives are needed to reshape engineering curricula to respond to growing demands in all sectors. With a large and growing population of graduate engineering students entering the workforce each year, it is vital that students obtain skills, both technical and professional, that will allow for employability and career growth.

Engineering Ph.D. recipients enter industry (48%) and government (8%) positions at a higher combined rate than academic positions (33%) (Denton et al., 2024). However, an overwhelming amount of research on recent alumni is focused on individuals who pursue an academic position, leaving a gap in the literature pertaining to individuals who pursue non-academic careers. While research on engineering M.S. and Ph.D. recipients who pursue non-academic careers is limited, one study has begun exploring career pathways of these recipients by examining job postings. Fleming et al. (2024) found that current job postings vary across engineering disciplines by degree level. These findings show a larger amount of positions require a master's degree compared to a doctorate degree. When examining the jobs requiring a graduate degree for civil, electrical, environmental, and mechanical engineering, 3,304 (82.6%) of the postings required a master's degree, and only 693 (17.3%) required a PhD (Fleming et al, 2024). These results

indicate that companies may have reasons for preferring master's degrees over PhD degrees that have yet to be investigated.

The purpose of this paper is to compare the perspectives of structural engineering executives and recent alumni of graduate engineering programs on the value of advanced degrees to employability. The research questions guiding this study are:

1. According to structural engineering executives and new engineers:
    a. How does graduate education prepare engineering students for an industry or government position?
    b. How can the difference between earning a master's or PhD degree impact an individual's preparation for entering industry?

Insights gained from these findings can inform students, faculty members, and hiring managers on the professional and technical skills that appear to be most helpful for future success in industry or government following graduate education in engineering. These findings can help conversations regarding the alignment and misalignment between graduate education experiences and future workforce needs.

Conceptual Framework and Literature Review

The Systems Approach for Better Education Results (SABER) is a conceptual framework for evaluating workforce development (WfD) developed by Tan (2013). SABER-WfD examines the extent to which the education system aligns with job requirements based on current market needs and demands. Using the principles of WfD, Tan suggests that a well designed workforce development system has a sturdy overlap between skill demands and supply of workers who possess those skills. These attributes foster economic growth by maximizing employability of trainees and supplying skilled workers that are able to increase productivity, determination, and overall quality. Prior research by Fleming et al. (2024) utilized this framework within the engineering education research context; the framework is depicted in Figure 1. That prior work elaborated on how specific professional skills are critical for an engineer's success in the workplace and analyzed the frequency with which engineering job advertisements noted different professional and technical skills. Our present paper joins this conversation through a different form of data collection: interviews with recent graduate alumni and executives.

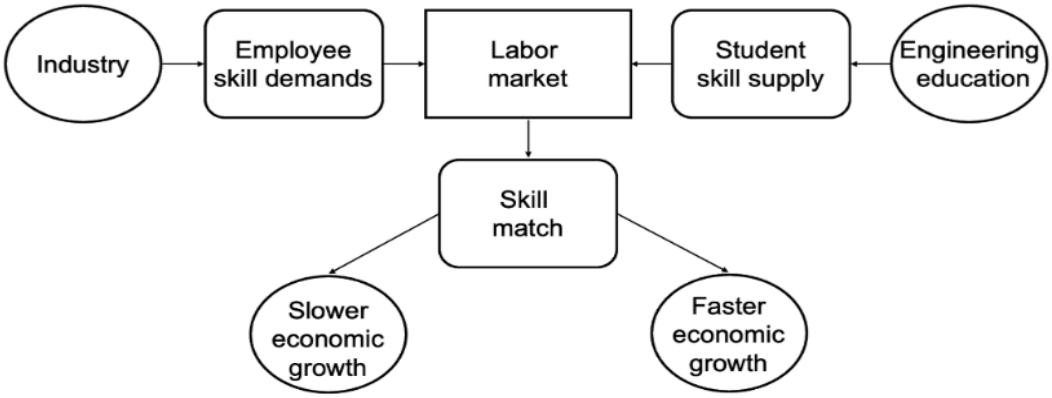

Figure 1. Conceptual Framework of Skill Demands and Supply from Fleming et al. (2024).

A common critique surrounding skill demands is that individuals do not possess the traits demanded by an employer (Weaver & Osterman, 2017). When surveying 2700 U.S. manufacturing establishments to focus on hiring mechanisms and skills of an employee, positions that were more common to have vacancies were related to a lack of advanced math and reading skills. Participants were from a wide background of skill levels from different educational backgrounds. The ideal respondent was someone who worked in human resources to have a wide knowledge of daily operations or someone in a plant managing position. Based on survey data, the researchers found that 76% of positions place an emphasis on reading skills and 74% place an emphasis on math skills for job success. The next area for assessing an employee is their technical abilities. Over 42% of the respondents stated that an individual needed some form of computer-aided design (CAD) skills. Focusing on interpersonal skills, their findings show that U.S. companies within this sector place a large demand on one's ability to work and be successful within a team dynamic and develop different ideas to fix existing problems.

From a study examining the issue of skill demands within the construction industry in the United Kingdom, a technologically driven skills management system was created to understand current workers and implement how to better manage and develop current skill levels. Within their study, Matsumoto et al. (2005) examined four types of reports: individual employees, discipline grades, team specific, and overall organizational through focus groups and interviews from a company where half of the employers were structural engineers. For all these reports, an employee's communication, IT, Financial, Legal, Management, and Technical skills were assessed to see how they offer a more holistic representation of employees within an organization. These attributes were explored more in different sub-groupings. Findings from these subfields as explored by deSilva (2015) state that an employee's development depends on three key skills: the development of employability attributes, development of self-promotional and career management skills, and a willingness to learn and reflect on learning.

In another undergraduate-focused study, Kinoshita et al. (2014) explored how internal and external factors impact learning and skill levels three years following students' graduation while they were in their jobs. Co-curricular engagements were often associated with the development of students' collaborative capacity and interpersonal relationships. Involvement in student clubs,

particularly those focused on different affinity groups, were found to relate to higher levels of teamwork, design, communication, and leadership.

Because our sample of executives focuses on structural engineering specifically, we also highlight prior work within this disciplinary space and particularly note the importance of this study. The American Society of Civil Engineers states how the labor market currently has more openings than qualified people for positions. In *Practice Periodical on Structural Design and Construction*, Karakhan et al. (2023) focused on seven workforce sustainability attributes to advance the field by nurturing, diversity, equity, health and well-being, connectivity, value, community, and maturity practices to increase workforce development and retention within the field.

Much of the engineering education research community has spent years lamenting the misalignment between curricular emphases and workplace needs. For example, Arat (2014) noted how higher education institutions are primarily only focused on the instruction of technical skills. However, many of these interpersonal skills are not embedded within engineering curriculum and students are expected to either learn these skills once they join the workforce off mentorship or gradually pick them up over their educational and industry experiences. In her book *The Hard Truth About Soft Skills: Workplace Lessons Smart People Wish They'd Learned Sooner,* Klaus (2009) states how professionals with advanced degrees in engineering and other fields such as law or medicine find professional skills to be the most difficult to acquire in the workforce. The blending of scientific and technological abilities, along with international competitiveness, is growing the need for more skills outside the core learning objectives to reach a mastery level. An employee's capability to improvise and adapt to new conditions is seen as an advantage in a rapidly changing work environment. With industry standards quickly evolving, if an employee cannot adapt with the times to perform unanticipated parts of their job, they would be losing opportunities or be overlooked by someone else who is willing to perform tasks and adapt with the times (Tan, 2013).

In her work that interviewed forty engineering PhD recipients, Cox (2020) found that communication was the most important skill for one to have, regardless of industry. Other highly rated skills were teamwork and problem solving. Individuals from that study explained how current and future PhD students should be exposed to current PhD holders in their desired field of work. This kind of graduate alumni networking could allow an individual to learn more about these careers in a more in-depth way. Additionally, being exposed to interdisciplinary settings and collaboration amongst wider teams is an added benefit. This study follows a similar interview-based approach but broadens the sample across both master's and PhD holders recently out of graduate school as well as executives who hold graduate degrees.

Methods

Data Collection

In this paper, we report on analyses of thirteen semi-structured interviews conducted with participants categorized into two distinct groups: eight recent graduate alumni of engineering programs and five industry executives. Recent alumni participants graduated from an engineering graduate program within the last 2-5 years and work in an industry or government position. Industry executives had a minimum of 20 years of professional experience in the field of Structural Engineering and had earned a graduate degree in engineering themselves. Participant recruitment followed a snowball sampling approach. After interviewing associate deans and faculty members for a different aspect of a broader project focused on nonacademic career pathways of graduate students in engineering, we requested that they recommend alumni in industry or government who could offer insights about how graduate education prepared them for their current work. Some of the participants who agreed to this interview were recent alumni across engineering disciplines, and others were senior executives within structural engineering. Snowball sampling was further employed during the interview process, as participants were asked to recommend colleagues who might also contribute valuable insights.

Recent alumni consisted of eight participants who completed a PhD or a master's level program, as shown in Table 1. Five of the participants completed a PhD, and three participants completed a master's degree with a thesis component. Participants' current employers included Amazon, Apple, NASA, and an engineering startup. As shown in Table 2, the five industry executives who participated held positions such as Chief Operating Officer, Senior Principal, and Partner and Owner. The executive-level participants each had at least 20 years of experience.

Interviews with the recent alumni were conducted by a graduate student researcher with five years of industry experience between their undergraduate and graduate training, and interviews with the executives were completed by a faculty member. Each of the interview sessions lasted around thirty minutes. All interviews were professionally transcribed to facilitate analysis.

Table 1. Participants from the *recent alumni* group

Pseudonym	Level of Education	Job Title	Job Sector
Aubrey	PhD	Remote Researcher	Federal Government
Cliff	Thesis-based Master's	Mechanical Engineering Lead	not stated
Ernesto	Thesis-based Master's	Energy Analyst	not stated
Emma	PhD	Technical Program Manager	Computer Science
Avi	Thesis-based Master's	Technical Program Manager	Computer Science
Bryan	PhD	Aircraft Developer	not stated
Alan	PhD	Supportive Works	Technology
Mike	PhD	not stated	Aerospace Engineering

Table 2. Participants from the *executive* group

Pseudonym	Job Title	Years of Experience	Area of Work
Jason	Chief Operating Officer	25 years+	Structural Engineering
Jordan	Principal	29 years+	Structural Engineering
Derek	Partner and Owner	29 years+	Structural Engineering
Sam	Senior Principal	not stated	Structural Engineering
Ryan	Chief Operating Officer and Senior Principal	20 years+	Structural Engineering

Data Analysis
Qualitative data were analyzed through thematic coding, supported by analytic memos to identify recurring patterns across the dataset. At the end of each round, one author discussed the themes with two other authors. The first round of coding involved categorizing responses based on similarities in answers to specific questions derived from the interview protocol relating to categories like preparation or international status. A second round of coding was then conducted to refine and consolidate themes, such as particular skill sets or educational levels.

For the executive leadership participants, the first round of coding produced the following categories: preparedness, level of education, desired future changes, visa sponsorship, desired traits, and miscellaneous responses. Three of the authors subsequently refined these categories into broader themes: education, skill sets, organizational footprint, sponsorship, and desired future changes. For each of these categories, the following definitions were used–this paper only focuses on findings related to the education and skill sets category:

- **Education:** minimum expectation that was required for a person to be offered employment within an organization
- **Skill sets:** tools one must be equipped with from previous educational or work settings
- **Organizational footprint:** how an individual would best assimilate into their work environment based on blending education and skill sets
- **Sponsorship:** if an applicant was born outside of the United States whether this company offer Visa Sponsorship
- **Desired future changes:** upon self-reflection, industry executives were given the opportunity to include information on how the educational process would change to include needed attributes

Similarly, for the recent alumni interviews, initial categories included preparedness, intended career path or motivations for leaving academia, job selection criteria, skills participants wished they had acquired during their educational program, international status, and future areas of interest. After the second round of coding, these categories were condensed into four primary themes: overall areas of concern, skills under development, career trajectory, and international status. For each of these categories, the following definitions were used–this paper only focused on findings related to the areas of concern category:

- **Overall Areas of Concern**: self-reflection of skills one felt they were lacking in when compared
- **Skills Under Development**: upon entering the workforce, what abilities one needed to obtain or grow to be a successful practitioner
- **Career Trajectory**: what drove someone away from academia or how they wanted their career to advance based on the level of education they obtained
- **International Status**: three of the recent alumni were born outside of the United States and required Visa Sponsorship to seek employment

Positionality
The research team consisted of six individuals: three professors, two PhD students, and one research scientist. The first author is a first-year PhD student who holds a Bachelor of Science in Biomedical Engineering and is in his first year of graduate school in engineering education. Two

of the faculty members have led multiple studies focused on graduate education and also served in administrative roles focused on graduate education. The remaining faculty member is an assistant professor with experience researching school to work transitions and workplace preparedness. The research scientist has also led several studies focused on graduate education. The other author was a PhD student in mechanical engineering and studied engineer preparedness for industry roles. These experiences motivated this work and informed how we interpreted results. We present quotations from participants throughout the results section in an effort to provide evidence to readers supporting our interpretations.

Limitations

The executive-level participants were exclusively from the field of Structural Engineering, which was a result of snowball sampling and was not the original sampling intent. As a result, the insights gained from this executive sample may not be applicable to other disciplines within engineering, but the findings point to open questions that could be addressed in those other areas. Structural engineering, with its specific requirements and practices, may have distinct hiring standards, skillset expectations, and workforce development strategies that do not fully align with those in other engineering disciplines or STEM-related industries. Thus, the transferability of our findings to other disciplinary spaces may be limited and warrants more research.

In contrast, the recent alumni interviewees came from a range of engineering backgrounds, but they did not represent the specific sub-discipline of structural engineering. We thus are unable to make direct comparisons between the recent alumni findings and the executive findings in this paper, but again highlight some areas that warrant future research. Of the recent alumni, all participants completed either a PhD dissertation or a master's thesis. Therefore, this paper cannot speak to hiring experiences for individuals who complete the non-thesis track for a master's degree.

We thus believe this paper can serve as a useful exploratory study that can inform future work aiming for a larger and more diverse sample, ideally incorporating participants from a range of disciplines at both the executive and recent graduate alumni levels. Such a design would enable more comprehensive insights into the relationship between educational experiences and industry hiring needs.

Findings

Recent Alumni Findings

Regardless of educational level and field of work, all participants noted skills and competencies that they felt they were lacking. Despite possessing an advanced degree in an engineering field, across all eight interviews, the participants remarked on how their academic training and preparation did not always align with particular skills demands of their employer. As noted, Avi explains how their educational journey impacted their career readiness: "I guess no, I didn't really feel prepared even after my master's. And honestly…the most important thing I got out of grad school was networking and interpersonal skills."

For individuals who recently earned a PhD, a recurring theme was how the very narrow focus associated with this level of education did not translate to industry norms. Although this level of

academic work requires specialized skills and training, the net result could be an alumnus who felt like their training was too specific and non-transferable to broader sectors. For these doctoral participants, it was noted how they felt disadvantaged at the beginning of their jobs when they had to begin with more generic, ill-defined problems. When PhD earners-turned-industry or government employees were asked to participate in larger, expansive teams, they felt they had a steep learning curve, as Bryan stated:

> "I guess how I didn't feel prepared, I mean, with a PhD, your focus becomes very narrow into, yeah, finding the greatest depths of a problem – that's finding something new to change.
>
> "There were some blind spots, I think, in terms of things I had learned but had not used in my PhD. So, I didn't feel overly confident, but I mean, I feel like going into such a different position compared to PhD – that really…expanded…my knowledge base because I just feel like I'm learning something new every day."

However, what recent alumni felt they lacked in industry experience or knowledge, they were able to offset by offering an abundance of professional skills that can transcend different sectors such as communication, technical delivery, and time/goal management. All recent alumni participants stated how they wished for a greater incorporation of working in teams and more cross disciplinary spaces during their graduate programs. Graduate education can be very individual work driven, but in industry and government roles, employees rarely see assignments that do not foster collaboration. As Aubrey noted,

> "I'd say my strongest skills were…like analytic understanding of how to do some computational modeling for problems, and being able to communicate those results, and kind of chatting with others about them. Those were things I was good at. I think collaborating with people who are maybe reluctant on some level is something that would have been good. Maybe more cross-disciplinary collaboration."

Across all eight interviews with recent alumni, preparedness was discussed and placed into the skills under development category. This category ended up having the largest subset of responses when compared to the others (overall areas of concern, career trajectory, and international status) at 13 direct quotes. The others had five, 12, and 3 respectively.

Executives' Findings

An important finding from the interviews with executives related to the desired level of education that an employee holds when they are going through the interview process and the importance of thesis versus non-thesis at the master's level. Participants noted that they were primarily looking for a candidate with an education background in structural or civil engineering. However, the content that is covered in the undergraduate years does not provide a sufficient amount of knowledge on the field of structural engineering. The course content at the master's level provides sufficient coursework to be a starting successful practitioner. Across all participants, a candidate holding a Master of Science in civil (and specifically structural) engineering was found to be most preferable and competitive for these industry-based positions, as the MS degree is a strong way for companies to level the playing field, Jason noted:

> "We find that master's degrees help level the playing field of those entering into our firm because they've had that extra year or two of schooling related to the specifics of what we do to design buildings."

Jordan alluded to how the depth of an education at this master's level allowed new employees to be able to adapt more quickly and decrease the amount of on-the-job training that was needed for an employee to make the transition from graduate school to industry or government.

> "I can't even think of an instance that our firm has gone, in recent times, the range out of master's or PhD. We believe that it's the most important part of the background of folks that come to join us, whether they join us as recent graduates or if they've got a whole range of experience. So, we are focused on that. We strongly believe that a master's degree, at least, is important in preparation of practice in our firm."

When these same individuals were asked about the importance of a master's thesis or about the specific dissertation topic for a PhD student, we did not observe consistent preferences from these executive participants. However, when considering graduate students who complete a one-year master's program compared to a student who does the master's thesis option, Derek noted:

> "I wouldn't say that we have any sort of bias in one direction or anything. But, I can tell you what my whole sense of it is. It's [that] the thesis is really important. What it does is it makes you focus on a particular subject, and you're committed to that subject. And it's extra work usually, but I think that's a great experience. And it's not only the technical work. It's the writing work that centers around a thesis. That a well written thesis is a way of launching into a business where you have to communicate. You have to write. And engineers are not great writers. They think they are. I thought I was. But you learn. You're forced to sort of collect your thoughts. Because a lot of the engineers do need to be able to communicate to other people. So, I'm a strong believer in a thesis. But, I wouldn't say that we hold it against anybody."

Participants did seem a bit more hesitant about hiring an individual with a PhD because of abnormalities of the pay structure surrounding someone with a PhD and the nature of one's education being too specific on a certain topic. Additionally, it was noted that employees currently holding a PhD tended to provide clients with a work product that is much more thorough than desired or requested. Since the executives at these companies do not pick the topics that customers want, being too focused on a topic doesn't always serve someone well in these workplace settings. Jordan expressed the following concerns about PhD applicants: "PhD students are too academic. Like, they're very tunnel focused on everything, and they have to explore all the things. But, the clients typically don't want to pay for that."

From our interviews with all five executives, we noticed the importance of a master's degree over an undergraduate degree. When directly comparing a PhD level degree with a master's degree, a greater emphasis was placed on a master's program as the PhD might become too specific in one area that is not related more broadly to the field of structural engineering. A student who obtains a master's degree with the thesis option was found to be the most ideal as

this individual would have had extensive research and writing practices that can be without having technical expertise become overly specific.

Discussion and Implications

The way a student obtains certain skills and can apply and transfer those skills to different contexts is of extreme importance (Matsumoto et al., 2005). Our findings can be best used to highlight for graduate programs in engineering the importance of incorporating professional skills into their curriculum. We often hear of this need at the undergraduate level, but the same kind of logic also applies at the graduate level. All recent alums stated that they had some on-the-job learning and growth required in certain areas, such as cross-disciplinary work, that are not always included in their educational content. This misalignment creates a gap centered on skill demands not being met by engineering graduate programs. At the same time, this misalignment raises questions about the extent to which engineering graduate programs should cater to industry demands.

The Systems Approach for Better Education Results in Workforce Development framework (Tan, 2013) provides a qualitative conceptual framework focusing on how skill demands, and skill supply have a direct impact on the growth of a productive workforce and employment results. An unsuccessful pairing of skill demands and workforce needs can lead to slower growth and joblessness. The WfD framework is used primarily to address two different expectations: enabling individuals to obtain a skillset and a collection of different attributes to grow as a practitioner and providing employers a way to display current expectations of their job.
The number of PhD engineering students who complete their program continues to increase (Smith et al., 2024). However, a large percentage of these individuals seek employment outside of the academic environment. This metric needs to be further evaluated to see how a person decides to stay or leave the overall field of academia and if this is associated with job demands. Regardless of which employment sector a student enters upon program completion, the graduate program must offer more opportunities to be successful in other career areas (Denton et al., 2024).

When relating our findings back to both research questions surrounding the preparedness of an individual with a graduate engineering degree, our findings further advance research related to a student's preparedness when transitioning from graduate school to industry or government. Understanding that recent graduates feel underprepared on professional skills is critical in finding ways to advance their career trajectories. For the alumni that believe their educational path was too specific and who searched for broad career paths, career options could be overlooked or result in making uninformed career decisions.

PhD graduates play a crucial role in developing innovation and knowledge. However, PhD recipients can be overqualified and underpaid based on their levels of education and expertise on a topic. Some open job positions do not hold employment opportunities (e.g. pay, skill, or knowledge) for doctoral recipients. If a PhD holder takes an open position to become employed, this can offer high amounts of negative mismatch or an environment that is not aligned with their overall educational and career interests. Skill misalignment in certain industries can lead to low job satisfaction and higher turnover (Di Paolo & Mañe, 2014). Across the executive interviews, the master’s thesis was found to be most ideal within structural engineering. Obtaining a

master's degree while pursuing the thesis track provided individuals with a level of research that was more transferable across industries without becoming too specific. Based on some industry standards, a PhD may not be the best overall educational plan to help an individual prepare for their professional career.

Conclusion

Our goal of this analysis was to further understand the importance of a graduate engineering degree, specifically of someone who obtained a master's degree while pursuing the thesis option over the non-thesis track; how a graduate degree advances the job candidacy of one individual over someone with only a bachelor's degree; and what level of preparedness these individuals have once they join the workforce. Structural engineering executives raised concerns relating to how an individual who obtained a PhD as opposed to a master's thesis or non-thesis option might not be able to fit their organizations' pay structure, raise questions about being overqualified, or offer expertise that is too specific to their business and client needs. However, the master's with a thesis option allows for an in-depth research and writing component that offers more transferability to market needs without a person becoming "too academic." Regardless of when a recent alumnus makes the transition from graduate school to industry or government, they are often still lagging in professional skills that are needed to be successful, such as collaboration, delegation, and working in cross-disciplinary skills. Graduate programs seeking to prepare their students for the most predominant career pathways in engineering (i.e., industry and government) should seek new ways to foster the development of such skills.

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References

Cox, M. (2020). *Demystifying the engineering PhD.* Academic Press.

Denton, M., Knight, D. B., Deters, J. R., Grote, D. M., & Borrego, M. (2024). Career Paths of Doctoral Recipients in Engineering and Computer Science: Trends by Sex, Race, Citizenship, and Discipline with an Emphasis on Biomedical Engineering. *Biomedical Engineering Education*, *4*(2), 185–197. https://doi.org/10.1007/s43683-024-00140-y

deSilva, D. (2015). (PDF) Employers' Preference on Employability Skills of Business Management and Accounting Graduates. *ResearchGate*. https://doi.org/10.53378/348730

Di Paolo, A., & Mane, F. (2014). *Are We Wasting Our Talent? Overqualification and Overskilling Among PhD Graduates* (SSRN Scholarly Paper No. 2456012). Social Science Research Network. https://doi.org/10.2139/ssrn.2456012

Duderstadt, J.J. (2010). Engineering for a Changing World. In: Grasso, D., Burkins, M.B. (eds) Holistic Engineering Education. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-1393-7_3

Fleming, G. C., Klopfer, M., Katz, A., & Knight, D. (2024). What engineering employers want: An analysis of technical and professional skills in engineering job advertisements. Journal of Engineering Education, 1–29. https://doi.org/10.1002/jee.20581

Karakhan, A. A., Nnaji, C. A., Gambatese, J. A., & Simmons, D. R. (2023). Best Practice Strategies for Workforce Development and Sustainability in Construction. *Practice Periodical on Structural Design and Construction*, *28*(1), 04022058. https://doi.org/10.1061/(ASCE)SC.1943-5576.0000746

Kinoshita, T., Young, G., & Knight, D. B. (2014, October). Learning after learning: Perceptions of engineering alumni on skill development. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings* (pp. 1-7). IEEE.

Klaus, P. (2009). *The Hard Truth About Soft Skills: Workplace lessons smart people wish they'd learned sooner*. HarperCollins Publishers.

Matsumoto, I. T., Stapleton, J., Glass, J., & Thorpe, T. (2005). Developing a framework to measure organizational and employee skills development in a professional engineering design consultancy. *Construction Innovation*, *5*(1), 53–66. https://doi.org/10.1108/14714170510815177

Smith, B., Alldredge, E.-E., Arbeit, C. A., & Yamaner, M. I. (2024). *Graduate enrollment in science, engineering, and health continues to increase among foreign nationals, while postdoctoral appointment trends vary across fields* (NSF 24-320). National Center for Science and Engineering Statistics (NCSES), National Science Foundation. https://ncses.nsf.gov/pubs/nsf24320/

Tan, J.-P. (2013). What matters for workforce development: A framework and tool for analysis. SABER Working Paper Series. https://documents1.worldbank.org/curated/en/608191468326178977/pdf/799020WP0SABER0Box0379795B00PUBLIC0.pdf

Thiry, H., L Laursen, S., & G. Loshbaugh, H. (2015). "How do I get From Here to There?" An Examination of Ph.D. Science Students' Career Preparation and Decision Making. *International Journal of Doctoral Studies*, *10*, 237–256. https://doi.org/10.28945/2280

Weaver, A., & Osterman, P. (2017). Skill Demands and Mismatch in U.S. Manufacturing. *ILR Review*, *70*(2), 275–307. https://doi.org/10.1177/0019793916660067