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The Impact of Gender Identity on Early-Career Engineer's Perception of Expertise

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I am an early-career engineering education scholar and educator. I hold a B.S. in Chemical Engineering (with Genetics minor) from Iowa State University, and an M.S. and Ph.D. in Chemical Engineering from The Ohio State University. My early Ph.D. work focused on the development of bacterial biosensors capable of screening pesticides for specifically targeting the malaria vector mosquito, Anopheles gambiae. As a result, my diverse background also includes experience in infectious disease and epidemiology, providing crucial exposure to the broader context of engineering problems and their subsequent solutions. These diverse experiences and a growing passion for improving engineering education prompted me to change career paths and become a scholar of engineering education. As an educator, I am committed to challenging my students to uncover new perspectives and dig deeper into the context of the societal problems engineering is intended to solve. As a scholar, I seek to not only contribute original theoretical research to the field, but work to bridge the theory-to-practice gap in engineering education by serving as an ambassador for empirically driven educational practices.

Madeline Roth

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Introduction

This full paper seeks to share insight on the relationship between early-career engineers' perceptions of personal expertise and their gender identity. This research is an effort to expand upon a previous study regarding engineers with 6+ year of experience and how their respective identities influenced their perceptions of personal expertise [1]. This experienced participant population was chosen based on the known links between expertise and experience [2][3], and this work suggested that identity, particularly gender identity and whether the participant had experienced a transition into a management role, impacts how an individual responds to the question, "What is your expertise?" [1]. Specifically, women were more hesitant to claim expertise and men were more likely to report having multiple expertise [1]. This result generated new questions regarding how these observations may or may not translate to the population of engineering practitioners we had not studied – those with up to five years of experience. Studying a sample of early-career engineers will provide insight into both how and when practicing engineers begin to perceive themselves as experts and whether that timing is influenced by gender identity, contributing knowledge to understanding expertise in workforce development.

This work is situated within a larger effort to define the construct of engineering intuition and its relation to engineering expertise. The work presented here progresses the over-arching goals of the larger effort by shedding light on whether gender and experience confound perceptions of expertise, and subsequently may influence engineering intuition.

Background

In this study we contribute to the existing knowledge surrounding gender dynamics in the engineering profession by looking at the impact of gender identity on early-career engineers' perceptions of their expertise. Women have historically lacked representation in the field [4] of engineering and their expertise is often devalued in workspaces dominated by men [5]. We are interested in how this dynamic subsequently shapes perceptions of personal expertise among early-career engineers.

Existent literature describes the expert as an individual who uncovers solutions to problems without conscious thought towards skill use [2]. Experts proceed through scenarios by utilizing key information effectively, which allows them to conjure a plethora of possibilities. So, while skill use is subconscious, experts are able to utilize declarative knowledge (knowing what) and procedural knowledge (knowing how) to consciously deliberate on the best solution [2]. Experts are able to easily obtain knowledge to do so by utilizing their working memory as opposed to short-term memory [2]. Gaining expertise requires unique skill sets, including (1) pattern recognition, (2) content knowledge, (3) knowledge application under varying circumstances, (4) ease of knowledge retrieval, and (5) flexibility in approach to unseen scenarios [3]. These attributes can be more broadly contextualized as expert knowledge, expert reasoning, and expert memory [2].

The underrepresentation of women in the scientific community can discourage women from remaining in STEM fields [4]. Literature suggests that gender composition in the workplace influences the extent to which women's expertise will be recognized, regardless of educational history or technical expertise [5]. Women's expertise is thus less influential in environments dominated by men, such as engineering, as the gender composition renders the expertise as perceived to be less valuable. These gender dynamics could discourage women in engineering, subsequently shaping their perceptions of their own expertise in a negative manner. This has the potential to further influence perceptions of overall career identity within engineering negatively, which can perpetuate the underrepresentation of women in STEM.

In this paper we characterize early-career engineers' perceptions of their expertise, with a particular focus on the potential impact of gender. We also provide a comparison of these results from early-career engineers to previous work with a population of mid- to late- career engineers. Experience is essential to expertise development [2][3]. Thus, early-career engineers may be more hesitant to claim an expertise as their own due to their lack of experience. Gender identity may further influence perceptions of expertise, as shown in our previous work with engineers having 6+ years of experience in which men tended to report multiple expertise as their own. This suggests that men are more confident and comfortable as experts in engineering fields, perhaps because they are predominantly surrounded by other men who value their expertise without question. We hope to understand if this trend extends to a population of engineers who have had little time to develop their engineering expertise in the workplace.

Methods

Data was collected through a series of semi-structured interviews with 10 early career engineers. Each respective interview underwent a robust qualitative coding process in accordance with best practices in literature [6][7][8].

Sample

The sample population consists of 10 practicing engineers in the early stages of their career (0-5 years of experience). This sample was chosen in effort to contrast our previous study, as literature identifies experience as essential to expertise development [2][3].

Participants were recruited from a population of engineering alumni from a private, liberal arts college on the east coast via a screening survey. We did not require participants to be employed in any particular engineering field in effort to gain a diverse range of perspectives. The chosen sample included five self-identified men and five self-identified women. (Note: no other gender identities were reported among the recruited sample pool.) Oversampling of women was deliberately pursued to amplify narratives and experiences of this non-dominant group. Ten participants were sufficient for saturation in this sample [6]. Table 1 summarizes relevant participant demographics in aggregate to avoid potential identification.

Table 1: Sample Population

Descriptor	Participant Representation
Gender	Women (n=5) Men (n=5)
Race/Ethnicity	White/Caucasian (n=10)
Years of Experience	1 (n = 0) 2 (n = 3) 3 (n = 3) 4 (n = 3) 5 (n = 1)
Role Change	Yes (n=6) No (n= 4)
Undergraduate Degree	Chemical Engineering (n=3) Biomedical Engineering (n=2) Civil Engineering (n=5)
Graduate Degree	N/A

Data Collection

Data was collected in Fall 2021 through semi-structured interviews via Zoom. Interviews, on average, lasted between 20 to 30 minutes. Two members of the research team were present in each interview – the primary interviewer led the conversation and a secondary interviewer observed and provided input. We utilized this approach to ensure that interview protocol was consistently met. Each interview was recorded and later transcribed.

The interview protocol was a slight modification of what was used in previous work [1][9]. Changes centered on adding additional probing questions to gather richer data, however, the core of the interview protocol remained, aiming to capture the interviewees': (1) academic and professional background, (2) development of expertise, (3) decision-making and problem-solving approaches used in the workplace, and (4) definition and perception of engineering intuition. Here, we focus solely on the development of expertise portion of the protocol.

Data Analysis

Data analysis included a robust qualitative coding process using a previously developed codebook [1][9][10]. Each interview transcript was independently analyzed and coded by two team members. Coded interviews were discussed line by line to ensure code consistency, which resulted in a singular, agreed upon coded copy of each interview.

Once code agreement was achieved, data was transferred digitally into qualitative coding software, Dedoose. This process entailed having a primary researcher input the agreed upon codes, followed by a secondary researcher to check for consistency. Participant demographic information was also input into the software.

Only select questions from the interview dealing with expertise and expertise development were analyzed, as noted in previous sections. In this study, self-reported gender identity is the

demographic of interest. Thus, we tabulated code frequencies to gain insight into trends across gender identity. In particular, mindset parent codes were further broken down into subcodes as shown in Table 2 [1]. The additional sub-codes align with the emergent themes uncovered in the previous study [1]. These subcodes either deal with the type of skill reported as expertise (technical vs professional) or the confidence one exudes in identifying with expertise (active vs passive) [1]. We analyzed the intersections between these additional subcodes and gender identity by looking at sub-code occurrences and frequency.

Table 2. Definition of Mindset Subcodes [1]

Mindset Sub-code	***Definition***	***Examples from Interviews***
Technical Skill	Qualities acquired by using and gaining expertise in performing physical or digital tasks [11].	"My expertise is high speed boundary layer transition…"
Professional Skill	Personality traits and behaviors; the behaviors you display in different situations [11].	"Being able to, to sit and look at things objectively."
Passive Ownership of Expertise	Lack of confidence in identifying with personal expertise.	"I wouldn't say I have like a deep expertise in something."
Active Ownership of Expertise	Presence of confidence in identifying with personal expertise.	"I know the products of my company better than probably somebody else who just quickly looked at the data sheet."

We analyzed code occurrences, co-occurrences, and code frequency across the remaining codes and looked for trends with gender identity. We did not normalize data reported, as there were an equal number of men and women participating in the study.

Results and Discussion

Data analysis yielded emergent patterns within the participant population with regard to overall career experience and gender identity. Table 3 shows the frequency of subcodes (Table 2) according to gender identity. Hits refers to the number of cases in descriptor sub-groups with one or more excerpts tagged with a particular code.

Table 3. Sub-code Occurrences by Gender (Hits)

	Women	Men	Total
Technical Skill	5	4	9
Professional Skill	1	1	2
Active Ownership of Expertise	5	5	10
Passive Ownership of Expertise	3	3	6

Gender Identity

In our sample population, gender identity did not appear to influence participant perceptions of expertise with regard to ownership of expertise and the type of skill reported. As shown in Table 2 above, the frequency of both active and passive ownership codes was split between men (n=5, n=3) and women (n=5, n=3). Similarly, the type of skill reported did not vary much between men and women. These results differ from our work with more experienced engineers, in which men tended to identify multiple expertise as their own [1]. The implications of these results may suggest that having a lack of experience acts as "common ground" across gender identity, allowing for more similarities in perceptions of expertise. Furthermore, the institution from which the sample was recruited from is a small liberal arts college, where small class sizes facilitate active learning, faculty availability, and supportive environments [12]. The nature of a liberal arts education prepares engineers for the workforce in a different manner than larger, research focused institutions [12]. Liberal arts institutions can be effective in facilitating environments that encourage women's retention in engineering by shaping courses to increase confidence [13]. These factors may have had a positive influence on our sample population's perceptions of expertise, where gender disparities were less apparent.

Degrees of Expertise Ownership

Of the 10 participants, six expertise statements reflected both active and passive ownership of expertise. These statements often began with dismissal of expertise through a negative sentiment towards a past expertise or a declaration of skills that they did not possess followed by what they considered their current expertise to be. For example, one participant proclaimed, "I have less of an expertise in some specific engineering and more of an expertise in engineering in conjunction with people management." This pattern of introducing expertise by first dismissing other expertise was unique to this sample. Our previous work with later career engineers did have instances of active and passive co-codes but did not display the same trends discussed above [1]. In directly comparing the two samples, lack of experience combined with the unique challenges of transitioning into the workplace may be key factors to the differences observed in expertise perception. The transition from being a student to a full-time practicing engineer can be a complex experience, despite the robustness of engineering degree programs [14] [15]. Developing expertise may be a confounding component of that complexity, particularly in regard to the process of establishing career identity [1][15]. The hesitancy seen in participant expertise responses may be attributed to the time period of adjustment and self-discovery early career engineers may be met with upon graduation [15].

Conclusions

Gender identity did not seem to impact whether a participant reported a technical or professional skill, either passively or actively among a population of early-career (0-5 years of experience) engineers. This result directly contrasts prior work with engineers who have 6+ years of experience, suggesting that experience may play a stronger role in perceptions of expertise in early-career than gender identity.

The relationship between experience and perceptions of expertise is further supported by how participants framed their expertise. More than half of the sample population responded to the expertise question with an initial sense of hesitancy and even denial of expertise, followed by a confident assertion of what they believed to be their current expertise. This emergent trend was unique to the early career sample, indicating that lack of experience does impact how one perceives themselves as an expert – often timidly.

These results bring to light potential extensions of this work to further verify methodology and contextual basis for emergent results. We acknowledge that the sample used in this study was recruited from a pool of engineering graduates from a singular liberal arts university and lacks diversity in other demographic categories such as race/ethnicity and highest earned degree. Expanding this study to include a wider range of demographics and diversity in type of institution used for participant recruitment will strengthen our existing results or reveal new ones.

The takeaways from this study will be used to strengthen our understanding of expertise development in the engineering workforce. Identity itself is complex and multifaceted and may be intertwined with expertise depending on a multitude of variables which warrant further exploration.

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