

The Glue in Leadership: Investigating how Women Leaders in Engineering Education Value People and Connections*

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The experiences and strategies of women faculty serving in leadership roles is understudied in the field of engineering education. This study begins to document how women leaders in engineering education engage in leadership using the Kern Entrepreneurial Engineering Network's (KEEN) Entrepreneurial Mindset (EM) as a lens. We conducted a thematic analysis of a series of artifacts associated with a workshop that aimed to generate conversation on leadership among a group of 14 women holding a variety of leadership positions in engineering education exploring how women leaders discussed their leadership roles. We also conducted in-depth interviews with 10 of the participants. We found that the women leaders in our study emphasized the importance of people in regard to connections. Within connections people were information sources to obtain insight and were considered when managing and assessing risks. The findings expand upon the current conception of connections as described in the EM framework. As we increase our knowledge of women's experiences and strategies in leadership in engineering education, it will improve our ability to recommend methods for establishing, growing, and using connections within the field.

Keywords: engineering leadership; women in engineering; leadership development; engineering education

1. Introduction

The discipline of Engineering Education (ENGE) is an exception to the typically male-dominated leadership reflected in other engineering disciplines. Many ENGE leaders who helped establish the field are women [1]. Additionally, many of the formal and in-formal leadership positions in ENGE programs are currently held by women, including Purdue, Virginia Tech, Florida International University (FIU), and more. Some of these women did not have prior leadership training or experience and just knew that the work needed to be done to create a new discipline and continue to sustain developing programs. Much of what is known comes from personal experiences and investigation of program media such as websites, as there is little published literature regarding this phenomenon. Recognizing

women faculty serving in leadership roles is understudied in ENGE, this study begins to document how women leaders in engineering education engage in leadership. Part of a larger study, this analysis specifically uses the *Valuing Connections* component of the KEEN Entrepreneurial Mindset (EM) framework [2]. Using a thematic analysis of a series of artifacts associated with a workshop that aimed to generate conversation on leadership among a group of women holding a variety of leadership positions in engineering education, our research addresses the question of **how do women leaders in ENGE value connections in their leadership roles?** Our findings expand the current conception of connections as described in the framework as the women leaders in our study emphasized the importance of people in regard to connections. People were information sources to obtain insight

and people were considered when managing and assessing risks. As we increase our knowledge of how connections are valued, it will improve our ability to recommend methods for establishing, growing, and using connections within ENGE leadership.

2. Literature Review

Literature exists in the field of leadership studies regarding what leadership “looks like” in terms of skills and characteristics, how to develop such leadership skills, and frameworks [3]. However, such research is not universally transferable in that it is important to understand the context of the literature to help ensure its applicability for a given audience and situation. For example, though skills and characteristics may be similar, differing contexts and settings may result in different dynamics and outcomes. Important for our work is understanding gaps in the literature regarding engineering education faculty leadership, gender differences, and applicable frameworks.

Existing literature regarding leadership experiences for ENGE administrators is not as prevalent. Much of the current literature on leadership in engineering education and the foundational work in the field focuses on studying engineering undergraduates’ leadership perceptions, development, and experiences [4–8]. Studies have also focused on efforts to evaluate and assess students’ engineering leadership skill development [9] and the long-term effectiveness of engineering student leadership programs [10]. In terms of faculty and academic leadership, there has been some work documenting leadership journeys of leaders in engineering and engineering education [1, 11]. For example, The Pioneers Project [1] focuses on the engineering education pioneers and early leaders that led to the development of the field as a research discipline. However, research regarding leadership development and training of engineering education leaders and administrators is lacking.

In the field of engineering education there has been some focus on the role of gender for leadership interventions [12, 13], leadership in engineering workplaces [14], and in STEM disciplines [15]. These researchers recognize a gender gap exists in engineering education leadership. They suggest that men and women are interested in leadership at a similar rate; however, men are more often identified as exemplary leaders by both men and women. Researchers also found women faculty who are interested in leadership positions want leadership development opportunities that include basic business skills to do their job well and skills related to the relational aspects of leadership positions such as

mentoring. They found that a more participative organizational structure was well suited for women’s leadership styles. Additionally, international scholars have posited that leadership in engineering education could support gender equity goals [16]. Again, there has been some research on interventions and engineering workplace leadership, but there exists a gap on leadership preparation and development for women in engineering education administrative and leadership roles.

However, for engineering leadership development, entrepreneurship and the EM framework has been recognized in several prior studies as valuable for leadership knowledge and skill development [17–20]. More specifically, studies of EM of engineering students have used the KEEN framework as the lens or focus of their work [21–25]. Thus, due to the gaps in literature and existing studies of EM for leadership development, this study used the EM framework to expand the current research examining women as academic leaders in engineering education.

3. Framework

The KEEN EM framework includes three C’s: Curiosity, Connections, and Creating Value [2]. Curiosity refers to the recognition that our world is constantly changing such that solutions for today may not be the solutions for tomorrow. According to the KEEN EM framework, those with an EM have a relentless *curiosity* which will contribute to their desire to investigate and make new discoveries. However, these discoveries must *connect* to other information and knowledge in order to gain insight and contribute to innovative solutions. Finally, an innovative solution is most meaningful when it *creates value* for others. Innovative solutions that are valued by others meet the needs of our changing world.

Other researchers have used the KEEN EM framework for understanding EM in engineering education [23–27]. Brunhaver et al developed an instrument that could be used to assess engineering student EM before, during, and after an entrepreneurial experience [23]. London et al organized engineering faculty and student’s entrepreneurial behaviors and mindsets according to the three Cs put forth by the Kern Family Foundation to develop a tool for assessing student EM [27]. Wheadon and Duval-Couetil claimed that the goal of EM learning provides more than entrepreneurship knowledge and skills, but additionally provides students an opportunity “to approach engineering problems and challenges in a more entrepreneurial way” [25, p. 17]. Bekki et al further

argued for equipping engineering students with a mindset that would “enhance their performance in any job they have in the future” [24, p. 7]. The characteristics they described are reflected in the KEEN EM framework.

In this application, we examined the experiences shared by the women leaders in Engineering Education who participated in the 2021 KEEN funded Women in Leadership (WIL) workshop. We adapted the framework for this context by replacing “student” with “leader” in the EM framework: **Curiosity**: Leaders will demonstrate constant curiosity about our changing world and explore a contrarian view of accepted solutions; **Connections**: Leaders will integrate information from many sources to gain insight and assess and manage risk; and **Creating Value**: Leaders will identify unexpected opportunities to create extraordinary value and persist through and learn from failure. This modified framework was the lens through which the workshop organizers explored the EM of women leaders in ENGE.

This study specifically focused on the connections component of the KEEN EM and identified emergent sub-themes. The KEEN EM identifies connections made by integrating information from many sources and by assessing and managing risks. Activities identified to inspire connection making include integrating technical topics, thinking about potential unintended outcomes of one’s work, planning for scaling decisions, and repeatedly assessing the “What if?” [2]. Our study explored how women leaders in engineering education perceive connections in their leadership roles and more specifically their integration of information and their assessment and management of risks.

4. Methods

We used qualitative methods and a case study approach where the “Women in Leadership” workshop is the case. A case study approach was fitting as we constructed knowledge through our investigation and interpretations of themes that emerged from the study. Additionally our study encompassed Stake’s four defining characteristics of qualitative case studies that include being holistic and interpretive [28]. We used thematic analysis due to the flexibility of this method to identify the themes that emerged from the participants sharing their leadership experiences. In addition, we were able to align how those experiences aligned with KEEN’s entrepreneurial framework to understand how these women leaders in ENGE perceive KEEN EM connections in their leadership roles. The systematic method of identifying, organizing, and applying insight into themes supported our efforts

to focus on “meaning across a data set” to understand the common or collective perceptions [29, p.57].

4.1 The Case and Participants

The WIL workshop project examined aspects of EM and mentoring of women in leadership positions within the discipline of Engineering Education. These women demonstrate an EM even though it is not labeled as such. The project included a discovery process as a first step in building an EM in leadership faculty development program for women leaders within engineering. A two half-day virtual workshop on June 8 & 9, 2021 with a follow-up meeting on October 19, 2021 was held with the intentional and explicit goals of establishing an agenda for a formal workshop on EM leadership for women in engineering. During the WIL workshop, large and small groups were organized to continue the exploration of their leadership experiences and the tools they used in their leadership roles. Participants were invited based upon their leadership roles, their faculty level, and length of service in their roles. Using the EM framework as a lens, participants were asked to capture and reflect on their leadership activities, challenges, and experiences. They were also asked to read literature regarding the EM Framework and volunteer to interview with one of the WIL workshop co-leaders. Of the 14 total attendees, 10 of the women participated in an additional interview. Fifteen academic institutions were represented by the participants and facilitators of this project. Both private and public institutions as well as research focused and teaching focused institutions. Women engineering educators at varying levels were also represented. Several shared the desire to connect again and build a supporting network due to the value they found in connecting with each other during the workshop. In addition to the participants valuing the overall opportunity to share and learn from one another, post discussions and analysis of the WIL workshop discovered emerging themes and subthemes. Although the initial analysis was grounded in EM with several supporting datasets, this study of women leaders in engineering education focused on the EM connections theme and sub-themes of integrating information and assessing and managing risks.

The sample size for this study is consistent with thematic analysis and qualitative research [29, 30]. The purpose of this study is to understand the experiences of these women and provide transferable insights. Qualitative research, including thematic analysis, promotes transferability of findings as opposed to generalizability [31]. Therefore, it should be noted that our findings from the 14

Table 1. Women in Leadership Workshop Data Summary

Pre-Workshop Materials	Interactive Workshop Materials	Documents
<ul style="list-style-type: none"> • Weekly Reflections (text) • Registration Questionnaire • One-on-one interviews (n = 10) 	<ul style="list-style-type: none"> • Day 1 Large Group Session • Day 2 Large Group Session • Shared Group Discussion • Breakout Sessions – Workshop notes 	<ul style="list-style-type: none"> • Pre-assigned Readings (4 articles) • Summary of Themes from project PIs/ participants

participants could be transferable to other contexts but we make no claims regarding generalizability of the data.

4.2 Data Collection

Our thematic analysis drew on the WIL workshop data. Data collected from the WIL workshop constituted pre-workshop materials attendees were asked to complete, one-on-one semi-structured interviews, and interactively generated workshop artifacts. Table 1 summarizes all the data used for analysis.

4.3 Thematic Analysis

Our thematic analysis (TA) followed the approach outlined by Braun and Clarke [29]. Multiple individuals (the six authors of this study) were involved in various aspects of the data collection and analysis. This approach contributed to the overall quality of the work by functioning as researcher triangulation [32, 33]. The process for TA took place as follows: Phase 1 – Get familiar with the data; Phase 2 – Generate Initial Codes; Phase 3 – Search for Themes; Phase 4 – Review Potential Themes; Phase 5 – Define and Name Themes. Phases one through four were conducted by Author 3, who had not attended the workshop, and then phase five was conducted by Author 1. Quality measures were taken by all authors on the research team and participants.

In getting familiar with the data, Author 3 initially used meetings with the project PI to generate contextual understanding of the purpose of the workshop, its format and timeline, and the associated data collection process. After reading the four articles that were assigned to workshop attendees to orient themselves to the KEEN EM framework, Author 3 then iteratively reviewed the pre-workshop materials (e.g., weekly reflections, questionnaire responses) and the data generated interactively by the attendees during the workshop (e.g., Jamboards and presentation slides). Utilizing the EM framework's 3C's (e.g., creating value, curiosity, connections) to form an initial set of a priori codes to guide the first analysis of the data, the data were reviewed in their original format where possible [29]. For example, video recordings of each interview were replayed at 1.5x the speed alongside the corresponding interview transcripts. Using a combination of annotated notes on tran-

scripts and voice memos, Author 3 tracked patterns and ideas that occurred during the coding process. For example, under the code of connections, many stakeholder groups were frequently emphasized in the data, and several participants demonstrated a penchant for intentional relationship building.

In searching for themes, Author 3 created categories of similar codes and grouped them into themes and sub-themes. Author 3 regularly reported preliminary findings and received feedback on initial data patterns from the project PI. Feedback from researcher triangulation with the author team led Author 3 to focus the subsequent coding round on just the interactive workshop materials. Briefly, Author 3 used NVivo qualitative analysis software to generate automated codes of the interactive workshop materials as a tool for identifying salient passages. All identified segments of text were manually checked and deleted if the auto-generated code and subsequent line of text did not readily adhere to one of the workshop topics. Comparing the codes from the manual analysis to the NVivo generated codes, the more salient codes seemed to coalesce around a shared leadership experience.

After developing the initial thematic patterns, Author 3 engaged in a recursive process of comparing the coded data, emphasizing the codes coming from the interactive workshop materials to the potential themes. This recursive process was supplemented by reviewing the Author's own recorded voice memos, written notes, and meetings with the project PI. All of the analysis components were used to evaluate how the coded content and complete data set fit with the themes.

The findings were considered against the larger context of engineering education and the most salient themes were examined holistically. The codebook with an example code for each theme can be seen in Fig. 1.

In the final analysis phase, the salient themes were defined and given names. Some themes were further condensed if they exhibited too much overlap or renamed to capture the scope of their meaning better. After Author 3 completed the recursive process of selecting potential themes, Author 1 picked up the thematic analysis to define and name salient themes. Author 1 met with Author 3 to facilitate the transfer of the data analysis then reviewed all the data collected as well as the

Theme	Sub-theme	Example Quote
INTEGRATE information from many sources to gain insight	Networking	"I reached out to others with expertise. I don't have to improve my leadership, specifically related to a particular topic. Well, I think I do a good job in this space, I know I can learn more and leveraging connections is one way to do that."
	Creating Space	"But I think that empathetic leadership approach really helps with creating an environment where people feel like they're respected, and their voices are heard."
ASSESS and MANAGE risk	Being comfortable with and persisting through failure	"...at some point, I think in our group, we mentioned having those difficult conversations, pushing the boundaries, not being afraid of being uncomfortable."
	Understanding Tradeoffs	"Because of me being a leader means I can no longer do the things I love like going to the classroom, and play with my robots, then I don't know if that's going to be a win for me."

Fig. 1. Codebook with example quotes for sub-themes.

potential themes selected by Author 3. After reviewing the themes Author 1 found a significant thread of connections related to the KEEN framework and scoped the thematic analysis for this paper to explore the women's perceptions of connections in their engineering education leadership roles.

Consistent with Walter et al.'s [33] description of qualitative research quality, in making and handling the data we considered quality through continuous investigator triangulation [30, 31] and member checking. As four of the authors (Beauchamp, Matusovich, Caricco, and Adams) were directly involved in the planning and facilitation of the workshops and three of the authors (Beauchamp, Matusovich, and Adams) are currently in academic leadership roles it was important to continuously reflect on researcher positionality throughout the project [34]. Additionally, Hall was a postdoctoral scholar and Vicente was a graduate student at the time of their analyses. Hall and Vicente were not involved in execution of the workshop, however, they conducted thematic analysis of the data, and conducted member checking with the rest of the authorship team to support research quality.

5. Results

To aid in answering our research question, "how do women leaders in ENGE value connections in their leadership roles?", we found that our participants described two primary categories in how they perceived connections: (1) integrating information from many sources to gain insight, and (2) assessing and managing risk. Importantly, each of these two categories also had sub-categories that directly related to connecting with people including networking, creating space, being comfortable with and persisting through failure and understanding tradeoffs. Fig. 2 shows these relationships. Note to

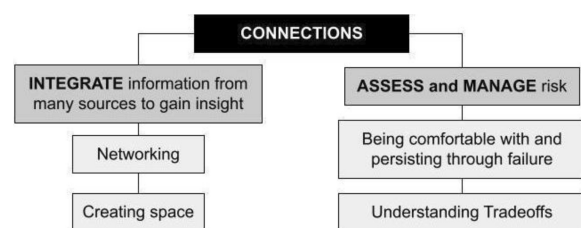


Fig. 2. Themes and subthemes.

the reader that text appearing in italics but without quotations is paraphrased content used to provide rich thick description of the themes without identifying participants or their institutional affiliation.

5.1 *INTEGRATE Information from many Sources to Gain Insight*

In our data, we found that women in engineering education leadership often viewed people as sources of information and worked to integrate information through building relationships, both inside and outside of their departments. As a result, the two sub-themes under *Integrate information* were networking and establishing their environment.

5.1.1 *Networking*

Networking is one way that many of the women discussed gaining insight from sources (i.e., people) as part of building a network outside of their primary department but still within the broader field of engineering education.

While communication was part of networking, the focus was on the parties involved, not necessarily the ideation of topics but rather creating connections and working well with others. While networking and relationships were salient in the data, this is not to suggest that participants felt particularly adept at networking. On the contrary, participants communicated difficulty networking, but all appeared to underscore the relative importance of having networks and leveraging those

networks in their leadership roles. Essentially there was an emphasis on knowing whom to know and how to connect to gain insight. One participant noted that in transitioning to a new institution they realized the value of networking in their leadership role, stating:

“It took me a while to realize how important that was [networking and relationship building], whereas now that I’m in a new institution, I do that more intentionally.”

Participants also noted the importance of considering your context in networking but that the context should not be limiting. As one participant reflected:

“. . . context can be very unique, but context does not influence the connections you can make or sustain, or how those connections have to happen. And so yea, I guess the big takeaway is connections are complex.”

Although the ability to form deep trusting relationships was definitely a necessary skill to have as a leader. Participants discussed how they used networking and relationship building to initiate change and gain honest feedback. One participant noted, “I think the more intimate ones [relationships] are the key because without them, no change can happen?” Relationships supporting change were referred to as initiating change in work context as well as personal change and growth. Along the lines of personal change another participant stated, “If you are within a more intimate circle, trust and connections and in-depth connections are really important.”

With regards to institutional context, many participants cited building and sustaining a network of peers and mentors outside of their home department, especially those with smaller or newer engineering education departments.

We found that women leaders at all levels, from assistant professors to deans, emphasized the importance of having internal connections and an external network, however, across the group they relied on connections for different purposes. For example, a participant in a newer leadership role described that they relied on their external network more heavily than their internal connections when asking for advice to receive an outside perspective. Another participant explained that due to the small size of their department they relied on their outside network for advice and also had to build strong internal connections with other faculty in their department in order to recruit and retain graduate students. For this participant, they realized that much of their initial leadership work as an early-career faculty member had gone unrecognized through conversations with an external mentor. It was through these conversations and the support of

their network that they were able to receive credit for their leadership.

5.1.2 *Creating Space*

Participants consistently mentioned or emphasized the need to “create an environment where everyone feels comfortable to share their thoughts” in their leadership roles. While some instances included formally creating a committee and setting aside a scheduled time and place to confer and work together, other discussions included intentionally fostering an inclusive climate to make connections in both their leadership and teaching roles.

One participant reflected on establishing an environment conducive to information sharing. They reported considering:

“How could we create this space where we learn from other people where we can ask questions like, ‘Oh, I’m looking for a new job, what things should I think about?’ Or, ‘Oh, I’m doing a [project] for budgeting, can someone share with me what you’ve done?’ Yeah, we just had a really nice conversation. We didn’t solve anything, but we feel like we’ve got a good sense of the space.”

This idea of information sharing relates to the overarching theme of integrating information and connections. Through establishing an environment in their own department they were able to create a space for faculty to learn from each other through the sharing of information. This sub-theme came up several times throughout the workshops particularly through the concept of “creating space”. A participant noted that while creating space is not necessarily a gendered concept, it had been a significant point of discussion and an important quality of leadership. They shared an example of connecting with a peer in a meeting to make their point:

“. . . I was worried about this person in a meeting because I was afraid they were feeling left out, so I connected them in. So I think that also relates back to a space, not unique to women, because as we said, gender is not a binary neither [are] characteristics, but it [creating space] does seem to be a resonating strength that has come up throughout the entire [workshop]. So just kind of . . . Surprisingly, maybe not surprisingly, it did not come up as a skill.”

Additionally, it was evident that mediating the climate was a skill that participants employed not only in their leadership roles but also in their roles as educators and leaders in the classroom. One participant described a successful intervention that they had created between faculty and students:

“And what it ended up doing was creating conversations between students and faculty on a very intimate way because there were things that faculty had not considered and there were things that students have

not considered but creating a medium so [their] value could be created commonly was very helpful.”

Other faculty discussed their efforts to create an inclusive environment in the classroom and overall were aware of the leadership role that they held in learning environments. This awareness led to an intentionality in establishing their classroom and laboratory spaces.

When explaining how they went about establishing an environment in their roles the women brought up different leadership relationship building strategies. One participant emphasized their leadership style and stated, “I think that empathetic leadership approach really helps with creating an environment where people feel like they’re respected, and their voices are heard.” Another explained how they were able to help create an inclusive space through smaller interactions and connections. Stating:

“On just a day-to-day meeting level, I think that [the] conversational turn-taking is the most powerful sort of skill that I have learned and the best way to build a sense of belonging in a group.”

While it may seem like a small action, the participant noted that the day-to-day interactions made a large impact in building relationships and creating an inclusive environment. Additionally, these daily interactions are an example of the broader theme of integrating information to gain insight within their environment.

Lastly, it is important to note that the various spin-off discussions on leadership often ended in consideration of the people impacted by whatever decisions were to be made. This demonstrates that participants valued their stakeholders and were mindful of their needs. Throughout the workshop, the leaders also showcased an appreciation for bottom-up communication by intentionally creating modes for formative feedback. With one participant stating in addition to their own information they were “. . . then also being so thankful and grateful that people have spent the time giving input.” On top of the intentional strategies discussed above, the leaders sought feedback within their environment as a way to gain additional information and insight. By considering the stakeholders within their environment and integrating feedback the leaders were able to establish an inclusive environment.

5.2 ASSESS and MANAGE risk

Throughout the workshops and reflections there was a discussion of “risk”. Calculating the risk often took into consideration: *to whom, at what cost, to what gain?* where participants discussed the nuances associated with taking risks as a leader.

One leader stated, “. . . at some point, I think in our group, we mentioned having those difficult conversations, pushing the boundaries, not being afraid of being uncomfortable.” In our data, we found that women in engineering education leadership assessed and managed risks associated with their position.

5.2.1 Being Comfortable with and Persisting through Failure

In assessing and managing risk, the participants were assessing for and attempting to manage possible failures. While many of the women did not see failure as a fully negative outcome, they felt that it was still important to minimize consequences and risks associated with such failure.

As previously stated, the participants discussed the difficulties with risk taking in leadership and potential for discomfort. Even with the potential for discomfort it was agreed that well calculated risks are worth taking. Despite the consensus of taking calculated risks, risk-taking in leadership was discussed with an air of humility as there was a shared experience of second-guessing oneself and needing reassurance and support after taking said risk. In one instance a participant describes:

“[. . .] But then, basically, running back to our group, this group of people or whoever our trusted colleagues are as a form of self-care, basically, as a form of, ‘I did this thing, help me make sense out of it,’ just a little assurance that this was the right thing to do, even though it felt really uncomfortable and it might actually fail or it might feel like failing.”

This story is a good example of how a leader was able to overcome the initial discomfort by relying on their network for support. Through community support they were also able to make choices that overrode their fear of failure. Throughout the workshops many of the women discussed how they had to learn to deal with and overcome discomfort in their leadership roles. Much of this discomfort was centered around the idea of failure.

In addition to dealing with discomfort, another strategy that was discussed to mitigate discomfort around failure was stopping perfectionism. It was noted that the women felt that they had to live up to higher expectations and standards as leaders than many of their peers, especially for participants with marginalized racial and gender identities. Perfectionism was discussed as a trait that contributed to failure and overwork despite its intention. Several participants discussed that they had become aware that their tendencies towards perfectionism were inhibiting their ability to lead and take calculated risks as a leader.

Lastly, several participants discussed approaching failure through reframing. Instead of viewing

risk and potential for failure as inherently negative several of the women discussed reframing failure as a learning opportunity. As one participant stated, “I think part of it is the learning through failure, . . . like okay, making the mistakes, figuring out, okay, I learned a lot of that this year.” Along the lines of reframing, several of the participants discussed embracing a growth mindset in their leadership role. This growth mindset allowed the leaders to focus on learning through failure and extending grace to themselves as well as those that they worked with.

5.2.2 Understanding Tradeoffs

Throughout the workshop, participants talked about understanding tradeoffs. These tradeoffs often informed participant’s risk assessment and management in their leadership roles.

An interesting finding was that participants considered and weighed the burdens of being chosen or elected to leadership positions to acknowledge that it was not easy work. Being a leader comes with its own downsides, like loneliness which can be exacerbated for women and especially minority women who may already have difficulty fitting in. One participant noted that even before they had started their leadership roles they observed their colleagues, stating:

“But, I watch my colleagues who are in leadership roles and I think, “Gosh, it must be exhausting to just have to be that nimble every single day.”

Another leader acknowledged the tension that often exists in academia between teaching, research, and service. Where leadership roles are typically considered to be aligned with service, the participant discussed that dedicating more time to a leadership role would decrease their research and teaching opportunities.

“If me being a leader means [that] I can no longer do the things I love like going to the classroom, and play[ing] with my robots, then I don’t know if that’s going to be a win for me.”

The acknowledgement of this tradeoff led to hesitation in taking on leadership roles due to the impact on other aspects of the faculty role. While they are currently in a leadership position, the participant’s ideas of a “win” and being able to dedicate time to teaching and research may not be a strong enough tradeoff for them to consider future advancement.

Additionally, isolation is an important tradeoff to note especially given the context that the participants all identified as women leaders in engineering education. This feeling of isolation is not uncommon for women in academia and is especially

prevalent for women of color. One participant noted,

“But I wanted to talk about the connection piece about feeling isolated. Everything that was discussed just makes me realize that as women it’s also gendered and racial for me and it is the most isolating. They already say leadership is isolating in general, but I don’t know if we have good solutions for being the ‘lonely only’ all the time in this(sic) spaces. I find that to be problematic because we know better, but no one is really changing anything to make it better.”

The participant acknowledges that while leadership in general can be isolating, leaders from historically marginalized groups are especially susceptible to isolation due to their race and gender. The isolation that the participants felt was discussed at times in combination with their efforts to establish an environment. It is possible that the isolation faced by these leaders was a motivating factor in making sure that the space they create is inclusive and supportive.

A strategy that many of the participants used to understand tradeoffs was reflection. While reflection was a key component of the workshop, several participants noted that reflection was also a strategy they commonly employed in their leadership roles. A participant told the team,

“I have been reflecting deeply about how my leadership efforts to create value may affect others who are trying to find value in their work and want to enact change authentically. In other words, as a leader in engineering education, how do I carve the way for others while recognizing that my value creation in terms of discovery, sustenance, and overcoming failure may be different?”

This reflection demonstrates the assessment and management of risk as well as the consideration of potential impact. The participant clearly values the work that they do and through reflection is hoping to answer how their leadership and work can contribute to carving out a pathway for others.

Despite the negative sentiment toward some of the undesirable aspects of leadership, participants deduced that their underlying desire to see a positive impact led to a worthwhile effort. One participant shared that they had faced significant challenges in their previous week that motivated them even more to continue in their leadership role in hopes of positive impact. They stated:

“Because of some of the challenges experienced this week, I have been more motivated to take risks in my self-advocacy but also in the advocacy that may support future generations in my field. I will be starting to talk with the gatekeepers and the people who can administratively make change happen.”

This desire for change and impact was also discussed by another participant as they recalled

their motivations for advancing into leadership roles:

“A lot of pioneers, a lot of you said when we were trying to understand why did you seek out these leadership opportunities, that you were the first one to be going down this path, or you brought something new and innovative to the team. And so obviously you kind of [are] voluntold or [told] to be leading that effort. But a willingness to serve, a call to serve to make a difference, to make an impact.”

In referencing the pioneers of the field of engineering education, this participant acknowledged that leadership pathways in the field have changed significantly since it has been established. While the pathways and opportunities may look different now, the motivations and desire to make an impact are still the same.

6. Discussion

The findings of this study add to and align with broader literature on women in leadership in engineering education. Throughout the study, it emerged that the women valued people as connection points for sources of information and that managing and assessing risk were a part of their journeys. This work also contributes to theoretical advances in the application of the KEEN EM framework. Using the framework enabled a deeper understanding of the importance of understanding “connections” as a key characteristic for ENGE leadership.

6.1 *People as Connections*

The results of this study allowed us to deepen our understanding of women in engineering education leadership positions. Several of the initial themes found in the data aligned with the KEEN framework, particularly the overarching concept of connections. This concept was seen throughout the workshop, individual interviews, and reflections through several sub-themes. While not all of the women’s insights and reflections directly related to the KEEN framework concepts and themes, it was found that the participants valued connections in their leadership roles and more specifically viewed people as sources of information. This is a unique contribution to the KEEN framework concept of connections which typically focuses on making connections between ideas or information. KEEN states that “making connections between disparate sources to gain insight is a key component of the entrepreneurial mindset” [2]. The women in our study made connections with the purpose of gaining insight, however, their primary focus was on people as connections and individuals whether their mentors, peers, or team were conduits.

This finding adds to and aligns with prior literature on women in engineering education leadership positions. In our study, the participants discussed the importance of networking and within networking the significance of mentorship. In prior literature, work by Layne [13] discussed how women engineering deans felt that mentorship played a significant role in their leadership. While many of the women felt that they were not particularly adept at networking, it was clear that they valued the concept of a network and mentorship. In addition to valuing their own network and mentors, the women in our study went one step further and prioritized establishing inclusive environments within their own spaces and contexts. This finding is important because the women were focused on having strong mentor and mentee relationships. Additionally, we know from prior research in engineering education that many women enter engineering fields that they perceive as people-oriented [35]. The women in our study valued people and their connections in their engineering leadership roles. In fact, some of the participants cited these values as the reason that they took on their current leadership roles.

6.2 *Risks in Leadership Roles*

The discussion of risk amongst the women is also a significant finding. Prior literature in leadership studies and higher education has shown that academic leaders who identify as women are more likely to face a variety of barriers [36]. The women in our study did not heavily focus on barriers they faced entering leadership positions, however, they discussed the barriers and tradeoffs faced once situated in their positions. These tradeoffs were acknowledged as part of their role as a faculty member and leader within the context of academia. The women in our study assessed and took calculated risks in their role. These risks often affected their work as faculty and related to the systems and structures of academia which traditionally does not place as much value on “service” roles, such as internal leadership positions, compared to the emphasis placed on research. It was also acknowledged by our participants that women of color faced additional barriers and tradeoffs in their leadership roles due to their intersecting identities.

Additionally, a study on female leaders in academic STEM disciplines in the US found that the main assistance women leaders had come from people, not training or institutional structures [37]. This relationship between connections and risk is also seen in our results. In our analysis, connections, the overall theme was related to the sub-theme of assessing and managing risks. Furthermore, our participants discussed how they

used their connections with other people to be comfortable persisting through failure and managing risk. Assessing and managing risk in leadership roles is important to consider for women leaders.

6.3 Contribution to the KEEN EM Framework

An important result of this paper is that people emerged as an important connection for women leaders in ENGE. These women leaders relied on other people as information sources where they gained insight. People were also considered in their assessment and management of risks, such that when evaluating their own actions and risks to themselves, they also considered how their actions could impact other people. The current KEEN EM framework does not emphasize people in connections as information sources or as a consideration in risk assessment and management; however, connections to people emerged strongly in our study.

Therefore, this research contributes a unique application of the KEEN EM framework to leadership in engineering education. While no framework is able to completely capture the nuance of a particular phenomenon or experience, we acknowledge that this framework provided a useful lens through which to view the data as well as to provide a springboard for future analysis and work. With the emphasis on the Entrepreneurial Mindset built into the conception, execution, and assessment of the workshop it meant that the participants were also exposed to the framework. The usefulness of the framework and need for nuance was also noted by some participants. One participant told the researchers,

“After reading, I feel a little bit better about EM as long as we take the focus away from starting a business and more toward being creative and using the qualities for engineering design and improving student attributes.”

6.4 Limitations

There are several limitations to this study. While the KEEN EM framework aligns with the overarching intervention and study, it also may have influenced the data collection. As discussed previously, the goal of the workshop was funded by KEEN and the participants learned about the framework partially through data collection. It is possible that the participants' prior knowledge or learning during the workshop affected the data they gave to the researchers. Lastly, it should be noted that while the purpose of the overarching intervention and research study was to support women in engineering education leadership positions the focus was not meant to imply a gender binary or exclude non-binary individuals in engineering education leader-

ship positions. The intervention was open to all individuals who identified as women regardless of sex assigned at birth.

6.5 Implications and Future Work

This intervention and subsequent research have implications for women leaders in the field of engineering education as well as for departments, engineering and engineering education programs alike. Overall, the concept of connections is important to consider as well as the risk posed by such positions. For women leaders in engineering education, the themes provide useful insights for what others in the field have faced (i.e., persisting and managing through failure, drawbacks) as well as strategies that they can use in their roles (i.e., creating a network, establishing an environment). For engineering and engineering education departments, understanding the experiences and needs of women leaders provides useful insight to guide future interventions, policy, and leadership training.

Moreover, the experiences shared by the participants illuminate that by making the importance of connections more explicit we can immediately improve ENGE's ability to develop leaders. The research also provides insight into how connections matter and thus insight into what could be added to formal leadership training. For example, in leadership training, it could be useful to incorporate discussions on the value of connections among leaders through networking with mentors and peers. Additionally, discussions on assessing and managing the risks that women in academic leadership face could be valuable. On a larger scale, creating space for women leaders in engineering education, whether formally through workshops and conferences or informally through resource lists, could provide significant value to the field as well as the broader engineering community.

Additionally, understanding the experiences and strategies of women in leadership positions in engineering education is important to our research community due to the positionality of engineering education as a field. Future work to support additional research on women in engineering education leadership roles stands to advance the field. Additionally, practical applications and interventions building upon this research have the potential to provide support to current leadership as well as increase the number of women in engineering education leadership positions.

7. Conclusion

This overarching project served as an intervention and research study to explore the experiences of

women in engineering education leadership positions. Through the lens of the KEEN Entrepreneurial Mindset framework, it was found that the women leaders valued people as connections. Our thematic analysis further found that within connections the women built relationships to integrate information to gain insight. The sub-themes under

integrating information were the value of networking and establishing environments. Furthermore, under the overarching theme of connections it was found that many women assessed and managed risks in their leadership roles. This required them to be comfortable with and persist through failure as well as understand tradeoffs from their position.

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