Mid-Career Transitions into Engineering Education Research via Structured Mentorship Opportunities: Barriers and Perceptions

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Abstract

Recent international calls have been made to build capacity in engineering by increasing the number of scholars using research-based instructional practices in engineering classrooms. Training traditional engineering professors to conduct engineering education research (EER) supports this goal. Previous work suggests that engineering professors interested in performing social sciences or educational research require structured support when making this transition. We interviewed 18 professors engaged with a grant opportunity in the United States that supports professors conducting EER for the first time through structured mentorship. Thematic analysis of interview data resulted in four findings describing common perceptions and experiences of traditional engineering professors as they begin to conduct formalised EER: motivation to conduct EER, institutional support and barriers, growth in knowledge, and integrating with EER culture. Within these findings, barriers to entering EER were uncovered with implications for professors interested in EER, funding agencies, and prospective mentors, resulting in suggestions for improving access to EER for professors developing as teaching scholars.

Introduction and Background

A consistent 21st century issue in Australasia has been a below-capacity engineering workforce (Nguyen & Pudlowski, 2007; Crosthwaite, 2019). Improving engineering professors' pedagogical skills improves educational outcomes, including retention (Boles et al., 2012; Sochacka et al., 2020). Employing research-based instructional practices (RBIS) to improve educators' pedagogical techniques has been suggested to support student outcomes and persistence (e.g., Streveler et al., 2007, Trask et al., 2009), though the implementation of RBIS has been limited. Prior work in bridging this gap has been conducted in training professors to adopt RBIS using engineering education research (EER) best practices (e.g., Borrego et al., 2013; Finelli et al., 2014). One method of increasing the adoption of RBIS may be increasing the Scholarship of Teaching and Learning (SoTL), which is a subset of EER research that integrates EER in the engineering classroom (Sochacka et al., 2020).

Many pathways to engage engineering professors in SoTL exist, including training in education practice via traditional graduate pipelines. By increasing the number of researchers who engage with EER, the findings which can be translated through SoTL research to scholarly outcomes can be increased. Additionally, by growing the number of professors who are EER researchers, the capacity of the EER community increases by way of increasing SoTL implementation and the impact and number of prospective mentors. This study focuses on the perceptions of engineering professors making mid-career transitions into EER research, including motivations for these transitions and barriers faced when entering EER spaces. Understanding these mid-career transitions may contribute to building the capacity of the EER community by supporting traditional engineering professors' transitions to EER scholarship. Making this transition has been documented as challenging (Borrego, 2007), non-linear, and highly individualised (e.g., Adams et al., 2007; Allendoerfer et al., 2007; London et al., 2021). Prior efforts have developed structured opportunities to help this transition using communities of practice (e.g., Adams & Wilson, 2014; Cross et al., 2021; Mann & Chang, 2012) and structured mentorship (e.g., Atwood et al., 2018; AAEE, *AAEE Academy*, 2020; AAEE, *Summer and Winter*, 2020).

To explore how these transitions can build the capacity of practising EER scholars, we studied the perspectives of a convenience sample of 18 professors engaged with a grant opportunity that supports researchers in traditional engineering disciplines to conduct EER projects through structured mentorship.

Relevant Literature

Emergence of Engineering Education as a Discipline

While scholarship in educating engineers and traditional engineering degree-granting programs are over a century old, literature reviews and academic definitions of EER as a discipline are recent, having emerged in the 1990s (Borrego & Bernhard, 2011, Klassen & Case, 2021). Writing about EER as a field of inquiry began in the United States (Klassen & Case, 2021); however, more recent work has described the history and development of EER in other settings (e.g., Godfrey & Hadgraft, 2009; Bernhard, 2018) and compared the needs and communities of EER scholars across multiple countries (e.g., Williams & Wankat, 2016; Kumar et al., 2022).

Previous work in PhD programs in the United States has leveraged structured mentoring approaches to help students develop EER skills (e.g., Adams et al., 2014; Spivey-Mooring & Apprey, 2014). However, recent estimates suggest that there may be fewer than 100 EER-doctoral-degree-granting PhD programs worldwide (Lopez & Garcia, 2020). Consequently, the majority of EER scholars are not trained through doctoral experiences. Instead, many EER scholars enter the field as established social scientists, or as professors trained in traditional engineering disciplines (Borrego & Bernhard, 2011).

Characteristics of Engineering Professors During Career Transitions

Mid-career research growth and development has long been recognized as important for the continued success of professors (e.g., Belker, 1985). During their careers, professors make transitions to gain experience with new research areas, techniques, and skills are common (Baldwin et al., 2008; Strage & Merdinger, 2015) and openness to these changes is even recommended (Baldwin et al., 2008) in research on the trajectories of academics. A sizable body of literature including work in Australia (e.g., Wood & Borg, 2010), the UK (e.g., Griffiths et al., 2014), and the United States (e.g., Dinkelman et al., 2006) documents the development of mid-career interests in researching education among schoolteachers, who transition to become teacher-educators. This population is characterised as being motivated by their experiences as schoolteachers, perceiving teaching as more than a mere duty as a professor (Griffiths et al., 2014), and who are strongly supported by mentors and supervisors. A smaller body of literature documents professional development for professors (e.g., Strage & Merdinger, 2015), including research training and also training to adopt RBIS (e.g., Borrego et al., 2013; Henderson et al., 2012; Romano et al., 2004). Below, we describe the characteristics of professors making these transitions in engineering and EER.

Professors trained in traditional engineering disciplines bring important perspectives to EER but are rarely formally trained in approaches to implement RBIS despite the potential benefit to student development and outcomes. Prior examples of approaches to train professors in

EER methods or practice have included workshops (e.g., Streveler et al., 2007) and learning communities (e.g., Cox, 2004; Herman et al., 2015).

While the beliefs and attitudes of engineering professors can differ widely between individuals (Perera et al., 2013), some work has characterised professors who engage with RBIS or research EER. Bielefeldt (2015) observed scholars practising SoTL in the United States and found those scholars to form a “distinct sub-culture” of engineering professors that is “more collaborative, less masculine, and less hierarchical” (pp. 7). Dart et al. (2021) interviewed a sample of participants, mostly from Australia, in an EER methods training program and observed that those professors’ values and motivations were centred on improving students’ educational outcomes. Ko et al. (2021) interviewed professors who had considered implementing RBIS or were explicitly transitioning from engineering disciplines to EER. They observed that motivation for this engagement was generally student-centred, valuing student outcomes and experiences. Evidence suggests that students are more supported by the motivations and outcomes for the population of engineering professors who engage with RBIS and EER (Perera et al., 2013; Smith et al., 2016). This evidence suggests EER researchers are capable, empathetic, and motivated instructors; thus, building the capacity of EER researchers supports improving students’ academic outcomes.

Barriers to Entry in Engineering Education

As described above, entry to EER generally occurs through non-traditional trajectories. Scholars interested in EER face many challenges, including conceptual difficulties in learning EER methods, not identifying as engineering education researchers, departmental power structures, or facing imposter syndrome (Borrego, 2007; Dart et al., 2021). Challenges exist for professors implementing RBIS as well; failure in implementation or achieving less than the desired student outcomes can also hinder one's motivation to adopt instructional innovation (Finelli et al., 2014). Cross and colleagues (2021) suggest that institutional support and the required shifts in professors' attitudes about teaching or teaching innovation can be barriers to adopting pedagogical tools or engaging with SoTL. Additionally, the existing job demands of professors may create challenges in conducting EER. Becoming familiar with new methods (Ko et al., 2021) and finding funding sources may inhibit professors from conducting EER (Dart et al., 2021). Many professors in both public and private universities in the United States are involved in a tenure system. In this system, promotions and job security are determined chiefly by research output (McPhearson & Shapiro, 1999). Reward systems for professors (including tenure) often place a higher value on research within the traditional discipline, thus disincentivizing discipline-based engineering education research (Dolan et al., 2018; Sochacka et al., 2020). Reward systems which unequally value EER are one of several barriers discussed within this manuscript. This study seeks to contribute to the literature which characterises the motivations, perceptions, and experiences of these professors transitioning to EER, including barriers to their transitions to EER scholarship. This study shares the ways in which professors approach and address these barriers with the help of structured mentorship but the identification of these barriers may be applicable to engineering professors making this shift in research focus.

Research Questions

We pose and address the following research questions:

- ➢ RQ1: What are the common perceptions (e.g., perceived value of EER and reasons to conduct EER, perceptions of EER as a field) of traditional engineering professors as they begin to conduct formalised EER in a structured mentorship program?
- ➢ RQ2: What are the barriers encountered by these engineering professors?

Methods

This work is part of a larger study exploring experiences of awardees of the National Science Foundation's Professional Formation of Engineers: Research Initiation in Engineering Formation (NSF PFE: RIEF) grant. The resulting data were collected and split to answer two distinct sets of research questions. This manuscript provides an overview of early-stage EER experiences, focusing on the lens of common perceptions and barriers to entry for professors on this trajectory. The project leveraged aspects of thematic analysis and phenomenological strategies of inquiry in data collection and analysis (Creswell, 2013). Phenomenologically informed approaches were selected for our interview design as our study is concerned with transitions to EER scholarship as a phenomenon, which includes experiences of mentorship and motivation for EER research; we were interested in the affective views of participants and the human interactions between mentors and mentees, aspects which align well with a phenomenological approach (Merriam, 2009). Thematic analysis approaches were selected to seek patterns across participants in how their lived experiences of transitions to EER scholarship were described (Braun & Clarke, 2006). This research was approved by the Institutional Review Boards at two institutions (University of Illinois Urbana-Champaign IRB #19398 and University of Nevada at Reno IRB #1361160).

Context

Participants in this study are recipients of the NSF PFE: RIEF grant, a government funding opportunity in the United States that supports scholars with limited experience in EER methods. Similarly, the Australasian Association for Engineering Education (AAEE) offers the opportunity to form collaborative expertise across institutions (AAEE, *Grants*, 2020). At the time of data collection, the NSF RIEF award supported over 45 projects. A requirement of the grant application process is a principal investigator (PI) Mentorship Plan describing how the PI will learn to successfully complete their grant's aims and develop expertise in their project's requisite techniques through the guidance of a mentor. Recipients of the grant typically collaborate for two to three years on an EER project. Participants take on the role of mentors or mentees, where a mentor is someone (typically a co-PI on the grant) with training in EER or social sciences research and where a mentee (typically the PI on the grant) has little to no experience in EER. These investigators design a plan to collaborate, sometimes remotely across institutions. Teams of mentors and mentees frequently meet to support the mentees' learning and ensure accountability towards the project's goals. Typically, the projects are managed by a mentee and supported by mentor(s); the degree of participation in the project by a mentor can range from consulting and advising with the mentee to actively conducting research alongside the mentee. Several similar structured mentorship programs also exist within the AAEE (AAEE, *AAEE Academy*, 2020; AAEE, *Summer and Winter*, 2020) and exist prevalently in other fields (e.g., Ewing et al., 2008; Vassallo et al., 2021). In sum, participants in the RIEF grant and in similar programs are involved with research development, EER projects, and structured mentorship and collaboration.

Positionality

The fifth and sixth authors on this project were previous recipients of the NSF RIEF grant. The fifth author is also a mentor in the NSF RIEF program and was an engineering professor trained in a traditional engineering discipline. The initial aims of this project grew from the fifth author's interest in learning more about what might impact future grantee pairs in their collaborations. The experience of these authors gave them perspective to relate to the experiences of the participants. The sixth author had the formal training of a PhD in EER and oversaw the methodological decisions of this project. Additional project team members included two postdoctoral researchers, one with extensive qualitative research experience in EER (the second author, who conducted the analyses in this project); a PhD student (the first author) in an education discipline with prior degrees in an engineering discipline; and an undergraduate student (the fourth author) in an engineering program. Each of these additional members developed an interest in educational research from their experiences as engineers or engineering students. Thus, their experiences mirror the transitions of mentee participants in this study. Intentional bracketing of personal experience and collaboration across team members mitigated coder experience significantly impacting data analysis. For example, the first author used his own experiences with barriers in learning EER methods as examples while clarifying questions to study participants.

Recruitment and Sampling

A convenience sample (Etikan et al., 2018) generated from a list of NSF RIEF grantees (mentees and mentors) was obtained from the publicly available NSF search function in September 2019, and every person listed as PI or Co-PI for any ongoing or completed NSF RIEF grant was contacted. A total of 18 participants (18% of 98 contacted grantees) responded that they were interested in participating in an interview.

Participants

As the goal of the overall study was to understand the development trajectory of engineering professors' early-stage EER experiences through structured mentorship, both mentors (N = 8) and mentees (N = 10) were interviewed. Participants were mostly fully tenured or tenure-track professors (N = 14, including three associate professors, eight assistant professors, and three fully tenured professors) and some held administrative roles; the remaining participants were teaching-focused non-tenure track professors (*N* = 3) or research-focused non-tenure track professors (*N = 1)*. Participants came from a range of institutional backgrounds: 11 were from public research-focused, high research activity institutions, and the remaining were from private research-focused institutions (*N* = 2), a private doctoral-conferring university with less research output (*N* = 1), and primarily undergraduate-serving institutions (*N* = 3). Twelve participants identified as women, and six participants identified as men. Participants could select multiple races; 12 participants identified as white, and participants also identified as Asian/Pacific Islander (*N* = 4), Black/African American (*N* = 2), and Hispanic/Latinx (*N* = 1). Mentor participants were professors who conduct EER research, whose doctoral research backgrounds ranged from social sciences to engineering education to traditional engineering fields. Mentee participants were professors whose doctoral research training was in an engineering discipline (e.g., aerospace engineering, chemical engineering). Given the small number of NSF RIEF projects we recruited from at the time of study, specific backgrounds, institutional types, and tenure status are not tied to participants to protect participant anonymity, and we do not report the specific engineering disciplines of participants.

Data Collection

We leveraged semi-structured interviews (Smith, 1995), and two separate interview protocols were developed. One focused on the content most relevant to experienced EER researchers (mentors) and how they mentored the mentees. Mentees were prompted with parallel questions to discuss their experience entering EER from traditional engineering professors' roles (see **Figure 1**). The design of both interviews centred on exploring the phenomenon of transitions to EER scholarship and mentorship as experienced by the perspectives of mentees and mentors (who observed their mentees' research transitions). Our interview design was grounded in the Cognitive Apprenticeship Model as a theoretical framework (Jensen et al., 2020; Jensen et al., 2021). More detail on the design of the interviews has been previously reported (Mirabelli et al., 2020). The interviews were conducted in October 2019 through January 2020 via Skype for Business online meeting platform and lasted approximately one hour. All interviews were recorded and then transcribed verbatim by a transcription service. The project team assigned participants pseudonyms and removed all identifying information including names, university affiliation, and project information.

Data Analysis

Throughout the analysis, our team considered multiple resources to address key components of quality in qualitative research (Walther et al, 2017). A detailed audit trail including interview field notes and analytic memos was maintained during the analysis, which supports the trustworthiness of qualitative research (Carcary, 2009).

We used thematic analysis in a collaborative coding procedure to uncover meaningful patterns within our data (Braun & Clarke, 2006; DeCuir-Gunby et al., 2011; MacQueen et al., 1998) to guide the development of a codebook and overarching findings. Two superordinate themes were selected as lenses through which the data could be inspected. This manuscript presents one theme: the experiences of mentees entering EER as a career transition. The second superordinate theme addressed mentorship more specifically and will be presented in a separate, forthcoming manuscript which focuses on the specific styles of mentorship used by mentors and mentees in this sample. In the initial phase of analysis, three coders each open-coded one-third of the dataset using the MaxQDA software (VERBI Software, 2021) to create a list of potential findings. Emergent units of meaning were then converted into codes, which were reviewed by the entire research team and discussed until consensus. These codes were developed into a codebook that included the list of code names, code definitions, and example quotes used to guide the interview analysis. All team members were involved in reaching a consensus in the final version of the codebook.

In the second round of coding, the inductive codebook was applied to all transcripts by a minimum of two project team members. The team met three times weekly for analysis meetings to evaluate the accuracy of the codebook, discuss text segments that were difficult to assign to a single code, and refine code definitions. Ultimately, consensus was reached on all coded segments by a minimum of two project team members.

In the third round of coding, a team member independently coded interview segments related to the thematic lens of research transitions to EER scholarship. The confirmed codes and definitions in this third round of coding finalised the codebook, which was then reviewed by the advisory board to add clarity and ties to the extant literature. The superordinate theme presented in this manuscript examines the early experiences of EER scholarship transitions, with four major findings presented below.

Limitations

The study participants were self-selected, so they may have viewed their EER experience more positively than the population at large. However, these grantees offer unique insight into the motivation, process, concerns, and goals behind receiving the funding and carry the perspectives of participants with interest in pursuing EER.

Additionally, the grant opportunity discussed within this context may not be easily transferable to international contexts where externally funded research is less common than in the United States (Deters et al., 2023; Klassen et al., 2023). However, we believe that mentorship is inherent to the academic undertaking, and applying structured mentorship to research interests is still applicable internationally. As they relate to promotion, motivation for research, initial knowledge gaps, and navigating new research communities, our findings have the potential to generalise to early-career researchers and researchers in other settings. Further, research field transitions are common, and professors engage in development of their research and teaching skills throughout their careers (Belker, 1985; Strage & Merdinger, 2015).

Results

The following results summarise four emergent findings that describe experiences of engineering professors entering EER via structured mentorship. Mentees and mentor reflections bring a shared perspective of starting EER to integrating into the community. **Table 1** contains finding definitions and an exemplar quote.

Table 1: Summary of results

Finding	Definition	Example Quote
Motivation for EER	Motivation for pursuing EER, including passion, benefits, previous research, and classroom inspiration	*This is not just my job to get paid. This is my mission. This is my meaning to be an educator.*
Institutional Support and Barriers	Ways mentees did or did not receive support in their academic contexts	*Her dean is always telling her how it's so amazing what she's doing… He's very, very supportive of what she's doing and gives her protected time as an associate dean to do this work.*
Growth in Knowledge	Knowledge barriers to effectively conducting EER	*I think just being able to read and digest literature was a huge barrier for her in the beginning.*
Integrating with EER Culture	Interactions with the broader EER community including perceptions of in-group out-group	*I feel like in engineering education, there are two tiers… the people who have a PhD in engineering education…and then there are the people who are teaching in the classroom, like myself.*

Motivation for Engineering Education Research

Many mentees were motivated by the specific desire to improve as an educator, leading them towards an exploration of engineering education best practices. There were many instances in which mentees learned about EER only after independently seeking to better an educational method. For example, Rose stated:

> I was thrown into teaching several classes… and it was easy to see… where the gaps are and problems were in our curriculum, and I worked with a colleague of mine initially to submit an assessment proposal… Then quickly realised that what we were proposing to do was not actually revolutionary at all. It was well documented in literature. It was just literature that I didn't know existed. (Rose)

Rose's teaching experience was difficult, creating a desire for improved teaching and learning. This led her to begin exploring options through which she found EER literature. It was in this somewhat unplanned way that mentees sometimes began EER work on their own before receiving structured guidance on how to study educational phenomena. Mentors often initially served to guide mentees towards EER literature and approaches. Mentees therefore did not always consider themselves new to EER, but they did look to mentors to help ground their study in established EER methods and theories.

Institutional Support and Barriers

A second factor that largely influenced mentees beginning or continuing their participation in EER was the institutional support and barriers they faced. Departments played a strong role in supporting mentees pursuing EER. Examples of this support found in the data included colleagues who "understand the validity" of EER; a dean and provost who envision growing EER on their campus; departmental interest in implementing findings of EER; and modifying a job description to accommodate conducting EER.

Conversely, a lack of institutional support was perceived by the mentees as a barrier. Some barriers were outside of the control of department administration, including a small community of fellow engineering education researchers or no graduate students at an undergraduate-only institution. These factors limited the size and scope of EER projects that mentees believed were possible at their current institution. Limited personnel at institutions might limit team capacity based on available researcher skills or available student work.

Additionally, many mentees in tenure-track positions strongly considered how their EER could impact their promotion. Motivation and promotion often intersected and conflicted, as they did for Abbie, a tenure-track, but not fully tenured, professor:

> I had seen people go up for tenure, [which] ...is kind of a necessary step. And so I was a bit nervous about doing anything like that before tenure and I thought, let me just not rock the boat and stay really traditional and do kind of the more traditional engineering research, do what people expect to see. And then after tenure I can try to broaden and do these other things that are outside of the realm of what people generally understand engineering faculty members to be doing research in. So that was my intention, was to kind of not really pursue this for a while. (Abbie)

Abbie discusses the tension between her interest in EER and the limitations of “traditional” tenure requirements for engineering professors at her university. As an example of this perceived conflict between EER and tenure goals, Abbie remembered a joking comment about her teaching award being the “kiss of death for tenure,” even though she had previously received NSF-awarded funding for education and thereby demonstrated that funding was available in this area. Another participant, Alex, shared, “I'm gonna just put the papers on my CV, but I'm not gonna include any of the papers in my tenure package 'cause it's like a waste of a spot,” since they perceived their EER held little value to their administration. Thus, for both Alex and for Abbie, teaching and EER practice were perceived as less important to tenure and promotion, which negatively impacted their motivation for engagement and dissemination.

Most mentees in the study were either not tenure-track or not fully tenured. Thus, these mentees commonly expressed concern about power dynamics and how their EER work might be perceived, particularly if their research might seem to intrude on their departments’ normal teaching practice or if their findings might suggest they believe other (potentially fully tenured) educators have poor teaching ability. For example, even though Abbie described her department as open to suggestions for teaching improvement, she did not feel comfortable saying anything when her colleagues engaged in teaching that did not align well with best practices. Like with Abbie and Alex's perceptions above, these participants, the pursuit of tenure was a barrier to participation in EER, which decreased their motivation for taking on EER projects.

Conversely, two mentees were fully tenured; they described being much freer to openly explore their research interests and share their findings to the benefit of others. However, time and commitment to fulfilling their job responsibilities was still important to post-tenure engineering professors. For example, one of these participants stated that, "if any other part of my job became more complicated, [EER] might be the first thing that gets cut."

Other mentees held non-tenure-track teaching-focused positions. Some of these professors used EER to bolster their respect among their tenure and tenure-track colleagues. Rose's research, which was initially viewed as a hobby, became "obvious[ly]… useful to the department," and her job description was adjusted to include research. This gave her "a platform among our tenure track and tenure colleagues, that [she] didn't really have before." This split allocation of time and resources provided an additional barrier to participants conducting EER, though it was also sometimes translated into support via departmental recognition and respect.

Growth in Knowledge

As mentees began their structured mentorship program, it became clear that significant growth in knowledge would be required. The movement from traditional engineering research to EER led mentees to grapple with why the distinction between the two felt so severe and if there were ways to lessen it. One of the most cited differences between EER and the traditional engineering research of mentees was the use of qualitative data analysis techniques. Mentees often entered the field perceiving qualitative or social science methods as “easy,” which translated into concerns over the validity of EER, which was described by mentor Ted:

> Getting people to understand and appreciate the value and the depth to which you can reach with qualitative research… can be a major challenge for others who are trying to make this shift. (Ted)

Mentees relied heavily on mentors not only to explain the value gained from qualitative research, but to guide them through the process of conducting educational research, such as learning the related tools and methods.

Mentors also guided mentees through EER literature, thereby building mentee’s familiarity with terminology and the field. This was critically helpful since EER writing differed from many mentees’ previous technical writing experience. Their lack of familiarity with EER language made it difficult for them to begin “knowing where to look” or which theoretical frameworks to consider. Mentors believed this formal training was important to assist mentees in moving away from basic data interpretations towards established approaches to sense-making of non-numerical data.

As the mentorship continued, many mentees built confidence to conduct research. As mentor Mark said:

> The breakthroughs are not these shining moments of like, "Hoooo," like "the holiness has come down from the sky. It's more [that] these small steps have led to the larger jumps when you start to take a step back and look at the amount of analysis she's done, the amount of data collection, and now she's talking about things with more precision. (Mark)

Mark discussed how the structured mentorship successfully, though incrementally, moved his mentee towards the ability to conduct EER. Mentees were eager to make use of their new knowledge; some findings from practical projects were immediately implemented by the mentees’ departments, while other, more scholastic outcomes such as publications progressed more slowly.

Integrating with EER Culture

Many participants described increasing social networks in EER to benefit mentees. Mentees often struggled with isolation at institutions with minimal EER resources; they felt that a network of support would be useful to counter these feelings of isolation and to encounter more EER content.

The American Society of Engineering Education (ASEE) Annual Conference was the most consistently referenced EER community event, and most mentees had attended ASEE prior to obtaining their grant. Through community events, mentees met other EER researchers they viewed as potential mentors or discussed their interests with prominent figures in the field who helped guide them. Challenges arose when mentees felt out of place at large conference events. Ellen and Mimi found ASEE too big, with Mimi describing ASEE as “overwhelming” with “too many people, too many divisions.” Mentees also felt pressure to know “who’s who” in the EER community, which they perceived as large and intimidating. This led to feelings of isolation and loneliness at large EER events. Other mentees were limited from ASEE conference attendance by costs and scheduling conflicts with their teaching schedule.

When talking about the field, some mentees felt that EER was welcoming and full of diverse participants of different social and technical backgrounds. Others perceived cliques which limited their comfort interacting with the field. Some cliques arose from distinctions made between practitioners who were educators making changes to their classrooms and theory-focused researchers who were trained in EER. These feelings were summarised by mentee Nancy, who shared:

> I feel like in engineering education, there are sort of two tiers. There's the one tier that are the people who have a PhD in engineering education, or education, or social sciences and that are publishing in journals. And that's thought of as the real engineering education research, the worthy engineering education

> research. And then there are the people who are teaching in the classroom, like myself, and, sometimes when presentations are given at ASEE, [when we share] … "Hey, here's this cool new thing that I'm doing in my classroom or whatever," it's thought of as less than [theory research]. (Nancy)

Nancy exemplified the perception held by several mentors and mentees of “tiers” within the EER community. Theory-building research was seen by mentees as the most exclusive and unattainable tier, while work in the classroom was a lower tier and therefore less valued.

Mentees linked this divide to a “crisis” of sorts in the field—research was being conducted in plenty, but as professors, they had usually not heard of findings they could implement in their classroom prior to the structured mentorship program. Nancy continued after the above quote to share that her mentor has done a good job of modelling the value of classroom practitioners by closing the “feedback loop” between those “on the ground in the classroom.”

Some mentees specifically mentioned a desire for contributing as practitioners but not theory-builders. Alex said, “I wish engineering education could allow for partial membership,” alluding to a common desire to make meaningful contributions to his own educational practice, even if EER was not his primary research focus. As Rose described:

> I wanted to get that work and make sure more people know how to apply it. I'm not all that interested in necessarily adding to a field with new learning theories or strategies. I want to make sure more of our students are exposed to these evidence-based issue practices that we already know about, which is… not widely available. (Rose)

Rose’s primary interest was in helping implement the existing techniques described in EER literature, not adding to EER theories and strategies. This desire to help implement research-based practices directly addresses the “crisis” in the field of educators requiring RBIS to implement in their classroom.

Discussion and Implications

Mentees' experiences detail a common trajectory for traditional engineering professors as they begin to conduct formalised EER in their structured mentorship program. Mentees often held a desire to improve engineering education, and this spark catalysed their initial engagement in engineering education. Many mentees attended ASEE and later learned of the structured mentorship program. As the mentees engaged with the program, guidance from their mentors supported them in learning and implementing established EER approaches as well as in connecting to the wider EER community.

Mentee Knowledge

Many mentees described several internal barriers to their engagement with EER as they developed as scholars, including initially discovering EER, conceptual difficulties implementing the research, and psychological support/growth in confidence.

Though mentees held a desire for improving engineering education, many were unaware of EER until after they had started independently experimenting. This lack of awareness is broadly documented as part of a critical gap between research results and their broader implementation in teaching practice (Boklage, 2018; Besterfield-Sacre et al., 2014; Finelli et al., 2014; Grove, 2008; Henderson et al., 2011; Pappas & Pierrakos, 2021; Reidsema et al., 2013). This gap in the dissemination of EER scholarship hinders increased quality in the practice of engineering education and limits the growth of EER as a field of inquiry. Tapping into this population of motivated engineering educators who are unaware of EER to perform scholarly research is one method of growing the community conducting EER. These motivated scholars may also be able to support grassroots departmental change toward more holistic educational practices.

Participants commonly described challenges centred around conceptual difficulties in implementing EER, including identifying and applying a theoretical framework, valuing qualitative approaches, and implementing qualitative techniques. If not overcome, these barriers directly inhibit budding researchers from engaging in theory-based engineering education research. These challenges were also documented by Borrego (2007) when studying engineering professors engaging with engineering education topics as well as other researchers (Talanquer, 2014; Choi et al., 2018). In this study, mentors provided valuable guidance and direction connecting their experience to the existing literature, which supported mentees in identifying and applying a theoretical framework. Mentor knowledge of the literature likely stems from their holistic understanding of the field instead of their specific area of expertise, which could have implications that future mentorship holds value even if there is not a specific alignment in subject interest. Additionally, mentors provided guidance in the specifics of implementing social science methods, such as submitting for internal-review board approval of human subjects research and conducting interviews.

Engineers' perception of qualitative work as "easy" has been documented as rooted in the positivist history of engineering (Borrego, 2007; Godfrey, 2009; Koro-Ljungberg & Douglas, 2008; Riley, 2015; Slaton & Pawley, 2017). This dismissal of social science approaches as "easy" is problematic because it can limit access to the value qualitative methods bring, such as nuance and specificity (Borrego, 2007). Explicitly discussing and addressing this early in the mentoring relationship enables mentors to elucidate this value. Additionally, this early implementation will allow the mentee to implement this knowledge in all their later EER.

Departmental Stance and Structure

Department systems significantly supported and hindered mentees' access to engaging in EER. Examples of these systems included reward structures such as tenure, relative positions of power within the department, and departmental recognition and respect.

In some engineering departments, promotion and tenure can significantly impact a researcher's pursuit of EER. Professors seeking promotions may not engage with EER if that work is not valued, despite how EER supports the educational practice of all traditional engineering disciplines. Prior research shows that cost and utility are two key factors professors consider with determining where to focus their efforts (Froyd et al., 2013; Matusovich et al., 2014), meaning that if tenure-track engineering professors perceive conducting EER as prohibiting their potential for success in tenure, they may be less likely to engage with EER. Conversely, our results suggest that post-tenure professors may feel more comfortable to broaden their research area, as they perceive fewer costs. Two methods for integrating EER in engineering departments are the Model for Action and Learning in Engineering Education Research (MALLER) (Mann & Chang, 2012) and discipline-based education research (National Research Council, 2012). A challenge when implementing these can be including knowledgeable EER reviewers in the tenure review process (Dolan et al., 2018; Sochacka et al., 2020).

In addition to the tenure system, relative positions of power within the department can support or hinder EER. Power relations may prohibit junior researchers from more broadly sharing findings that implicate more senior professors teaching. Departments are harmed by this barrier on sharing results since disseminating the results would likely be departmentally beneficial. Also, this prohibits recognition of junior professors' EER.

Departmental recognition is a key component to supporting successful growth in EER. This might include showing an interest in and implementing implications of a professor's EER. This support encourages growth and development for both the researcher and the department. This aligns with prior research that demonstrated that supporting autonomy, competence, and relatedness increased a teacher's intrinsic motivation (Grove, 2008). This type of departmental support is also consistent with previous engineering education research that suggests organised support, including access to resources, is a pathway to department-wide adoption of teaching innovation (Cross, 2021; Mann & Chang 2012).

EER Community

Integration into the EER community is one of the aspects mentees sought to gain out of the mentorship program. Many mentees felt isolated at their institutions, which had few other EER practitioners. Specific barriers to EER community integration included access to networking events as well as feelings of exclusion based on "the clique" of theory-focused researchers.

Conferences are a key part of learning about a research field, including the field of EER. One opportunity to address the barrier of conference attendance cost is creating funding opportunities to support these participants' participation. Virtual networking and education events increase access via location, cost, and time investment. These findings have been leveraged for workshop opportunities aimed to directly benefit stakeholders (Jensen et al., 2021).

Mentees described a divide between theory-focused and practitioners who were classroom practitioners, which is also described in EER literature (Borrego et al., 2008; Cross, 2021). These feelings of separation contributed to feeling less included at large EER conferences as well as a desire for more small-scale publication venues focused on SoTL. Feelings of exclusion are problematic because they inhibit growth via people who are new to the field (Pitterson et al., 2020), especially when those people may be operating at the intersection of closing the theory-to-classroom gap. Increasing feelings of inclusion is one method of encouraging a more diverse engineering community (Pollock et al., 2022). Encouraging participation in opportunities for smaller-scale interactions such as at regional conferences may be a way to integrate some of this desire for a more intimate community. Additionally, encouraging the adoption of local communities of practice for new and growing EER researchers (e.g., Adams et al., 2014; Mann et al., 2011) can build community at the institutional or regional level.

Implications for Practice

To summarise the ways in which our findings translate to practise, we propose the following actions for engineering departments and those in the broad EER community. These suggestions are grounded in the barriers and perceptions described above by our participants. Importantly, local and national contexts and resources must be considered when adopting policies which support EER researchers, for the institutions which host these researchers exist within broader systems and policies (Klassen et al., 2023). Additionally, we echo the recommendations to individual scholars made by Dart et al. (2021), namely that scholars interested in EER transitions in departments with few formal resources should "look broadly" for EER researchers at other institutions, apply for grants which introduce SoTL into their teaching practice or research to contribute to engineering SoTL, advance their own EER knowledge, and reflect on their own motivations and beliefs (pp. 1087).

Engineering Departments:

- Generate buy-in of EER within engineering faculty, especially via interventions that are long-term (at least one full semester) and integrated with the university system (Borrego & Henderson, 2014; Finelli et al., 2014; Henderson & Dancy, 2007; Henderson et al., 2011, Pappas & Pierrakos, 2021; Reidsema et al., 2015).
- Meaningfully value social responsibility within engineering culture, including in both education and research (Brodeur, 2013; Cech & Sherick, 2015; Chance et al., 2021; Douglas et al., 2010; Polmear et al., 2021).
- Change the promotion process in engineering departments to equally reward EER (Dolan et al., 2018; Sochacka et al., 2020). Additionally, increase opportunities for recognition and respect for EER.
- Reduce departmental power structures, and increase safety of junior faculty (Sochacka et al., 2020).
- Support and reward participation in national and international conferences which promote SoTL and EER such as the Australasian Association for Engineering Education (AAEE), Research in Engineering Education Symposium (REES), Frontiers in Education (FIE), American Society of Engineering Education (ASEE), and European Society for Engineering Education (SEFI) conferences.
- Encourage programming for structured mentorship, workshop, or professional development opportunities, especially those which support underrepresented populations in engineering such as women (e.g., Atwood et al., 2018) or indigenous peoples (e.g., Cicek et al., 2021) to broaden participation within EER.

EER Community:

- Create and widely disseminate low-barrier-to entry material on EER methods, especially qualitative approaches and theoretical frameworks. These would be outside of paper publications, and examples might include videos, podcasts (Bruggerman, 2020; Cooke & Wint (2022-present); Pearson (2020-present); Streveler (2018-present)), instructional documents, and virtual short courses.
- Host regular, well-advertised networking and educational event opportunities for those entering EER, being mindful of equitable access in design, such as by considering time zones (Cross et al.; 2020; Mann & Chang, 2012; Jensen et al. 2020; Jensen et al. 2021). Some of these networking opportunities may also double as low-barrier-to-entry events (Beddoes et al., 2015).
- Generate more opportunities for small-scale publication venues with focus on the theory-to-classroom gap and teaching-focused research (e.g., Mann & Chang, 2012).
- Support the formation of local or institutional research groups as EER communities of practice such as those described in Mann et al. (2011).

Conclusion

This qualitative study examined the experiences of 18 professors who engaged in a structured mentorship program that was structured to support developing engineering education researchers. Thematic analysis revealed four key findings: motivation for EER, institutional support and barriers, growth in knowledge, and integrating with EER culture. Our study identified common perspectives and articulated barriers and implications to support traditional engineering professors that want to conduct EER, which provides opportunities to broaden the

EER community and research field for both engineering departments as well as the EER community.

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Appendix

***Figure 1**: General mentee* interview schedule used during data collection.*

Part 1	What led you to start in EER?
	Tell me about your RIEF project and how you and your mentor(s) developed its proposal. *
	What interested you in your project's topic?
	What publications, presentations, or other products and results came from your RIEF grant?
	What projects, if any, have you become involved with since starting your RIEF?
	How would you describe your research interests in EER?
Part 2	How effective do you think your mentor(s) and the RIEF program were in preparing you for EER? *
	What informal components of your EER work, such as networking, proposing research ideas, or attending conferences, were different between EER and your previous experiences?
	What other barriers or challenges faced you when you began EER?
	How integrated do you think you've become in the EER community and in your engineering department?

	What do you think it takes to succeed at EER? What would you change about EER? What should the field be doing better, or what areas of research do you think need more attention?
Part 3	What training, events, or other resources do you think would be useful to engineering faculty starting in EERh that are not currently available or accessible? Is there anything about EER in general that you would like to share?

Note. *A similar protocol was developed for mentor interviews