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Crossing Boundaries: Understanding Scholars' Pathways into Engineering Education Research

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Introduction

Engineering education research (EER) is an interdisciplinary field that draws scholars from engineering, education, psychology, and other disciplines. These scholars come from diverse academic and professional backgrounds and contribute unique perspectives to EER [1]. EER blends perspectives from engineering disciplines and social-science-based education fields to address challenges in the system of engineering education that cannot be solved within a single paradigm [2, 3].

The discipline of EER has informally existed since engineering degree programs, but only in the past several decades have formal doctoral programs been developed to train scholars to conduct engineering education research [4]. Historically, the "pioneers" of the discipline entered mid-career through serendipitous opportunities [5]. These entry points are often described as lucky and not entirely planned [2]. Existing work largely documents "pioneer" trajectories into EER, where scholars discover the discipline unexpectedly or shift into it after years of disciplinary practice [5, 6].

With the existence of several notable graduate programs in EER within the United States, doctoral degrees in the discipline are becoming a key entry point. The first two EER PhD programs began at Purdue University and Virginia Tech in 2004. In recent years, nearly twenty additional programs have been established in the United States [7]. The development of these programs has established doctoral experiences as an additional pathway for individuals to enter the discipline of EER. As EER doctoral programs become a more common entry point into the field, there is a growing need to understand how scholars experience this transition and what motivates them to pursue EER. Yet, there is little work examining the decision points that precede formal entry into EER doctoral training.

In this paper, we focus on scholars who did their undergraduate academic training in a traditional engineering discipline or computer science and then pursued a doctoral degree in engineering education. The purpose of this study is to explore the push and pull factors that lead these scholars to EER. This focus allows us to study a dominant segment of the EER community, illuminate patterns that may represent emerging norms in the discipline's maturation, and generate insights for supporting future scholars transitioning into EER with traditional engineering backgrounds. Understanding these pathways is key to developing structures that support both successful integration into the EER discipline, as well as support for scholars navigating differences in disciplinary norms. Using approaches from critical incident analysis and narrative analysis, we sought to answer the question:

What factors cause scholars to choose to pursue doctoral degrees in engineering education after completing traditional engineering degrees at the undergraduate level?

Background Literature

Most engineering doctoral programs build directly on undergraduate and master's level programs, providing specialized research training in similar disciplines. These disciplines often have similar approaches to inquiry and views of knowledge. In contrast, the transition into EER from a traditional engineering discipline requires an epistemological (e.g., related to beliefs about knowledge and knowing) transformation. In traditional engineering disciplines, knowledge is often seen as absolute, objective, and measurable with quantitative data and statistics being used to evaluate hypotheses [8, 9]. EER scholars use a broad range of approaches that include quantitative, qualitative, and mixed methods paradigms to answer questions about human behavior and perspectives. Individuals transitioning from engineering to EER are faced with learning these new approaches that can consider the complexities of human beings. Many of these approaches are quite different from the approaches used in traditional engineering disciplines. For example, in many qualitative interview studies, EER scholars view knowledge as being co-constructed between the researcher and research participant and embrace the influence that the researcher has on the research process. In EER, the researcher is responsible for designing and implementing the data collection tools and it is important that these tools consider the context of each individual research study. On the surface, interviews and surveys can seem like they do not need technical training because the presence of specialized tools is less obvious. The beliefs about research (epistemological views) that come out of traditional engineering disciplines can lead to the sentiment that qualitative research, and EER more largely, is "soft" and not rigorous [10, 11]. This tension requires EER scholars to navigate and meet differing domain expectations [12]. Scholars transitioning from engineering or other STEM disciplines into EER often face unique conceptual and identity-based difficulties [12, 13]. Additionally, this transition often includes the potential for professional isolation, especially for those who are embedded in a traditional engineering discipline and are the only EER scholar at their institution [14].

The successful transition of scholars into engineering education research is critically dependent upon support networks, both locally and large scale, field level [6]. Both structured and informal mentorship are highly impactful and a key theme in many successful transition stories (e.g. the PEER Collaborative National Network formed in 2009 by a group of twelve engineering education researchers [15]). As the discipline of EER matures and continues to grow globally, the community has acted to further support systems for its scholars. These supports include developing national funding opportunities, establishing publication venues, and creating professional development and mentorship opportunities. Substantial work has been done by those who have already transitioned into the discipline to create publication venues [16] and professional networks [15, 17-19].

Previous work has brought attention to the lack of understanding about how careers in EER come to be [6, 20]. Existing studies offer limited insight into the specific moments, experiences, or realizations that prompt scholars to pivot toward EER. This gap limits the discipline's ability to normalize diverse entry pathways and to design supports for scholars at earlier stages of their transitions. While the EER community has established infrastructures for supporting scholars once they enter the discipline, relatively little is known about how scholars – particularly those transitioning after a background in a traditional engineering discipline – arrive at EER or make sense of their transition. To address this gap, our study examines scholars' stories focusing on the critical incidents that mark their transition into EER.

Methods

We used an interpretive research design to examine why scholars trained in traditional engineering disciplines transition into engineering education research in their doctoral studies. We used critical incident analysis to capture both variation in participants' experiences and the pivotal moments that shaped those experiences. By isolating these key events, decisions, and realizations that influence the participants' career trajectories, we were able to reach a nuanced understanding of why scholars move into EER.

This work is a secondary data analysis [21] on two distinct interview-style qualitative data sources that were originally collected for different purposes. Secondary data analysis allowed us to examine scholars' career trajectories across two sources while using consistent analysis techniques. To ensure analytic cohesion, all participants are discussed using consistent deidentification practices, including those drawn from publicly available datasets.

Data Sources

Participants were drawn from two data sources. The first consisted of semi-structured interviews conducted as part of a larger study on EER teams. These interviews included questions prompting participants to reflect on their educational and professional trajectories into EER. The second data source consisted of publicly available podcast episodes from the *Engineering Education Research Briefs [22]* and *Engineering Education Research Briefs 2.0: Scholars and Scholarship [23]* podcasts, each produced through Purdue University. The podcast brings engineering education scholars to discuss methods, frameworks, and findings in the field. We selected episodes in which the interviewee discussed how they entered the discipline of EER.

Participants and Inclusion Criteria

Because scholars enter EER through multiple disciplinary routes, we developed explicit criteria to determine what data to include in this study. For the purpose of this analysis, an individual was considered for analysis if they (a) were obtaining or had obtained a doctoral degree in engineering education, or (b) were obtaining or had obtained a doctoral degree in a traditional engineering discipline but conducted engineering education research for their dissertation. To qualify as having "entered EER," participants needed to describe a discernible transition from a prior discipline, either traditional engineering or computer science, into engineering education research. This transition could include changes in research interests, identity alignment, methodological orientation, professional community, or broader career trajectory. These criteria helped ensure that cases represented substantive movement into the discipline rather than temporary engagement or multidisciplinary overlap.

The initial dataset included over 50 participant accounts across both data sources. Applying the inclusion criteria described above resulted in a final analytic sample of 21 participants whose trajectories reflected a transition from undergraduate training in traditional engineering or computer science into engineering education research.

Data Preparation and Organization

The interview transcripts were provided to us as deidentified data and did not require transcription or deidentification. The podcast audio files were transcribed verbatim using the software Descript and deidentified prior to analysis. Participant numbers and later pseudonyms were assigned to all participants to ensure confidentiality.

We conducted targeted keyword searches (e.g., journey, path, entering, transition, moved into) within each transcript to locate segments relevant to each scholar's professional trajectories. We organized the participant data into a structured data table to support systematic analysis and cross-case comparison, as well as to ensure consistency across the two sources

Our final data table included the following for each participant:

- Unique identifier
- Date of data collection
- Participant's original discipline, including degree types and fields
- Current position
- Brief description of the incident
- Type of incident (e.g., mentorship, teaching epiphany, negative disciplinary experience)
- Push or pull factor designation
- Context/time of incident
- Short-term outcome
- Long-term impact or shift described by the participant

Critical Incident Analysis as an Analytic Approach

Critical incident analysis was developed for reporting significant events or "incidents" in job performance. It began in the fields of aviation [24] and anesthesia [25] to create safer practices. Recently, critical incident analysis has been used in social work and education to support reflection on core experiences. In education research, critical incident analysis has been widely used in teacher education studies (e.g. [26-28]). These studies demonstrate the value of focusing on retrospectively meaningful events to understand how individuals interpret and make sense of their career transitions. In this literature, critical incidents have been defined as subjective interpretations of objective events in teachers' stories about their career decisions [29]. In practice, critical incidents are often expressed as questions that lead an individual to reflect on decisions [30]. Drawing on this literature, we applied critical incident analysis to the context of engineering education research to identify the moments scholars describe as influential in their decision to pursue EER.

Identification of Critical Incidents

Following the preparation and selection of data, we conducted an initial round of analysis to identify critical incidents. For this study, we operationalized Flanagan and Tripp's [24, 31] conceptualization of a critical incident for our context and defined a critical incident as an excerpt that meets one or more of the following criteria:

- The participant explicitly identified a turning point or defining moment (e.g., a conference, a new project, a critical conversation).
- The participant described a shift in motivation, identity, sense of belonging, or professional values.
- The participant reflected on a decision that changed their trajectory.
- The participant named a clear tension or conflict, such as mismatch between disciplinary expectations and personal values.
- The participant described a strong emotional response (e.g., excitement, frustration, recognition)

We wrote a description of each critical incident and added it to our data table. Each identified critical incident was summarized, contextualized by where it fell in their educational/professional timeline, and coded to characterize its role in the participant's trajectory.

Categorization of Incidents as Push or Pull Factors

Data analysis proceeded in several phases. First, incidents were categorized based on their overall effect on the participant: push factors – experiences that drove participants away from their prior discipline – or pull factors – experiences that attracted participants toward EER. Examples of push factors included frustration with disciplinary norms, feelings of limited impact, or experiences of exclusion. Pull factors included mentorship invitations, exposure to EER communities, serendipitous opportunities, value alignment around education, or increased desire for student-centered work.

"Push" and "pull" factors have been used in the field of economics [32, 33], as well as to describe factors affecting women's interest and persistence in STEM fields [34].

Pathway Construction

Critical incidents from each included participant formed a natural division of events that either drew them into the discipline of EER or ones that made them want to move away from their prior discipline. Incidents were then categorized based on their overall directional influence: push factors, which motivated movement away from a prior discipline, and pull factors, which attracted participants toward EER.

We used the distinction between "push" and "pull" factors to describe some of the common pathways by which participants who pursued a traditional engineering discipline transitioned into EER. Each of these three pathways represents a patterned sequence of push or pull incidents that participants described as part of their transition into EER.

Findings

Participants' transitions into EER were shaped by a series of key moments, evolving interests, and opportunities that often emerged unexpectedly. The pathways presented below illustrate common ways participants described making sense of their pivots into EER, highlighting that there is no single or "correct" way to arrive in the discipline.

Pathway 1: Teaching Felt like Home

For several participants, the move into EER was not a departure from their original goals, but rather a delayed realization of them. These individuals often entered engineering because of their aptitude in math and science or encouragement from teachers and family members. However, they described a longstanding interest in teaching that came before their awareness of EER as a discipline. One participant said

> I would say I've always wanted to be an educator… and then along the way also realized I really enjoy science. I really enjoy math…the classic response …was 'Hey, you ought to be an engineer.' And I was like, what's that? So I started looking at it and realized I could always go back to education. I can do the engineering thing and hey, maybe I can even teach engineering.

For these individuals, critical incidents frequently occurred when participants were given opportunities to teach, either during graduate school or other early teaching experience, and often without much training or preparation. These experiences were described as both frustrating and rewarding. While participants found teaching meaningful, they also became aware of gaps in their understanding or ability to support student learning. It was not until they learned about the Scholarship of Teaching and Learning [35] and engineering education research that their concerns were validated, and they were given a way to study teaching more in depth.

One participant described initially emulating her own instructors' teaching styles, only to feel frustrated when her students struggled in ways she did not understand. After exposure to the engineering education research community, she says, "I had all of this exposure to teaching methodologies and education research I got excited and I started to experiment with my teaching."

Overall, these participants framed their transitions not as abandoning engineering, but as finding a way of integrating their traditional engineering background with a long-held desire to focus on students and learning.

Pathway 2: When Engineering No Longer Fit

Another common pathway involved participants who experienced disengagement during graduate training in a traditional engineering discipline. These participants describe feeling increasingly disconnected from their work, often realizing they did not see their research or impact as meaningful. One participant described this as:

> I always kind of felt like either I was just completely bored by what I was doing or it was just beyond me, or I was just not getting something. And I think that it was mostly because I wasn't interested enough to go deeper. It didn't excite me.

Sometimes, participants saw engineering education as a chance to apply what they had been learning in a way that felt more meaningful to them. In one case, that had to do with youth development and STEM outreach:

> I saw [an engineering education doctoral program] as an opportunity to merge my engineering training that I had decided I didn't want to really want to further with….what I felt was my calling to serve youth, particularly Black urban youth. And I wanted to focus on the K-12 engineering education and using that as a way to kind of engage youth through engineering.

In several cases, the transition toward EER came after an encounter with a mentor or fellow student who named EER as a legitimate alternative pathway. In one case, a participant's advisor recognized they were not happy in mechanical engineering and supported them when they expressed interest in pursuing EER. In another case, a participant working as an environmental engineering consultant after her undergraduate degree felt she was not able to understand some of the social aspects of her job. A colleague suggested she pursue graduate studies, which she had not previously considered, leading her to quit her job to begin a doctoral degree and eventually pursue an EER topic. Although this participant did not specifically describe disinterest in her prior discipline, she discussed wanting to understand more about the social factors involved, which is often an under-recognized aspect of engineering.

For a smaller subset of participants, negative experiences within their previous disciplinary contexts served as explicit push factors away from traditional engineering. These participants described moments of discouragement that made them believe they were not made for the discipline they were studying. One participant shared:

> I had a bum first REU experience and I took that that I was not cut out to be a research chemist…looking back, that is a complete farce, but that was my [sample size] of one and that's what I knew.

Other accounts described feeling that their research topics were disconnected from the kind of impact they hoped to have, prompting participants to search for, or at least remain open to, other opportunities. One particularly salient example involved a participant whose research advisor reacted negatively to their interest in transitioning to EER:

> I told my professor (an electrical engineer) that I was going to leave, and he got quite angry with me. He told me that I was never going to succeed. No one was ever going to hire me. No one knew what engineering education was, so it didn't have value.

Thankfully, this participant was able to find a different advisor who was supportive of them doing EER work, highlighting the critical role mentor support plays in shaping career trajectories.

Across these accounts, losing interest in a research direction, experiencing discouragement, or encountering explicit resistance within a disciplinary context served as critical incidents that prompted participants to reconsider their trajectories. Sharing these challenges with mentors or peers often created openings for EER to emerge as a viable and sustainable alternative.

Pathway 3: Stumbling into Engineering Education Research

Some participants were lucky to have early exposure to the discipline of EER. This exposure to EER came from classes outside engineering, undergraduate research or teaching experiences, and asking questions about learning. Participants recalled becoming aware of questions related to learning or student experiences that traditional engineering frameworks did not fully address. Their eventual exposure to EER is what gave them the language to express their interests. One participant realized they were interested in how engineers "live out their holistic sense of identity" and noted not having the language for it until working with a group doing EER, prompting them to begin conducting research to investigate identity.

In several cases, it was the opportunity to take classes outside of engineering (notably in women's studies, philosophy, educational research methods, and philosophy) that sparked participants' interest in EER and related topics:

> A colleague recommended I take a women's studies class. So I had not been particularly aware of gender in engineering up until that point… that term it focused on feminist approaches to science and science fiction…and that was mind altering. I, I was not able to shut that critical

> eye off. So I started taking science and technology studies courses, sociology courses, and more women's studies courses. And usually I was the only engineer there.

For many participants, these experiences marked the first time participants encountered language, theories, or methods that resonated with questions they had previously been unable to articulate.

Other participants traced their early exposure to teaching-related experiences, particularly through teaching assistantships. While serving as teaching assistants (TAs), they noticed patterns in student learning or frustration that they could not explain using their existing disciplinary teaching. These instances sparked curiosity about pedagogy and learning, leading participants to seek out additional resources or opportunities related to EER. One participant noted being "completely mystified by how students weren't learning from the excellent explanations and sheer brilliance in the classroom," which prompted them to talk with another TA who was doing research on student learning in the classroom. As a result of their teaching experience and conversation with a peer, this participant began doing their own research on student learning.

Across these accounts, participants emphasized they did not enter these experiences with an intention to pursue EER. Instead, it emerged as a possibility through exposure and encouragement. These pathways highlight how early encounters, often incidental, can reshape long-established career goals and broaden one's view of what questions can be answered through research.

Discussion

Scholars in our study pivoted into EER through critical experiences. This transition follows decision points characterized by varied experiences, culminating in push or pull factors. These experiences include but are not limited to desire for greater impact, mentorship opportunities, feelings of exclusion, and enthusiasm for student-centered work. These push or pull factors may co-occur and accumulate, eventually prompting career transitions from traditional engineering disciplines to EER. This process usually does not involve a single defining moment but rather consists of occasions that become significant only in hindsight.

Scholars' transition stories into EER created three composite pathways shaped by push and pull factors. The pathways driven by push factors consist of unpleasant experiences that cause individuals to seek more fulfilling careers outside traditional engineering disciplines. Specifically, negative experiences and growing loss of interest in a traditional engineering discipline prompted some individuals to pursue career paths in EER. For instance, when scholars feel disengaged from traditional engineering fields as students or develop feelings of inadequacy from their traditional engineering research or internship experience, they often seek advice or encouragement from mentors, advisors, or peers. These individuals often encourage the participants to pursue work more aligned with their interests. Similarly, scholars working professionally in traditional engineering disciplines may discover they are interested in questions more related to social science, leading them to seek other opportunities where they can combine both their traditional engineering expertise and social science approaches. In addition, undergraduate students can develop feelings of inadequacy from their traditional engineering research experiences, which can gradually shift their interests to disciplines that build on their background and offer more personally rewarding experiences. This pathway emphasizes that losing interest in a research direction and sharing this challenge with a mentor or peer can lead to a realignment of their work to something they find more personally interesting and sustaining.

In contrast, pull factors are positive experiences or features of EER that attract scholars. For example, scholars are often drawn to EER by their desire to teach and through early exposure to the field, such as during their undergraduate program or before beginning graduate school. Some scholars may have held strong interest in teaching but initially did not consider teaching a career they should pursue. However, when these individuals are given opportunities to teach in the university or other academic settings, they may recognize their passion and talent, motivating them to seek professional training in education and recognize EER as a well-established career path. This transition is often sustained when individuals are encouraged by or join communities of educators, where they can meet and interact with people who share similar backgrounds and interests. Other scholars gain early exposure through courses or teaching experiences that reveal student learning challenges, sparking interest in EER research.

Implications for Aspiring Engineering Education Researchers

Our study findings illuminate pathways into EER from traditional engineering disciplines, offering insight into critical experiences and emphasizing openness to emerging interests. In doing so, the study enables individuals not only to recognize experiences that signal a potential career shift toward EER, but also to identify possible next steps that can support a successful transition. For instance, aspiring scholars who feel disengaged from their current activities in a traditional engineering discipline may seek mentorship and weigh the possibility of entering EER.

Implications for Mentors and Advisors

Our study findings also validate the critical role mentors can play in ensuring a well-supported transition of aspiring scholars to EER. As seen in some of the participant pathways, mentors can open a viable career path for students when they encourage them to pursue EER based on the students' academic interests. Simply naming EER can legitimize it as a viable career pathway. However, discouragement may result if EER is dismissed or devalued by scholars who do not support its goals and approaches. Making EER visible early to students and creating opportunities through exposure or classes outside engineering are key for allowing students to discover what could potentially be their perfect academic "fit."

Limitations

This study has several limitations. First, the sample size (n = 21) and purposeful sampling strategy of pre-existing data provide insight into the various pathways through which EER scholars enter the discipline; however, findings may not capture all possible pathways. Further, the decision to present findings as composite pathways does not allow for all data to be well represented. Second, the study only includes scholars who ultimately pursued EER; individuals who considered but did not pursue EER are not represented, possibly ignoring factors that deter entry into the field. Third, the use of secondary data (e.g., podcast and interview data) prevented researcher control over questions and follow up probing. Future work could extend this analysis through longitudinal research designs that follow scholars as they navigate early exposure to EER and transition from traditional engineering to EER doctoral training. Future studies can also investigate other pathways to EER beyond the transition from an undergraduate traditional engineering degree.

Conclusion

This study examined how scholars with undergraduate training in traditional engineering disciplines come to pursue doctoral degrees in engineering education research. By applying critical incident analysis, we identified three composite pathways shaped by push and pull factors, highlighting that entry into EER is rarely linear or preplanned. Instead, participants' pathways were marked by evolving interests, moments of disconnection with current research, and opportunities that participants later recognized as influential.

For students and early-career scholars, these findings underscore that there is no single "right" way to arrive in EER. Career plans often shift, interests may emerge and evolve over time, and pivots can foster growth rather than signify failure. For the field of EER, understanding these pathways provides a foundation for making early EER more visible and legitimate, especially for those who began their academic journeys in traditional engineering spaces. By illuminating how scholars find their way into EER, this work contributes to ongoing conversations about access to and future development of the field.

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