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Work-in-progress: Mentoring experiences of students at an Engineering Research Center

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Abstract

In this work-in-progress paper, we present an investigation of students' mentoring expectations and perceptions as members of an Engineering Research Center (ERC). The goals of this study are to understand students' mentorship experiences with their mentors at the ERC and to identify opportunities for improvement in mentoring practices. Mentoring relationships can play an important role in the development of engineering students' professional identities. While there is a plethora of studies on mentor-mentee relationships in engineering disciplines, these relationships have not been extensively examined in the context of a National Science Foundation (NSF) ERC. In 1985, the NSF launched the ERC program to foster research, education, and technology and make a positive societal impact in the US; since that time it has successfully sponsored a growing number of ERCs. Students in these ERCs are major contributors to the power engine that drives the momentum of ERCs' directions. Yet, because ERCs are multi-institutional, interdisciplinary, and project-based organizations, students' may not gain easy access to mentorship, and their experiences may not be optimal or may be misaligned with their expectations.

To lay the groundwork for improving students' access to mentorship and their experiences in this unique setting, we have formulated the following research questions: (1) How do students at an ERC describe their ideal mentoring relationships? and (2) What are the key factors that shape students' perceptions of effective mentoring in this context? To address these questions, we utilized an inductive qualitative research approach to gain a deeper understanding of students' mentoring perceptions and experiences. A total of 14 students at the ERC participated in the full study. The full study included conducting pre-interview surveys and semi-structured interviews facilitated by participant-drawn sociograms. The survey responses and sociograms were used to supplement the qualitative analysis of the interview data. The full analysis and presentation of these data will be used in the future work.

The preliminary findings reveal that ideal mentorship includes providing (1) guidance for research activities, (2) career development opportunities, and (3) empathy towards students. These findings provide practical implications for ERC mentors because they can use this information to improve their mentoring guidelines and educate students about social capital resources within the center. For example, this study found that students most commonly valued research guidance from their principal investigators (PIs), while some also expressed a desire for more holistic mentoring that supports their professional and personal growth. A few participants appreciated their PIs' thoughtfulness and efforts in ensuring their well-being and sense of inclusivity. However, students also expressed a desire for more opportunities to efficiently and effectively interact with others at the center, beyond their immediate research group. This study offers an in-depth understanding of the students' mentoring needs and perceptions at an ERC, which can inform the design of more effective mentoring programs and training for faculty or mentors. Future studies may examine the perspectives of other members at the center, such as faculty members and staff members, to gain a more comprehensive understanding of mentorship dynamics and opportunities to leverage for improvement.

Keywords: Mentorship, mentoring expectations and perceptions, engineering research center, mentor-mentee relationship

Introduction

Engineering Research Centers (ERCs) are funded by the National Science Foundation (NSF) in the United States, with goals to promote the unique intersection of engineering disciplines and its impact on social issues [1]. Through an interdisciplinary intersection of engineering and science, problems that cannot be solved by a single discipline can be tackled by a group of engineers and scientists from different backgrounds. As of now, there are 19 active ERCs [2], which work on societal issues and promote strategic advances in complex engineered systems.

Mentoring within the context of ERCs presents unique opportunities and challenges that distinguish it from other mentoring environments. Unlike traditional classroom settings, ERCs can support the fostering of close mentoring relationships between students and their principal investigators (PIs), offering personalized guidance and direct oversight on projects. Beyond these direct relationships, students also have opportunities to engage with a broader network of potential mentors, including lab members and collaborators from other labs or institutions, creating a dynamic and multifaceted mentoring ecosystem.

Students serve as the primary drivers of ERC projects, contributing significantly to the research and operational success of these initiatives. Effective mentorship is essential for motivating students and encouraging their active participation in ERC projects, ultimately enhancing both their personal development and the overall research productivity of the center.

This work-in-progress (WIP) paper presents a part of our preliminary findings of a work on studying mentoring ecosystems at the center. In this WIP, we show methods used for data collection and analysis, as well as initial findings of students' perceptions and experiences with their PIs at the center. The work provides evidence-based recommendations for ERC PIs and project managers to refine and improve their mentoring programs. By addressing the unique aspects of ERC mentoring environments, this paper aims to support the development of mentoring practices that reinforce student engagement and foster a culture of collaboration and innovation within ERCs.

Literature review

Mentoring has long been a critical component of engineering education, with numerous studies highlighting its importance in supporting students' career development [3], [4], professional identity [5], [6], [7], and retention in STEM fields [8]. These mentoring relationships have typically focused on the role of faculty mentors, who provide valuable resources and guidance to their mentees [8], [9], [10].

However, there is growing recognition that the scope of mentoring opportunities should extend beyond the confines of having only one mentor. For example, a prior study suggested that there are various forms of mentoring, such as mentoring triads, groups, or networks, where mentees receive guidance from multiple mentors [11]. In this way, mentoring becomes more flexible and tailored to meet the unique needs of each individual more effectively. In another study, the authors suggested that mentoring ecosystems should be utilized when designing a mentoring

system so that student mentees and faculty mentors could feel resourceful and capable of accessing mentorship effectively [12]. Mentoring in the context of multi-institutional research projects can further offer students a broader network of professionals as well as access to a wider range of resources and experiences that can complement their academic training.

To this end, ERCs are uniquely positioned to offer diverse mentorship opportunities for students, as their projects are inherently interdisciplinary and collaborative. To fully leverage the benefits of the ERC context, it is essential to gain a deeper understanding of students' perceptions and experiences with their PIs. This insight can help enhance students' professional development, learning experiences, and research performance. To address this issue, the following research questions are posed for this study: (1) How do students at the ERC describe their ideal mentoring relationships? and (2) What are the key factors that shape students' perceptions of effective mentoring in this context?

Methods

This study employed a convenience sampling technique [13] to recruit participants at an ERC. After receiving approval from the institutional review board, we distributed an email across all members at an ERC, informing them about the importance of this study and requesting their participation. Of the trainees, a total of 14 students and postdocs agreed to participate in the study. Their participation included completing pre-interview questionnaires and semi-structured interviews, where participants also created sociograms [14] to illustrate their relationships at the center (refer to Figure 1). These sociograms, along with survey responses, provided valuable context and enriched the qualitative analysis of the interview data.

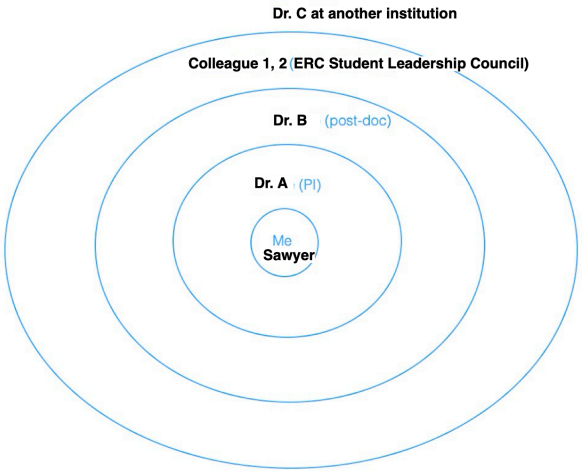

Figure 1. An example of a sociogram drawn by Sawyer (pseudonym) with names de-identified for publication purposes.

Each participant was given a definition of mentorship to help guide their reflection on the meaning of mentorship during the interview. As defined by the National Academies of Sciences, Engineering, and Medicine (NASEM), "mentorship is a professional, working alliance in which individuals work together over time to support the personal and professional growth,

development, and success of the relational partners through the provision of career and psychosocial support." [10, p. 2] Next, participants were asked to draw a sociogram that reflected their social networks of people whom they work closely with and feel comfortable talking to.

Once they drew the sociogram, the interviewer asked questions about their experiences with their mentor. Examples of interview questions include, *"Please tell me a little bit about your experience with your mentor.", "How long has your mentor been mentoring you?"*, *"How did you get connected with this mentor?"*, and *"Please tell me about an encounter with your mentor where you sought out their help or assistance."* These questions helped participants to describe a type of mentorship experience they want and those they actually have with their current mentor(s). While answering these questions, participants used their drawings to reflect on their experience with mentors.

We employed inductive qualitative data analysis to gain a preliminary understanding of the data [13]. Interview transcripts were primarily used to interpret participants' experiences. During this process, the survey responses and sociograms helped enrich the understanding of participants' responses. Once full data analysis is complete, data triangulation will be employed to ensure the transferability of qualitative findings [15].

Preliminary Findings and Future Plans

The preliminary analysis of student interviews highlights key elements of an ideal mentorship relationship within the ERC context. Students emphasized the importance of receiving guidance for research activities, access to career development opportunities, and empathy from mentors. This finding aligns with existing literature that underscores the dual role of mentors in providing both psychosocial and career support [10].

Additionally, some students expressed a desire for mentorship opportunities beyond their immediate lab, indicating the value of a broader network of mentors who can offer diverse perspectives, resources, and support for professional growth. This finding suggests that ERCs should consider expanding mentorship frameworks to include access to multiple mentors, leveraging the collaborative and interdisciplinary nature of their projects.

Finally, a few students highlighted the significance of faculty mentors demonstrating thoughtfulness and care for their well-being, reinforcing the role of empathy as a critical component of effective mentorship. These responses suggest that fostering holistic and inclusive mentoring practices can enhance students' overall experiences and outcomes within ERC programs.

Students in ERC are the engine to achieving the organizational goals. Students in the ERC work with various experts, professionals, and peers in diverse fields and gain opportunities to engage in various types of meetings and events. As part of the center's Engineering Workforce Development (EWD) and Diversity and Culture of Inclusion (DCI) missions, student mentorship is a key area that helps illuminate and improve ways to broaden the participation of the engineering workforce and create an inclusive engineering culture.

To better understand the mentorship structure and maximize the benefits of multi-institutional learning environments, future research will employ interpretative phenomenological analysis

[16] to explore faculty members' perceptions and expectations of their mentees. Comparing these perspectives can provide a comprehensive view of mentoring dynamics at the center, highlighting potential misalignments and opportunities for improvement.

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