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Work in Progress: Exploring Elements of a Mentoring and Professional Development Program in Engineering Education

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My name is Cyra Anderson and I am a Junior studying Industrial & Operations Engineering at the University of Michigan. This Summer, I gained research experience, under mentor Dr. Joi-Lynn Mondisa, in which I helped cultivate and attend a virtual mentoring and professional development program for undergraduate and graduate students. On campus, I am an active member of the National Society of Black Engineers (NSBE) and the Co-Programming chair of U of M's Collegiate Midnight Golf Program. I also enjoy playing soccer and hanging out with family and friends.

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Introduction

There is a need to increase the mentoring and professional development skills of undergraduate and graduate students in engineering to help ensure their matriculation and success in the STEM workforce (National Academies of Sciences, Engineering, and Medicine, 2020). To increase the readiness of STEM students, they need positive reinforcement and knowledge about the types of environments they will occupy and exposure to unknown established curricula.

Mentoring involves an experienced individual (a mentor) educating, guiding, and counseling a less experienced person (a mentee) to help them develop skills and realize their dreams (Eby et al. 2007; Kram 1983). Professional development skills are the interpersonal skills acquired when continuing education and career training within the workforce (Antley, 2020). Having these skills can help people develop new skills, stay up-to-date on current trends, and advance their careers. Mentorship is present in science, technology, engineering, mathematics, and medicine (STEMM) contexts through operationalized career support (e.g., career guidance, skill development) and psychosocial support (e.g., role modeling) that is catered toward mentee talent expansion (Byars-Winston, Dahlberg, 2019). Effective mentorship can complement other processes of professional maturation like coaching or teaching, making it essential to all aspects of development into STEMM professionals and to navigating the culture of STEMM (Byars-Winston, Dahlberg, 2019).

In this study, the principal investigator (PI) leveraged a Research Experience for Undergraduates (REU) supplement to conduct a 3-month, bi-weekly undergraduate and graduate virtual mentoring program in which undergraduate and graduate students would learn about navigating the academy, research, and professional development skills. The guiding research question for this study is what are some elements of a mentoring and professional development program that students value? This work shares details about the elements of the program that supported student development and impacted attendee awareness of the "hidden curriculum", or the unstated enforcement of certain behavioral patterns, professional standards, and social beliefs (Miller & Seller, 1990). We also present insights about potential future opportunities for these types of programs to potentially help students more easily navigate academic and socio-political customs needed for success.

Literature Review

Mentoring and Professional Development

Mentoring reflects a unique relationship between individuals, one different from other interpersonal relationships (Eby et al, 2007). Mentors provide coaching or guidance to assist mentees with career advancement while developing relationships to properly foster mentees' personal growth and self-efficacy (Kram, 1985). Mentoring scholars also found that varied applications of mentoring can be used to predict different outcomes of the mentee: career performance is indicative of a mentee's later compensation and promotion, while psychosocial functions tend to be strongly influenced by the mentee's overall satisfaction with the guiding relationship (Allen et al., 2004; Wanberg et al., 2003).
Effective mentoring can dramatically impact the social and academic career outcomes of both mentees and mentors.

After a person enters the workforce, professional development refers to ongoing education and career training that will help them gain new skills, stay current with industry trends, and advance their careers. (Antley, 2020). In 1997, the Accreditation Board for Engineering and Technology (ABET) released Engineering Criteria2000 (EC2000), an outcomes-based undergraduate accreditation standard designed to encourage the development of “soft” engineering skills such as teamwork, communication, and group problem-solving (Volkwein et al., 2004). This report addressed a need for engineering education to better support non-technical outcomes for students (Sarin, 2000) such as increasing effective communication, providing a broader understanding of the global and societal impacts of engineering solutions, and reenforcing how to use engineering tools and skills in practice (Lattuca, Terenzini, & Volkwein, 2006).

Programming and Models of Mentoring and Professional Development

Existing research has shown that participation in cocurricular activities increases student interaction with their community, intellectual development, career development, ability to think critically, and overall satisfaction with the college experience (Montelongo, 2002; Pascarella & Terenzini, 1991; Terenzini, Springer, Pascarella, & Nora, 1995). Researchers speak to the importance of skill development for students in undergraduate engineering education (Fisher, Bagiati, & Sarma, 2014). In 2013, a comprehensive development framework emerged from analyses of student organizations of a preeminent American undergraduate engineering institution and existing literature on different types of student involvement (Fisher, 2013; Fisher et al., 2014). This framework identified engineering-relevant skills and attributes (e.g., interpersonal communication, teamwork, and public speaking)) associated with each type of cocurricular involvement.

Currently, research exists on issues related to diversity in STEM, but not on the social interactions and cultural practices that influence real solutions and permanent changes to those issues (Brown Jr., 2011). A “multicontextual” model documented by Edward E. Brown Jr. may be more effective in achieving favorable “affirmative outcomes”, such as a nationwide increase in diversity in colleges, that should have been accomplished by previous initiatives. This model suggests that the answer to increasing the number of underrepresented students pursuing STEM baccalaureate degrees lies in examining and addressing the culture of the engineering classroom and the engineering laboratory (Ibarra, 1999). The methods through which engineering faculty choose to enrich and mentor students makes just a significant impact in what they are being taught. Brown Jr. offers fours components needed for strengthening the relationship between underrepresented students and STEM baccalaureate degree pursual: (1) prioritizing diversity; (2) providing mentoring; (3) involving students in professional development activities; and (4) incorporating real cultural context within the framing of research (2011). Implementation of such elements within the study’s Biomechatronic Learning Laboratory for rehabilitation robotics and engineering education proved integration of research, education, mentoring and professional development as successful within the students’ academic environment (Brown Jr., 2011). Subsequently, there is a need for additional models and examples that illustrate ways to support the professional development of students and help increase diversity in engineering.

For engineering faculty and students to best navigate their surroundings, they must become familiar with what they should know to succeed and the experiences they may encounter. While such expectations are not explicitly written, the *hidden curriculum* is the unacknowledged advancement of certain social beliefs, behavioral patterns, and professional standards as one navigates their learning experience (Villanueva et al., 2018). This concept unknowingly manifests within the unconscious, unspoken spaces of a classroom or professional setting as it influences individuals' perceptions and interpretations of the environment. Therefore, students can be put at a disadvantage or in embarrassing situations within their classroom when what is not recognized by the educator is not being imparted to the student.

Background: Overview of the Program

For this study, the PI leveraged a National Science Foundation REU supplement to conduct the Mentoring and Professional Development in Engineering Education (MPD-E^2) Program. The MPD-E^2 Program was a virtual three-month, bi-weekly mentoring program for undergraduate and graduate students to learn more about navigating the academy, research, and professional development skills from faculty mentors. The program sessions engaged undergraduate and graduate students and featured mentoring training and career and professional development topic discussions led by 2-3 faculty mentors. The MPD-E^2 Program had 36 student participants and 8 faculty mentor participants. The faculty mentors came from education, engineering, and engineering education communities. They had diverse research lab groups and engaged in conversations with undergraduate and graduate students. Six, 1-hour program sessions occurred from May 2022 through July 2022. Sessions included topics about conferencing and networking, careers, collaborations, job offer negotiation, and general discussion about the "hidden curriculum" of graduate school.

Theoretical Framing: Mentoring and Social Community

This study uses mentoring theory and social community model elements to examine the elements of an REU mentoring program and how these elements might contribute to forming and supporting social community within the program. According to Kram, mentoring can enhance a person's personal and professional development in both early and mid-career (1983). Mentoring can serve different purposes in student development. These include, career functions, psychosocial functions and emotional support. Career functions involve providing advice and guidance with regard to school, career trajectory, and professional development (Kram, 1985). Psychosocial functions include helping to build community and a network of support structures (Byars-Winston & Dahlberg, 2019). Emotional support includes providing help with navigation through challenging times (Eby et al, 2007). In STEM and related fields, like medicine, mentoring can facilitate skill development and can increase exposure for entering such fields (Byars-Winston & Dahlberg, 2019). This is evidenced, for example, in mentoring relationships where the mentee participates in research with the mentor. This type of mentoring was also found to increase the likelihood of the mentee pursuing post-baccalaureate studies (Byars-Winston et al, 2015). In addition, mentoring was found to be especially beneficial in mitigating the academic isolation faced by underrepresented groups in higher education (Mondisa, 2018).

The Social Community Model was developed based on research involving STEM intervention programs that support minoritized populations. "A social community is an environment where like-minded individuals engage in dynamic, multidirectional interactions that facilitate social support" (Mondisa & McComb, 2015, p. 4). Successful STEM programs for underrepresented populations feature elements such as having a community of practice, which involves self-identifying with a particular group with shared values and practices (Wenger, 1999). These communities can help members increase their self-efficacy and sense of belonging, as well as provide resources and access to mentors (Mondisa & McComb 2015). In this work, we provide details about a group of faculty and students that coalesced into an informal community over a brief period of time. This community included formal and informal activities such as engaging in discussions in breakout rooms on Zoom, as well as attending a group dinner during an annual conference in 2022. During the program, social community elements emerged in that participants had access to more experienced individuals through mentoring and engagement, and they were exposed to information relative to careers, graduate school, and networking opportunities.

Researchers' Positionalities

The project team consisted of three researchers: 1 Black man and 2 Black women. The first and second authors served as primary researchers and the third author is the PI for the project and supervised the research conducted. The first author was born and raised on the West side of Detroit, MI. Growing up, her parents exposed her to science, technology, engineering, and mathematics (STEM) programming for youth in metropolitan Detroit such as Detroit Area Pre-College Engineering Program (DAPCEP) and Wayne State University's C2 Pipeline. As she grew in talent, intelligence, and capacity to excel in STEM fields, further investments were made toward her education, which included pursuing her bachelor's degree in Industrial and Operations Engineering at the University of Michigan. She is currently a sophomore and reached out to the PI looking to gain experience through the University's Undergraduate Research Opportunity Program (UROP). Once learning about the PI's project within mentoring and engineering education, she was intrigued to learn what goes into a mentorship program from an administrative perspective and the research behind what would make one successful. As an engineering student, she knew the support and guidance mentors can provide is priceless. Therefore, being able to aid in developing such an impact on other students further motivated her to participate in this study.

The second author is a first generation immigrant from Jamaica. He holds chemistry, chemical engineering and engineering education research degrees. He is a Black man who has worked in STEM higher education for approximately 20 years as a chemistry instructor. He also worked as a chemical engineer for several years. He is currently pursuing a PhD in engineering education research where he is examining racial allyship. The motivation for participating in this area of research was born out of feeling othered for most of his career. This stemmed from being one of few Black people in courses, research teams or professionally. He recognized the importance of social networks for students in general, especially minoritized groups. He strongly believes that "students don't know what they don't know" and with access to resources and mentors, students can find a successful career path. The third author, an African American woman, conducted the program leveraging her mentoring research findings to guide the program's development and facilitation. She also provided feedback to the primary authors about the research design, findings, and interpretations of the data.

Methods

For the study, we used open coding and thematic analysis to address the study's research question (Creswell & Poth, 2016). Specifically, we examined the program's general functions and elements using session notes and discussion of our observations. Throughout each program session, general notes about participant responses and the content of that meeting was transcribed in real time by the research team. Our research team later reviewed the notes. First we reviewed participants' comments and discussed the implications of their reflections as it pertained to that session's topic. Then, we characterized particular perceptions and/or experiences that were relevant to answering the guiding question. For example, we read through, discussed, and analyzed the participants' comments and our general meeting notes to identify elements of the MPD-E^2 Program to which the participants responded positively. Finally, we identified and summarized emergent themes.

Results

In this work, we present information about the participant pool and details about the elements of the program that support student development and insights about potential future opportunities for these types of programs. Specifically, there were three themes that emerged. The participant pool was composed of 5 undergraduate students and 31 graduate students. No specific demographic information about the participants was collected as this study was designated as "Not Regulated" by the institutional review board given its focus is on the broader aspects of the program. Based on general participant feedback during sessions, the following themes emerged.

Theme #1: Clear, Consistent Expectations

With program participants being mostly graduate students and faculty, the program needed to be conducive in fostering high-level thinking. We began the first session by sharing the program's established purpose, desired level of engagement, and the expected outcomes. This gives participants a clear understanding of what was being asked of them and allowed participants to attend confidently, on time, and prepared to take part in the discussion. Carrying out the program in a concise, organized manner supported the effectiveness of communication throughout each session.

Theme #2: Transparency Amongst Participants

The third author and REU principal investigator had previously conducted research on the ways that elements of people's interactions can contribute to the creation of a social community and the manifestation of beneficial outcomes for community members. She was able to define social community by proposing a conceptual model for understanding how a community's design plays a role in the enrichment of its members. This led us to design an open environment in which participants were comfortable asking questions and sharing experiences to strengthen the program's intent to help students' professional skill development. A foundation of trust and honesty encouraged networking even in a remote setting and allowed participants to feel comfortable engaging in academic communication with others of a shared professional identity.

Theme #3: Engaging Content

Incorporation of relevant discussion topics made participants more likely to engage in this virtual setting and led to equally important side conversations about arising topics as connections were made. An aim of the MPD-E^2 Program included operationalizing mentorship for STEM contexts through providing faculty career guidance, role modeling, and insight on some aspects of the "hidden curriculum" of STEM culture, such as how to effectively navigate conferences, graduate school and careers. Participants learned from one another and created informal mentoring relations that now span across several institutions.

Discussion

The intent of the program was to expose participants to a formalized structure for learning professional development skills and information, asking questions, and engaging with peers and faculty members from their communities. Social communities like this can assist in giving students skills needed to successfully navigate college and careers (Mondisa, 2015). The informal, safe environment established for participants allowed for intentional questioning and transparency, sharing of valuable knowledge on vast topics, and consistent attendance at sessions. The elements of this program that supported student development addressed the frequent lack of information that some students (particularly marginalized populations) may encounter in academia. This speaks to the hidden curriculum phenomena as mentioned earlier (Laiduc & Covarrubias, 2022). In particular, the findings seem to indicate that the program helped assist in cultivating an environment for asking questions and sharing transparently, as well as supporting the exchange of knowledge and information. Therefore, over the course of the program the participants resembled members of a community of practice (professional development), and had access to information and support (Wenger, 1999). The informal, safe environment established for participants allowed for intentional questioning and transparency, and sharing of valuable knowledge on vast topics. These assertions were affirmed based on participant engagement and feedback during Zoom meetings over the six meeting sessions.

Conclusion

There are several implications for future research and practice related to mentoring and professional development programming of this nature. First, future researchers should examine ways to cultivate the environment in both in-person and virtual contexts. This might include exploring ways to create and build community among participants through interactive activities that can be performed in-person or virtually. Also, future research might examine ways in which the program elements are transferable to various contexts or program structures. For example, one might explore existing formalized programs that provide concentrated systematic professional development information to undergraduate and graduate students.

In summary, the MPD-E^2 Program was successful in educating undergraduate and graduate students on navigating the academy, research, and professional development skills from faculty mentors. Likewise, the broader impact of this program are the resourceful connections made amongst participants. The elements of this program that support student development can be emulated in similar program settings to aid in the production of well-prepared undergraduate and graduate students to help meet the needs of our emerging workforce.

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