Examining the Value of Mentoring in Youth Engineering Programs: What Motivates a Mentor to Mentor?

Racheida S. Lewis[1], Cherie Edwards, Walter C. Lee[1], David Knight[1],
Kayla Maxey[2], Jessica Rush Leeker[2], Monica E. Cardella[2], Morgan M. Hynes[2]
[1] Department of Engineering Education, Virginia Tech
[2] School of Engineering Education, Purdue University

Abstract — **The purpose of this research study is to examine the motivations of undergraduate students, graduate students, and teaching professionals to serve as mentors for elementary school-aged kids participating in the Summer Engineering Experiences for Kids (SEEK) program hosted by the National Society of Black Engineers (NSBE). Data collection was conducted through semi-structured interviews (n=25), which we analyzed using a two-pronged approach: 1) through attribute coding, we identified demographic information, and 2) through value coding, we identified the participant motivations for mentoring, which enabled us to identify the value attributed to the mentoring experience and thus each participant's rationale for participating in the mentoring experiences. The themes that emerged from this analysis were mentors valuing their roles as influencers for the younger generation, mentors' enjoyment in teaching and sharing their interest in science, and the belief that their roles in the camp enhanced their professional opportunities. The results of this study contribute to the literature on mentor motivation and provide empirical evidence for educators and administrators who aim to incentivize mentor engagement.**

Keywords—K-12 engineering; pre-college programs; outreach programs; student beliefs; motivation; persistence

I. Introduction

The Summer Engineering Experience for Kids (SEEK) camp is a 3-week signature summer program hosted by the National Society of Black Engineers (NSBE) for children in 3rd-5th grades in about 15 different cities across the country. Founded in 2007, the mission of SEEK is to "To increase elementary school students' aptitude in math and science and their interest in pursuing STEM (science, technology, engineering, math) career fields, by having them engage in interactive, team-based engineering projects." [1]. Through site location and student recruitment designed to expose African-American youth to STEM fields, SEEK engages students in three week-long curricular units focused on different aspects of engineering, providing 105 contact hours per camp.

Each camp leverages NSBE members, primarily college students who identify as African American, as mentors who have educational backgrounds in STEM or education. Seen as knowledgeable and experienced advisers, mentors are touted as vital agents in professional and educational development. Mentors are also essential to the recruitment and retention of students from underrepresented races, ethnicities, and genders [2,3,4,5,6]. As a result, much of what we know regarding mentor/mentee relationships in youth engineering programs center on the impact these relationships have on the youth who engage in them [2, 7, 8, 9, 10]. More recent empirical work, however, has focused on the reported academic and interpersonal growth for mentors of youth engineering programs [11, 12]. While the engineering education community's understanding of what mentors gain from these experiences continues to grow, there is still much to learn about what draws mentors to these roles in the first place [3, 13]. Thus, to explore these experiences, we sought to answer the following research question:

RQ: What motivates students and professionals to pursue mentoring roles in SEEK?

II. Literature Review

Engineering outreach programs are typically developed for one or more of the following goals: increase engineering enrollment, diversify engineering, educate our future, teach the teacher, and undergraduate student development [14, 15]. To achieve these goals, Jeffers, Safferman, and Safferman [16] discuss six common themes in the approaches of outreach programs: active learning through hands-on activities, inquiry-based learning, curriculum supplements, engaged role models, younger student focus, and K-12 teacher involvement. The SEEK program implements all six common themes during the three-week summer camp. The purpose of this study is to focus on the motivation(s) for engaged role models, referred to as mentors in the SEEK program.

A. SEEK Site-Based Mentoring Structure

The mentoring structure of SEEK capitalizes on a current shift in youth mentoring programs across the United States, from formal mentoring relationships to site-based mentoring programs. Historically, formal mentoring programs such as Big Brothers Big Sisters of America (BBBSA) dominated the landscape [17, 18]. These formal mentoring relationships

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consisted of adult volunteers as mentors, one-on-one mentor/mentee relationships, and the freedom to engage in different activities across different settings at a mutually convenient time [18, 19]. However, the growing body of research highlighting the positive development outcomes of effective mentoring relationships has generated public eagerness to increase access for all youth to have the opportunity to develop productive nonfamilial adult mentor relationships. This public eagerness has prompted an increase in site-based mentoring models utilized in youth programs [18, 20, 21]. In general, site-based mentoring structures are defined as programs where the mentoring relationship is developed at predefined locations (e.g., school or out-of-school programs) and within the goals of the program (e.g., facilitating engineering design) [18, 22]. In addition, the role of the mentors in site-based mentoring structures often include additional programmatic support responsibilities (e.g., curriculum instruction) in comparison to mentors in traditional mentoring programs [9, 11, 12]. In the case of NSBE's SEEK summer camp, the mentoring sites are predominantly based in local schools. At each site, mentors are responsible for the facilitation of the engineering curriculum in addition to providing supportive mentoring relationships to their student(s) [23, 24, 25]. As a result SEEK's site-based program structure and the recruitment of racially and ethnically diverse undergraduate and graduate NSBE members with STEM and education backgrounds, provides an opportunity to increase access to racially and ethnically diverse role models to support the development of students who are historically underrepresented in STEM careers.

B. Outcomes of Effective Mentoring

Since the growth and development of the student is the nucleus of mentoring relationships, a vast majority of the research favors student outcomes [18, 19, 22, 26, 27] over effective relationship characteristics [28], program effectiveness [29], and motivations of or benefits to participating mentors [30]. In effective mentoring relationships, students' outcomes can manifest as improved academic performance, improved emotional health, college preparedness, and career development [32]. Despite these positive student outcomes, mixed research findings are common because of the variable and personal nature of each mentoring relationship [18, 22].

In addition to student development outcomes, other research explores characteristics of effective mentoring relationships and program effectiveness. One study relevant for the all-girl SEEK sites was conducted by Leyton-Armakan et al. [28] sought to understand the characteristics of mentors that fostered positive mentoring relationships through feelings of trust, empathy, and mutuality [28]. The authors evaluated three pre-existing characteristics of female collegiate mentors — self-worth, cultural empathy, and mental health — and their influence on adolescent girls' satisfaction with the mentoring relationship and self-reported improvement. However, similar to other studies on youth mentoring, Leyton-Armarkan et al.'s work focuses on the student outcomes over the motivations or benefits of participating mentors.

C. Mentoring in Engineering

In alignment with the broader research agendas, mentoring relationships within the context of engineering education concentrates heavily on developmental outcomes of engineering students. Unlike research around youth mentoring programs, the work focused on mentoring in engineering is situated primarily in higher education [5, 13, 33]. The benefits of mentoring for engineering students include enhanced career development, a network of support, and access to role models [4, 13, 34]. In addition, engineering education mentoring research suggests that mentoring is a critical aspect of the success of underrepresented student populations [5]. Mentoring provides opportunities for underrepresented student populations to develop interests [35], identity [10], support networks [4, 6], and for organizations to improve recruitment and retention strategies [2, 5, 36]. For example, programs, like SEEK, who utilize racially and ethnically diverse mentors provide opportunities for engineering students to see their future selves within the discipline and improve their sense of belonging [10]. Based on these findings, research in pre-college engineering education outreach programs include mentoring as a critical component of their outreach program and suggests a positive relationship between mentoring and the effectiveness of the program [9, 12, 16].

D. Reciprocal Benefits of Mentoring Relationships

Despite mentors being critical players in productive mentoring relationships, there is limited research exploring the reciprocal benefits of mentoring for the mentors [14, 30, 31]. For example, a study by Good et al. [3] evaluates the mentoring component of the minority engineering program established to improve retention rates of minority students at a predominantly white institution. Understanding mentoring within the context racial and ethnic diversity is pertinent for the evaluation of SEEK program goals to establish mentoring relationships by pairing students from underrepresented backgrounds in engineering with mentors of similar racial or ethnic backgrounds. Good et al. [3] examined the academic and the interpersonal development of African-American tutors through journaling. The tutors' journals demonstrated the following academic growth because of their mentoring relationship: improved study skills, improved critical thinking and problem-solving abilities, improved understanding of core engineering concepts, and increased incentive or motivation for academic success. The mentors' interpersonal gains included ease of social interaction and communication, development of responsibility and leadership skills, sense of self-satisfaction, and belonging [3]. The reciprocal benefits of mentoring relationships illustrated in the work of Good et al.'s study support the need for further investigation the benefits of mentors engaging in these activities. Other research findings suggest that mentors experience a renewed commitment, a sense of satisfaction from being a part of someone else's growth, and improved communication skills [30, 31].

Without willing and motivated mentors in engineering, it will be difficult for outreach programs to effectively support

engineering interests and development of students from underrepresented communities. As a result, it is necessary to understand how mentors are influenced by the mentoring relationship and program structures they support. By continuing to engage mentors in outreach programming with a minimal assessment of their engagement and well-being, the engineering education community runs the risk of creating environments that unintentionally support toxic and ineffective mentoring relationships [33]. Despite good intentions, this risk may be too high and may further prohibit students from underrepresented communities from pursuing engineering career pathways. Because of SEEK's site-based mentoring structure and the program's focus on improving engineering career pathways of students from historically underrepresented communities, we have an opportunity to investigate the complementary nature of mentoring relationships. This study intends to understand the motivations of mentors who participate in the SEEK program. The findings from this investigation intend to support mentor training, program development, and assessments of pre-college engineering programs with a focus on mentoring initiatives.

III. Overview of SEEK's Mentor Training

To support classroom instruction and the development of mentoring relationships during SEEK, the mentors completed an on-site training module in each of their host cities. The on-site training included an interactive walk-through of the SEEK curriculum where mentors learned about the SEEK's engineering design process [42,43] then the mentors practiced using diversified and inclusive messaging about engineering [44, 45] and facilitation strategies for engaging students with engineering through positive collaboration [46, 47, 48, 49, 50, 51, 52]. The content focused on diverse and inclusive engineering messaging and facilitation strategies was interlaced with Gay's [53] (2010) tenets of culturally responsive teaching to demonstrate to the mentors how to recognize and encourage the multiple abilities of their students in the classroom and in their mentoring relationships [54, 55].

IV. Theoretical Framework

To explore reasons why mentors choose to mentor, our research team chose expectancy-value theory as the theoretical framework for this study. Using this framework allowed for a deeper exploration of the perceived benefits for engaging in mentoring experiences. Expectancy-value Theory (EVT) is a motivational model that links achievement performance, persistence, and choice to an individual's expected outcomes and task value beliefs [37]. Eccles et al. [37, 38] states that choices can be influenced by either positive or negative experiences with all choices having a cost associated with them. This cost is what allows a particular choice to outweigh other choices in consideration for the individual. According to EVT, expectancies and values may directly influence a person's performance, persistence, and task choice through perceptions of competence, the difficulty of tasks, and personal goals. Eccles and Wigfield (2002) identify four components of task-value: attainment, intrinsic, utility, and cost. Attainment value is defined as the relevance of doing a task that aligns with an individual's beliefs and identity. Intrinsic value is defined as the enjoyment one receives from doing a particular task. Utility value is defined as an individual's perception of how useful completing the task will be in current and future goals. Lastly, the cost is defined as the negative aspects of doing the task and the amount of effort needed to be successful. Cost may have an individual question "what will I have to sacrifice to achieve X?" or "is the potential of getting X outcome worth the time and energy I will need to invest" [37]. Using EVT we were able to explore mentors' intrinsic and extrinsic motivation to participate as mentors for SEEK.

V. Methods and Analysis

A. Data Collection

Data were collected through semi-structured interviews of 25 SEEK mentors. Mentors were interviewed during site visits to six SEEK camps across the country and were conducted by researchers in Engineering Education from Virginia Tech and Purdue (a separate team from the programming team for SEEK). Interviews were recorded and transcribed for analysis. Only excerpts addressing mentor motivation were identified and marked for analysis. More specifically, responses to the question, "What is your motivation for mentoring in the SEEK program?", were isolated for analysis.

B. Analysis

Statements related to participants' motivations for engaging in mentor roles were isolated for analysis and coded using an in vivo approach to coding [39]. Next, the *in vivo* codes were organized into focused codes that reflected patterns emerging from the first round of coding. Lastly, focused codes were organized into categories that aligned with the domains of the expectancy-value theory through hypothesis coding [40]. A final review of the focused codes allowed the research team to identify themes that emerged from the data.

Focused Code	**Construct/ Hypothesis Code**	**Definition**
Positive Influences for Young Girls	Attainment Value	Mentors placed personal importance of doing well in their roles. The roles are important when mentors view them as central to their sense of self.
Influencing Younger Generations		
Enjoyment of Teaching	Intrinsic Value	Mentor engages in the role because of the enjoyment gained from mentoring
Joy of Engaging in Science		
Teaching Encouragement Through Mentor Role	Utility Value	Mentoring fits into future professional plans for the mentor.
Enhanced Professional opportunities		
No present	Cost Value	

Fig. 1. Mentor Expectancy-Value Theory Constructs

VI. Results and Discussion

The first stage of analysis yielded 59 in vivo codes. The codes identified in the first stage of analysis were organized into five focused codes (Positive Influences for Young Girls, Influencing Younger Generations, Enjoyment of Teaching, Joy of Engaging in Science, Teaching Encouragement Through Mentor Role, Enhanced Professional opportunities). Fig. 1 outlines the hypothesis codes informed by the expectancy-value theory as well as the focused codes that comprised them. Each theme will be discussed in reference to the categories and direct quotes that supported its development.

A. *Mentors value their roles as influencers for a younger generation in general and young girls, specifically*

For SEEK mentors, there was an attainment value placed on their roles as influencers for a younger generation in general and young girls, individually. These themes were developed from the categories of being a positive influence for young girls and being able to influence younger generations. This theme aligns with pre-existing characteristics of female collegiate mentors identified by Leyton-Armakan et al [28]. A mentor at one camp expressed this form of motivation as "bettering the next generation because right now we don't have a lot of good role models for the next generation." Mentors at the all-girl camps shared these statements "I think that's part of the more the mentoring part, to let them know we're all professional women" and "Helping the young girls. I am all about the younger girls because they are the future. Just helping kids in general, they are the future, so if I can help them and lead them into the STEM-based fields, I want to do that because we need more African American people." With that fact, there are slightly more female mentors than males. While our sample of participants is an accurate representation of the ratio of female to male mentors in SEEK, it also means that in the future, we will need to be more intentional about interviewing men to gain their perspective on this phenomenon especially given the low number of men compared to women in the field of elementary education [41]. Future exploration of this study may seek to answer the question of "How does motivation for engaging in SEEK differ across gender, education levels, and professional status?"

B. *The enjoyment of teaching is a valued interest of mentors; A desire to share their interest in science through teaching motivates mentors.*

For SEEK mentors, intrinsic value was identified through the enjoyment of teaching as a valued interest of mentors and a desire to share their interest in science through teaching. These themes were developed from the categories of finding the enjoyment of teaching and having the joy of engaging in science. One mentor shared their enjoyment of teaching as an admiration of the children: "They [kids] have a bright mind. They're unapologetic. They just think outside the box. They're not restricted. They don't think, 'Oh no, if I do this, this is going to happen.' They have so many new ideas, so if I give them a pitch, they'll be like, 'Oh but we could do it this way.' I'm like, 'You're right,' and it's so amazing to think like that." This admiration for students' creative thinking details the support mentors provide to students and expands on the research that suggest mentoring opportunities for underrepresented students enables those students to develop their interest, identity, and support networks [4, 6, 10, 35]. The joy of science was expressed by one mentor as they exclaimed "I did ask for different gifts that helped, like during birthdays and during Christmas I would ask for science books and different stuff so I can play around and really get introduction to it". Another mentor shared "I just have a love for kids. A love for teaching." Most of the mentors interviewed mentioned a career pathway either in or strictly closely related to education. More specifically, a mentor identified their intrinsic value as "SEEK was a good opportunity to meet at all the intersections of my interests and kind of work on the ground and be able to be the change in that area." From the emergence of this theme, new questions arose as potential research questions for future work such as "How does educational background influence motivation for engaging in SEEK?" and "How does engaging as a mentor for SEEK influence men to pursue career paths or increase outreach efforts in K-12 education?"

C. *Mentors are further encouraged to pursue teaching careers through their roles with the camp; Mentors gain enhance professional opportunities through their roles at the camp*

SEEK mentors found their experiences during the camp useful through exposure to real life experience that aligns with their career interests. These themes were developed from the categories of being encouraged to teach through the mentor role and the access to enhanced professional opportunities. Because SEEK camps take place in local school buildings and can be sponsored by a school district or an engineering company, mentors can develop relationships with SEEK that enables them to pursue career passions beyond the SEEK camp dates. This expands on the work conducted by Good et al. as an illustration of benefits mentors gain by participating in this experience [3]. This access to professional development and hands-on experience with SEEK was expressed by one mentor expressed as "the opportunity to, again, be able to see the change and be the change on the ground level without seeing it from the high in the sky, 1,000 miles up researcher's perspective or policy maker's perspective." One mentor described the usefulness of SEEK as "I am planning on probably going to take my practice to be a teacher. So, by working with this program, it will help in a lot of ways ... of teaching, give me more experience and hands-on experience, and know how to deal with the children."

VII. Implications and Future Work

Through conducting this study, we were able to explore the nuances of each category within expectancy-value theory. While the categories of EVT provide a high-level explanation of motivation, our approach allowed for more exploration into each category regarding motivation specifically related to the mentoring experience. As discussed in the literature review, there are few studies that examine the mentor gains and motivations of the mentoring experience; this study begins a discussion within that underexplored area. Therefore, while doing this study was fruitful in answering our research question and contributing to the literature on mentor motivations, through further analysis of the results, new questions arose prompting ideas for future work. These questions, previously discussed in the results and discussion section, include but not limited to:

1. How does motivation for engaging in SEEK differ across gender, education levels, and professional status?
2. How does educational background influence motivation for engaging in SEEK?
3. How does engaging as a mentor for SEEK influence men to pursue career paths or increase outreach efforts in K-12 education?

As we continue into summer 2018 SEEK camp cycles, we are modifying our survey and interview questions to gain more targeted insight of how motivation is developed and described by SEEK mentors of various backgrounds.

VIII. Conclusion

The purpose of this study was to examine the motivations of undergraduate students who mentor at SEEK Camps. Informed by expectancy-value theory, our research question was addressed through a qualitative analysis of 25 mentors from the SEEK 2017 cycle. Our analysis resulted in three key themes summarizing why mentors were drawn to engage in the experience: teaching, professional development, and influencers. The mentors who participated in our study indicated that teaching is an interest of theirs and by participating in SEEK, they can share their interest for STEM through teaching and are further encouraged to pursue teaching as a career path. This, in turn, supported their professional development as they received hands-on experience of being a teacher to elementary school students. Lastly, mentors found value in being able to influence the younger generation positively toward the STEM profession, specifically young girls.

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