Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #48880

Cultivating Future Engineers through Mentoring Experiences: Undergraduate Student Perceptions of Mentorship in an Educational STEM K-12 Summer Program (EBR)

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Cultivating Future Engineers through Mentoring Experiences: Undergraduate Student Perceptions of Mentorship in an Educational STEM K-12 Summer Program

Abstract

The Goldberg Gator Engineering Explorers (GGEE) Summer Program is an informal STEM education program that offers free summer camps for K-12 students from under-resourced communities. Camps are held in the K-12 student's local school district and emphasize skills development in computational thinking, engineering design, technology, and systems thinking through hands-on, collaborative, student-driven projects. Camp sessions are co-facilitated by local K-12 teachers and undergraduate student mentors from the University of Florida. The GGEE program prioritized the hiring of undergraduate student mentors who were from the school districts hosting the camps.

In this exploratory mixed methods study, undergraduate student mentor perceptions of near-peer mentorship are used to assess the GGEE program's impact on participant STEM identity and explore the personal benefits of participation. This paper reports on the following research questions: *1) How does serving as near-peer mentors to K-12 student mentees in an educational STEM summer program impact undergraduate students' STEM identity? 2) What did undergraduate student mentors feel that they got out of the experience? 3) What were undergraduate students' perceptions of mentorship in the program?* Data was collected in the form of online pre- and post-surveys and virtual one-on-one exit interviews. Quantitative data underwent descriptive analysis, and qualitative data underwent thematic analysis. Results show that participants' STEM identity increased by the end of the camp and that participants gained several benefits including improved professional skills, improved technical skills, and determination to persist in STEM. Providing near-peer mentoring experiences for undergraduate students, therefore, may serve to improve their mental concept of being an engineer, potentially increasing the likelihood of degree completion.

Keywords: *near-peer mentorship, STEM identity, under-resourced communities, undergraduate students, K-12 students, workforce development, informal learning environments*

1. Introduction

Informal learning environments, such as STEM summer programs, provide K-12 students with out-of-school-time (OST) opportunities to actively engage in their own learning and pursue interests that may otherwise be unavailable to them [1], [2]. These opportunities are particularly important for K-12 students from under-resourced communities who have historically lacked access to high-quality science, technology, engineering, and mathematics (STEM) programs within their school districts [2], [3], [4], [5]. Many studies have demonstrated that STEM summer programs build STEM identity in K-12 students [6], [7], [8], [9], [10], [11], but a growing body of evidence suggests that undergraduate student mentors, who often facilitate or co-facilitate these programs, also benefit from increased STEM identity [12], [13], [14], [15], [16], [17].

This paper focuses on the impacts on undergraduate student mentors' STEM identity, professional skills, and perceptions of mentorship after serving as near-peer mentors in an educational STEM K-12 summer program. *STEM identity* refers to one's self-concept as "a STEM person" [18] and is often tied to a sense of belonging in STEM [19]. "Interventions that foster STEM identity may be particularly effective in promoting greater persistence in STEM majors" [18], making this an important construct in STEM education research. *STEM recognition* refers to being recognized as a "STEM person" by others and is an important contributing factor to STEM identity development, as being recognized as a STEM person can lead to self-recognition as a STEM person [18], [20]. A recent study on STEM identity in undergraduate students suggested that out of several constructive factors related to STEM identity development, STEM recognition is the most impactful [20]. In engineering specifically, "helping [students] associate a perceived engineering identity with their personal identity and demonstrating the value of this association" can increase persistence [21]. *Professional skills* are defined as non-technical skills necessary for engineering practice [22], such as teamwork, leadership, and communication. *Perceptions of mentorship* are defined as an individual's thoughts and feelings about their experience as part of a *mentoring relationship*, which may form between any more experienced individual (*mentor*) and any less experienced individual (*mentee*).

1.1 The GGEE Summer Program

The Goldberg Gator Engineering Explorers (GGEE) program, designed in 2021 and first implemented in 2022, serves K-12 students from under-resourced school districts at STEM summer and afterschool programs across the state of Florida at no cost to their parent(s) or guardian(s) [23], [24]. These programs are meant to foster a computational thinking and engineering mindset in K-12 students and empower them to succeed in STEM through hands-on, collaborative, student-driven projects. K-12 students in the GGEE summer program are typically 10 to 15 years old, with most students entering grades 6 through 9 at the end of the summer. Undergraduate students from the University of Florida are recruited to serve as co-facilitators of the program with local K-12 teachers and as near-peer mentors for K-12 students.

During the first years of the GGEE program, only impacts on K-12 students were investigated. As the program was shown to positively impact K-12 students in the summers of 2022 and 2023, the IRB protocol was modified and the study expanded to include investigation of the impacts on teachers and undergraduate student mentors, starting with the 2024 summer cohort.

1.2 Near-Peer Mentorship Between Undergraduate Students and K-12 Students

Mentorship experiences are known to play a crucial role in the professional development of STEM students, especially those from under-resourced school districts [25]. Effective mentorship can help keep such students in STEM, which can strengthen and diversify the future STEM workforce. Mentoring is often hierarchical [26], but may take different forms. *Peer* or *near-peer mentorship* can be defined as "mentoring relationships formed between individuals who are at approximately the same stage of career development" [25]. Mentors and mentees with shared identities and perspectives may find peer or near-peer mentoring particularly effective as "the goal is assisting the mentee in becoming more expert in a role [they and their] mentor already share" [26]. Undergraduate students from under-resourced communities that serve as peer mentors to other undergraduates have been shown to benefit from increased STEM identity, sense of belonging, and self-efficacy [27]. Undergraduate students can also serve as near-peer mentors for middle and high school student mentees [12], the GGEE program's target audience (Figure 1).

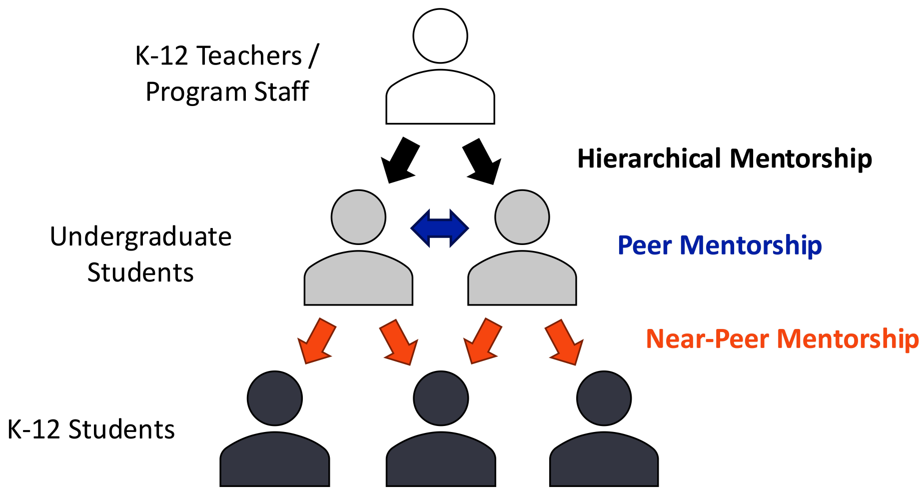

Figure 1. Types of Mentoring Relationships that May Exist in the GGEE Program.

Undergraduate student mentors have been shown to gain "personal, educational, and professional benefits" from mentoring their K-12 mentees [12]. Tenenbaum et al. [12] studied the impacts of the "Gains in the Education of Mathematics and Science" (GEMS) summer program, targeting middle and high school students from under-resourced communities, on undergraduate students who served as near-peer mentors. Near-peer mentors in the GEMS summer program received two weeks of pedagogical training prior to the start of the program. Near-peer mentors also received a stipend for their work. Data was collected via an online survey containing 20 open-ended questions and thematically analyzed using a deductive-inductive process. The two primary themes reported were "growth and maturation" and "perceptions of near-peer mentorship". Overall, the authors reported that by the end of the program, near-peer mentors had improved professional skills and behaviors as well as increased self-confidence and self-efficacy. The specific skills mentioned in the study include "adaptability to change, professional attire, timeliness, being responsible, workplace performance, and content knowledge". The authors reported that several near-peer mentors tied their experience teaching in the program to increases in their confidence and technical skills. Additionally, near-peer mentors reported increased motivation to pursue STEM careers, with some sharing that they were interested in academia as a result of the experience.

In a follow-up study, Anderson et al. [13] reported that near-peer mentors in the GEMS program "advanced their career aspirations and personal maturation" . Data was collected via pre- and post-surveys with open-ended questions; data was analyzed thematically as described in the previous study [12]. Near-peer mentors were again reported to have improved their professional skills and behaviors and to have become more motivated to pursue their career goals. Furthermore, near-peer mentors reported an increased commitment to teaching and mentoring in their future careers.

In a 12-year retrospective study on the long-term benefits of near-peer mentor involvement in the GEMS program, Anderson et al. [14] demonstrated that individuals who had previously served as near-peer mentors while they were undergraduate students had increased STEM persistence. This finding was evidenced by 95.7% of respondents either currently working in a STEM or STEM-related field (47.5%) or pursuing a STEM degree (50%). Respondents also reported that their involvement resulted in an increased desire to become involved in STEM outreach opportunities.

Verma and Ali [15] evaluated the impacts of the Xavier University of Louisiana's Mobile Outreach for Laboratory Enrichment (XULA-MOLE) project, a six-week long mobile STEM outreach program for high school students from under-resourced communities with undergraduate students from the same or similar communities serving as near-peer mentors. This program was meant to increase access to high-quality STEM education. The near-peer mentors in this program received laboratory safety training and pedagogical training. Data was collected in the form of self-reflections, which indicated that near-peer mentors improved their communication and teaching skills and increased their conceptual understanding as a result of their involvement in the program.

Torres et al. [16] reported on the graduate student led six-week long Journey for Aspiring Students Pursuing Ecological Research (JASPER) near-peer mentoring program, which targets rural high school students and is facilitated by undergraduate mentors. This program is integrated into the authors' Theodolite Overlooking Predators and Zooplankton (TOPAZ) research project, which tracks gray whale foraging behaviors. All students in the program are paid, including high schoolers. The first two weeks of the program include safety and technical training, onboarding activities, and team-building activities, while the remaining four weeks are comprised of gray whale research activities with site visits from the principal investigator. In anonymous open-ended post-surveys, near-peer mentors reported improvements to their professional skills in areas including leadership, critical thinking, communication, and teamwork. They also reported increased STEM identity and self-confidence, as well as increased technical knowledge. The authors additionally followed-up with previous near-peer mentors to find that 88% persisted in STEM, whether they were currently working in a STEM field or pursuing STEM degrees.

Rayford et al. [17] assessed the benefits of near-peer mentoring on undergraduate mentors in the Renaissance Engineering Summer camp, a week-long STEM summer program for incoming seventh, eight, and ninth graders. This program was implemented remotely due to the Covid-19 pandemic. Data was collected through daily journal entries and semi-structured interviews. Near-peer mentors reported improved teaching skills, an increased sense of belonging in STEM, and increased conceptual understanding as a result of the program. In reflecting on the study results, the authors described near-peer mentoring as "a valuable enrichment opportunity to supplement undergraduate core engineering education".

The benefits discussed in this section are summarized in Table 1, below and on the following page.

Table 1. Summary of Benefits Undergraduate Mentors Receive According to the Literature.

Reference	Near-Peer Mentorship Context	Undergraduate Mentor Benefits
[12]	Undergraduates mentoring middle and high school students from under-resourced communities in a STEM summer program	• Improved professional skills and behaviors • Increased self-confidence and self-efficacy • Increased motivation to pursue STEM and/or teaching careers

Reference	Near-Peer Mentorship Context	Undergraduate Mentor Benefits
[13]	Undergraduates mentoring middle and high school students from under-resourced communities in a STEM summer program	• Improved professional skills and behaviors • Increased commitment to teaching/mentoring • Increased motivation to pursue STEM and/or teaching careers
[14]	Retrospective on undergraduates who had mentored middle and high school students from under-resourced communities in a STEM summer program	• Increased STEM persistence • Increased desire to become involved in STEM outreach opportunities
[15]	Undergraduates mentoring under-resourced high school students in a STEM outreach program	• Improved professional skills (specifically in communication and teaching) • Increased conceptual understanding
[16]	Undergraduates mentoring high school students from under-resourced rural communities in a STEM summer program	• Improved professional skills (specifically in leadership, critical thinking, communication, and teamwork) • Increased technical knowledge • Increased STEM identity and self-confidence • Increased STEM persistence
[17]	Undergraduates mentoring incoming seventh, eight, and ninth graders in a remote STEM summer program	• Improved professional skills (specifically in teaching) • Increased conceptual understanding • Increased sense of belonging in STEM

Undergraduate mentors in the GGEE program, therefore, are expected to incur similar benefits.

2. Research Questions

The study reported here is part of a larger research project, approved by the University's Institutional Review Board (IRB# 202102451), designed to explore perceptions of mentorship and STEM identity construction in undergraduate mentors and K-12 students, as well as self-efficacy in K-12 teachers, as they participate in an educational STEM summer program. This study aims to answer the following research questions:

1) *How does serving as near-peer mentors to K-12 student mentees in an educational STEM summer program impact undergraduate students' STEM identity?*
2) *What did undergraduate student mentors feel that they got out of the experience?*
3) *What were undergraduate students' perceptions of mentorship in the program?*

3. Methodology

3.1 Recruitment, Hiring, and Training of Undergraduate Mentors

Undergraduate mentors are paid employees of the GGEE program. This position is open to undergraduate students with a STEM background currently attending the University of Florida, a large, public, R1 university in the United States (U.S.). For the 2024 summer program, a member of the research team who serves as the GGEE program coordinator created a flyer advertising the position and emailed it to the College of Engineering undergraduate student LISTSERV, all College of Engineering student organizations, and to any undergraduates who had previously worked for the program. Information about the position was also spread organically by word of mouth to friends and acquaintances by previous undergraduate mentors.

After the application window closed, potential undergraduate mentors were interviewed for the position. Those who were hired were background-checked and fingerprinted, in accordance with the university's youth compliance policies. Once the hiring process was completed, undergraduate mentors received twelve hours of skills training led by program staff to prepare them to assist K-12 teachers on-site for the duration of one or more camp sessions. This training includes an overview of program activities and facilitation strategies, as well as best practices for working with K-12 students. Undergraduate mentors, however, are not explicitly trained in mentorship practices.

3.2 Study Population and Sampling Methods

In the summer of 2024, there were twenty-six total camp sessions hosted at twenty-two different sites across fourteen counties in the state, serving 322 K-12 students. Each camp session included 40 contact hours in either a one-week full-day or two-week half-day format. Twenty-two undergraduate students were hired into the 2024 summer undergraduate mentor cohort. The number of undergraduate mentors working at any one site was dependent upon both their locality to the site and the number of K-12 students signed up for a given session, with each group of up to twenty K-12 students having one teacher and a maximum of two undergraduate mentors.

The population for this study included all twenty-two undergraduate mentors who worked for the GGEE program between June 3rd and August 1st, 2024. Out of those twenty-two individuals, twenty volunteered to participate in this study, resulting in a 91% participation rate.

3.3 Data Collection Methods

Data Storage and Data Collection Timeline. All data collected in this study was saved to a secure University-hosted instance of the file storage service Dropbox, according to IRB requirements. Data collection occurred in three steps, below, following a generalized timeline (Figure 2):

1) Participants completed a pre-survey after their twelve hours of training but before any summer camp sessions began,
2) Participants completed a post-survey after sessions had concluded, and
3) Participants were interviewed after submitting their post-surveys.

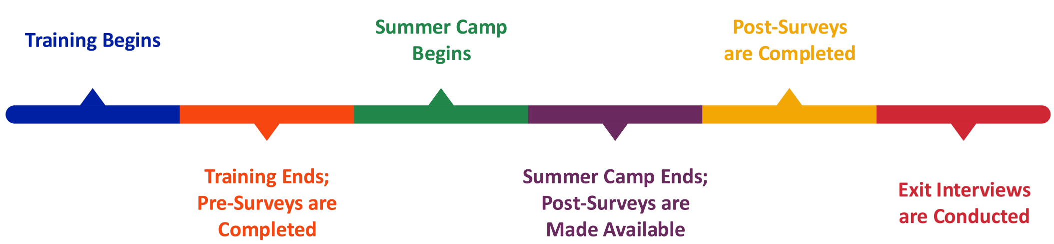

Figure 2. Data Collection Timeline Relative to Training and Summer Camp Sessions.

Surveys. All surveys were conducted virtually via the online survey software Qualtrics [28]. Participants were provided with an anonymous link to the pre-survey though the collaboration software Microsoft Teams at the end of their last training session, with time reserved for survey completion. This time was provided to ensure that pre-surveys were completed before any summer camp sessions had begun. The timing of the post-survey was variable for each participant as anonymous links were shared to the Teams channel as soon as a specific summer camp session had concluded. Once all surveys had been completed, survey data was exported from Qualtrics into the proprietary spreadsheet software Microsoft Excel and stored on Dropbox.

Survey instrument. The pre- and post-surveys were primarily quantitative but included some qualitative open-response questions. The first part of each survey collected demographic data, such as gender, race, ethnicity, and intended major, while the second part contained questions related to the study aims. Open-ended survey questions were adapted from Schill's Student Survey Instrument [29]. In the following paragraphs, the close-ended survey questions are discussed. Please refer to Appendix A for a list of relevant pre- and post-survey questions.

As part of the survey design process, a literature review of possible tools to measure STEM identity was conducted. Several tools were considered, including the STEM-ID Scale [30], Dou and Cian's STEM Identity Instrument [20], and the STEM Professional Identity Overlap (STEM-PIO-1) Measure [18]. As the GGEE program wanted a tool that could address STEM identity across all project participants (i.e., K-12 students, teachers, and undergraduate mentors), the STEM-PIO-1 Measure was ultimately chosen (Figure 3). This validated single-item graphic tool is appropriate for use with a wide range of participants, making it useful for eventual cross-sectional studies.

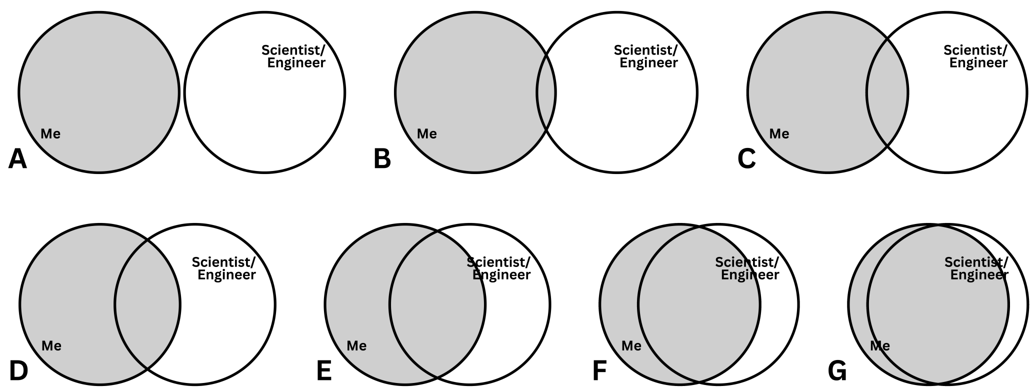

Figure 3. The STEM-PIO-1 Measure, as Presented to Participants in Pre- and Post-Surveys.

The STEM-PIO-1 Measure allows participants to indicate how much their sense of self overlaps with their idea of a STEM professional using graphics labeled from A to G, with A showing no overlap and G showing almost complete overlap. In the present study, this tool was adapted to ask about feeling like a scientist or engineer and appeared on both the pre- and post-surveys.

To explore the perceived benefits of participation, participants were asked, "How would you rate your coding skills?", on both the pre- and post-surveys. This question utilized a 4-point (None, Basic, Medium, or High) Likert scale. This question was created for the program to assess participants' technical gains.

Interviews. One-on-one semi-structured interviews were conducted at the participant's earliest convenience after they submitted their post-surveys at the end of the camp. All interviews were conducted virtually on the online conferencing software Zoom by one of three members of the IRB research team inclusive of the researcher, with each interview lasting between 15 to 30 minutes. Participants were deidentified using a random code generator and interviewers manually transcribed participant responses in real-time using the proprietary word processing software Microsoft Word in documents hosted on the secure Dropbox.

Interview questions. Interview questions relevant to this study (Appendix B) were divided into those discussing STEM identity, those discussing benefits of participation, and those discussing perceptions of mentorship. Questions were adapted from Schill's Student Interview Script [29].

3.2 Data Analysis Methods

Quantitative analysis. Quantitative data was tabulated and averaged in Microsoft Excel to determine the percentage of participants who selected each survey option. The resulting XLSX file was imported into the RStudio integrated development environment (IDE) [31] and visualized using the open-source programming language R [32].

Qualitative analysis. Qualitative data, which included anonymous participant responses to the open-ended survey questions and deidentified participant responses to the interview questions, underwent exploratory reflexive thematic analysis [33] using a hybrid deductive-inductive coding approach [34]. This combines deductive approaches, which utilize themes derived from the existing literature, with inductive approaches, wherein patterns in the dataset are interrogated and emergent codes are identified [35]. While an inductive (i.e., data-driven) approach is appropriate for preliminary, small-scale studies, such as this one, and empowers the researcher to "prioritize and honor the participants' voice" [35], utilizing deductive (i.e., theory-driven) approaches in tandem serves to strengthen the resulting analysis [34]. To further enhance the rigor of the research, thematic analysis was guided by the six steps outlined in Naeem et al.'s systematic model [36].

Step 1: Transcription, Familiarization with the Data, and Selection of Quotations. Once all qualitative data had been collected, the researcher compiled participant responses into an Excel spreadsheet hosted on Dropbox and organized the responses by question. The researcher then read through the entire dataset until they reached saturation, as recommended by Braun and Clarke [33], [37]. At this point, they began to make note of patterns in the data and select stand-out quotations that would serve to illustrate the participants' perspectives. As this was an iterative process, the researcher returned to the dataset multiple times to ensure that the patterns they were identifying were those most pertinent to the study aims. For example, the researcher would take special care to capture information regarding participants' STEM identity.

Step 2: Selection of Keywords. During this step, the researcher began to identify keywords derived directly from the data, which would later assist in theme creation. Keywords should allow one to glean conceptual understanding of the ideas contained in the dataset. In this study, the researcher made note of keywords as they appeared. Once all keywords were identified, the researcher performed a keyword search to quantify the keyword frequency in the dataset.

Step 3: Coding. In the coding step, datapoints of interest are labeled with codes, which further aided the researcher in identifying essential data. This was done manually in Excel, with the researcher copying participant responses into a new sheet and capturing relevant information in a new column beside the extract, and then color-coding, similarly to the method described by Bree and Gallagher [38]. The anonymized or deidentified participant identifier was retained to allow the researcher to keep track of where codes originated from during this process. Since coding is a process of meaning-making and creation, several iterations of this step were necessary.

Step 4: Theme Development. Themes are recurring patterns of meaning in the data, however, just because a theme is prevalent does not make it relevant to the study. In this step, codes were sorted into categories and the relationships between those codes were explored. This step included interrogating theme definitions or descriptions until they are robust and of high quality. As this research was conducted using a hybrid deductive-inductive approach, the existing literature was consulted often throughout the theme development process to corroborate known phenomena and assist in theme creation.

Step 5: Conceptualization through Interpretation of Keywords, Codes, and Themes. The conceptualization step is all about refining the thematic analysis work done up to this point. Concepts should be grounded in the "real data", that which was collected during the study, to ensure that participants' lived experiences are reflected in the results of the analysis [36].

Step 6: Development of a Conceptual Model. As this work is still in its exploratory phases, the conceptual model is still in development and will be disseminated in a subsequent publication.

4. Results and Discussion

Out of the twenty participants, all completed the pre-survey (100%), fifteen completed the post-survey (75%), and those who completed the post-survey were interviewed. Nineteen of the twenty participants (95%) were engineering students. Table 2 compares participant demographics to data from the U.S. Census [39] and the National Science Board's *STEM Labor Force* report [40].

Table 2. Undergraduate Mentor Demographics Compared to U.S. National Data.

Category	**Participants**	**Total Population** [39]	**STEM Workers** [40]
Gender			
Male	40.0%	49.5%	65.4%
Female	60.0%	50.5%	34.6%
Race			
American Indian or Alaska Native	0.0%	1.3%	0.3%
Asian	15.0%	6.4%	9.5%
Black or African American	0.0%	13.7%	8.2%
White	45.0%	75.2%	62.9%
Other Race Alone or in Combination	35.0%	3.3%	4.3%
No Race Selected	5.0%	-	-
Ethnicity			
Hispanic or Latino	50.0%	19.8%	14.8%

With this data in mind, it is critically important to ensure that the participants complete their degrees and make it into STEM careers to create a more diverse STEM workforce.

4.1 Impacts on Undergraduate Mentors' STEM Identity

The impact to participants' STEM identity was quantitatively reported by changes in the survey results for the STEM-PIO-1 Measure [18] as shown in Figure 4, below.

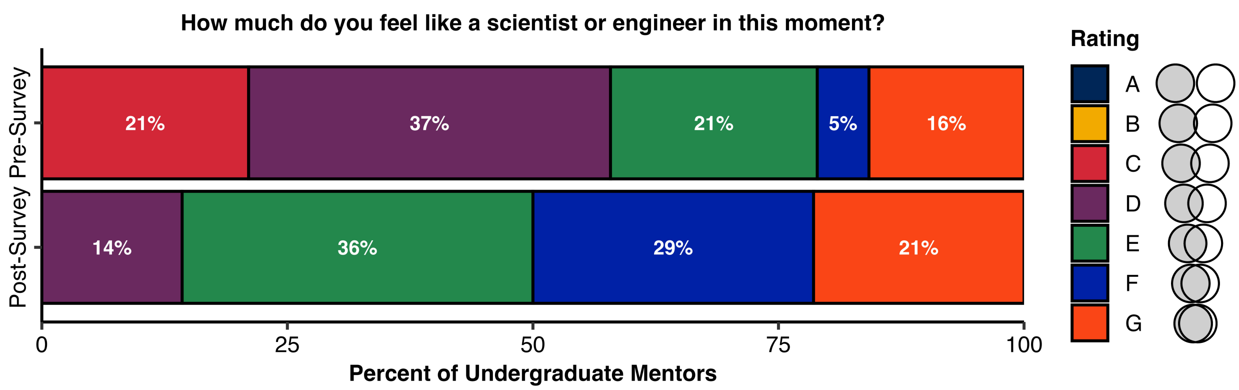

Figure 4. Participants' STEM Identity Between Pre- and Post-Surveys (n_{pre} = 19; n_{post} = 14).

After their participation in the program, 86% of participants rated their STEM identities at an E, F, or G, options that represent feeling almost completely like a scientist or engineer, as compared to only 42% selecting those options on the pre-survey (Figure 4, below). This 44% increase in participants' STEM identities marks a considerable shift towards seeing themselves as scientists or engineers. It is also notable that option C – selected by 21% of participants in the pre-survey – did not appear in the post-survey, while option D decreased from 37% in the pre-survey to 14% (a 23% drop) in the post-survey. Options A ("not at all") and B ("barely") did not appear in the data.

When asked to elaborate on how participation impacted their STEM identity in the interview, 87% of participants felt that their STEM identity improved or was reaffirmed due to working as an undergraduate mentor at the camp. One participant stated that,

> "*Being in that position of being a mentor over just being an assistant or just lecturing really made me feel like I was an engineer. Not just because I was obviously doing hands-on activities, but because I was able to share what I knew, share my technical experience, and share this in a way that could help others*."

Another participant said,

> "*Part of me has always wanted to be a scientist or engineer and this solidified that. I do not think the camp changed my feelings exactly but rather reinforced my desire to be a scientist or engineer even more*."

A different participant noted that the improvement to their STEM identity stemmed from the "*external validation*" they received while serving in their role as an undergraduate mentor. One of the two participants who did not feel that their STEM identity had changed stated that their STEM identity was "*already set in stone*." The other shared that since they were "*not doing any of the sciencing or engineering*," their STEM identity was not affected. Both individuals, however, felt that other undergraduate mentors may have experienced changes to their STEM identity.

STEM Recognition. When asked if they felt recognized as a scientist or engineer by K-12 students, teachers, other undergraduate mentors, or program staff in the interview, all participants agreed that they had felt recognized in some way: 87% of participants felt recognized by teachers, 80% felt recognized by K-12 students, 47% felt recognized by other undergraduate mentors, and 27% felt recognized by program staff. Additionally, 67% of participants described feeling "*like the expert in the room*." This mirrors the earlier quote about external validation being important to participant STEM identity development.

4.2 Undergraduate Mentors' Perceived Benefits of Participation in the Program

When prompted to share what they got out of the program in the post-survey, some participants (36%) described improving their coding skills and conceptual understanding of computing. Supporting this claim, 10% of participants rated their coding skills more highly on the post-survey using a 4-point (None, Basic, Medium, or High) Likert scale (Figure 5, below).

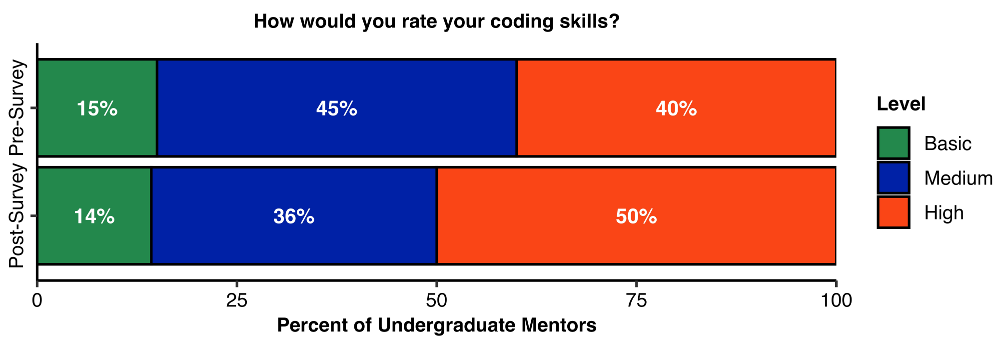

Figure 5. Participants' Coding Skills Between Pre- and Post-Surveys (n_{pre} = 20; n_{post} = 14).

Many of the participants (79%) felt that they had gained or improved their professional skills in areas such as leadership, collaboration, adaptability, time management, and communication, with 33% of participants specifically mentioning that they gained teaching skills and experience. When asked to elaborate in the interview, one participant shared,

> "*I feel like <u>I got to work on a lot of skills for teaching</u> and being able to explain the process of something because that was something that I, I mean, I am not perfect at it, but <u>it really helped me work on my explanation skills</u> and seeing how the kids responded to it.*"

Mentorship often involves the mentor teaching the mentee [17]. When near-peer mentors teach their mentees, the mentor may benefit from deeper learning [17], as expressed by this participant:

> "*I always really liked <u>teaching them the process of debugging</u> and <u>it helped me find a different way to debug my codes</u>, it was interesting to see how the kids do it from*

> *an outside perspective. <u>As you are teaching them things, they are teaching you things</u>, it just gives you a whole new perceptive because kids look at things in such a different way than adults do.*"

4.3 Undergraduate Mentors' Perceptions of Mentorship

During the interview, participants were asked to define mentoring. One participant distinguished mentoring from teaching by explaining,

> "*For me, <u>mentoring is like helping and guiding students</u>, so it is like teaching in a way, but more <u>helping them through each and every step without telling them exactly what to do</u>. <u>Showing them how to think and find the right path for themselves</u>, whereas in teaching it is more like showing them exactly what needs to be done*."

Participants were then asked to describe a mentor.

> "*A mentor is someone that kind of helps you improve in your pursuit of whatever concept you are looking into, so <u>an engineering mentor would help you get more into engineering and more embedded into the field. It would be someone who would point out internships or scholarships or help you get more involved with engineering itself.</u>*"

When asked to describe a mentor's attributes in no more than three words, 50% of participants offered one of these words: attentive, caring, helpful, observant, or supportive. About a third (29%) of participants described mentors as either knowledgeable or understanding, and the remaining 21% of participants described them as patient.

When prompted to share what aspects of mentorship they brought to the program, participants described sharing their knowledge/expertise (50%) and providing psychosocial support (33%), two major aspects of mentorship discussed in the literature [25]. When asked about these aspects in the interview, one participant described sharing their "knowledge of being" with students:

> "*I believe that <u>I was able to put my knowledge of being, studying engineering and computer science, and to put that knowledge and give that to the young kids</u>. I think I was able to guide them through certain problems and situations so they could grow and learn more and <u>I was able to give them my knowledge so they could grow within engineering</u>*."

All participants reported having mentored K-12 students at least half of the time they were working at the camp in the post-survey, with 72% of participants reporting that most of their time was spent mentoring K-12 students. When asked to elaborate on this in the interview, one participant said,

> "*<u>It was a perfect opportunity to mentor</u>. You are with them [K-12 student mentees] for hours every day, and you are trying to keep them focused, but with the projects*

you really have a lot of time to engage with them and get them excited about what they are doing."

Since undergraduate students serving as near-peer mentors to K-12 student mentees are often themselves mentees of more experienced individuals [12], participants were asked who they felt had mentored them during the program in the post-survey. Nearly half (43%) of participants reported that they had been mentored by K-12 teachers, the same percent (43%) reported that they had been mentored by program staff, 7% reported that they felt mentored by other undergraduate mentors, and 7% selected *Others*. When prompted to specify, this participant wrote, "I did not necessarily feel mentored, but it was a collaborative effort to learn the micro:bit with the teacher and other undergrad." The mentoring relationships participants reported above aligned with the research team's anticipations, as outlined in Figure 1.

4.4 Study Limitations

Survey responses were not matched between individual participants. Since undergraduate mentors are employees of the program, it was important to ensure their anonymity, therefore no identifying information was collected. This, however, made survey-matching impossible. In the future, the research team will prompt participants to create their own unique ID so that the identity of the participant will remain unknown to the research team, but their pre- and post-surveys can be matched for improved analysis.

5. Conclusions

This study investigated the impacts of near-peer mentorship for undergraduate student mentors in an educational STEM K-12 summer program. Participants reported a 44% increase to their STEM identity by program completion. They also reported numerous benefits gained through their participation, including professional skills development, especially in the areas of mentorship and teaching, and improved technical skills, as evidenced by a 10% increase to their coding skills. Additionally, participants gained a deeper understanding of mentorship with relation to both the development of their mentees and their own professional development. These results indicate that serving as near-peer mentors to K-12 students in this program built participant STEM identity, mentoring skills, and technical abilities.

As 95% of the participants were engineering students, these findings suggest that providing undergraduate engineering students with near-peer mentoring experiences in similar contexts may promote STEM identity construction, professional skill development, and reaffirmation of their decision to persist, all of which are contributing factors in their cultivation as future engineers.

6. Acknowledgements

This work was conducted through funding from a University of Florida Foundation Grant "Goldberg Gators Engineering" program as part of the EQuIPD project at the University of Florida. The researcher would like to thank the study participants for their willingness to share their insights and experiences. The researcher would especially like to thank their co-authors and the rest of the research team for their assistance and support throughout this study.

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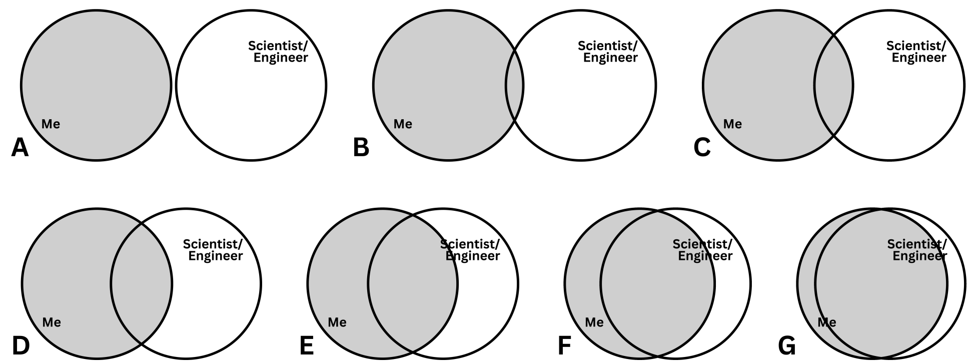
Appendix A – Relevant Pre- and Post-Survey Questions Organized by Topic

STEM Identity

1. How much do you feel like a scientist or engineer in this moment? Please select the option that most applies:



Perceived Benefits of Participation

2. How would you rate your coding skills?

   a. None   b. Basic   c. Medium   d. High

3. What did you gain from this experience?

4. What was your most valuable take away?

Perceptions of Mentorship

5. To what extent do you feel that you mentored K-12 students during this experience?

6. What aspects of mentoring did you bring to the program?

7. Do you feel that you were mentored during your participation in this program?

Appendix B – Relevant Interview Questions Organized by Topic

STEM Identity

1. Did participating in the camp enhance your personal feelings of being a scientist or engineer? Why or why not?

    a. [If not] Think about a hypothetical undergraduate student; how do you think participating in camps like this one might impact their feelings of being a scientist or engineer?

2. Have you felt recognized as a scientist or engineer by the camp, K-12 students, teachers, or other undergraduate mentors?

Perceived Benefits of Participation

3. Why did you choose to participate in this camp?

4. What personal benefits did you derive from your participation in this camp?

Perceptions of Mentorship

5. How do you define mentoring?

6. What is a mentor?

7. Use three terms to describe the attributes of a mentor.

8. What did you do in the camp that included aspects of mentoring?

9. Are there elements of the camp that facilitated or inhibited these aspects?

10. Did you experience different types of mentoring relationships while at the camp?

11. To what extent do you feel that you were mentoring your K-12 students?