

RESEARCH REPORT

A Quantitative Analysis of a Customized Mentoring Program with STEM Underrepresented Students

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Abstract: *This article highlights a customized mentoring program that successfully supported underrepresented students in science, technology, engineering, and mathematics (STEM) disciplines at a university in the northeastern part of the United States (U.S.). Because of the national and regional needs to augment underrepresented, minority, first-generation, and low-income STEM college students, this study investigated efforts to expand the number and retain such population in higher education STEM programs through a customized mentoring program based on a National Science Foundation (NSF) grant. In particular, we evaluated the necessity of strong and broad-based mentoring characteristics using assessment tools and surveys. The study was conducted with 34 participants in STEM fields. The participants' motivation mean scores in STEM was measured at three different points in time (pre-, mid-, and end-year) and compared using descriptive statistics and repeated measures analysis of variance (ANOVA). Results obtained indicated significant improvement in mentoring characteristics such as goal orientation, resource management, and academic performance with mean scores ranging from 4.99 to 5.21. Although additional findings from the repeated measures ANOVA showed no statistically significant differences, however, the marginal mean scores suggest the customized mentoring program had some positive effect and the mentoring practices supported underrepresented groups toward successful navigation of STEM disciplines. We discuss the study limitations, implications, and future research directions.*

Keywords: *Customized mentoring, mentoring, STEM program, underrepresented students*

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Introduction

Underrepresented students in science, technology, engineering, and mathematics (STEM) disciplines, including females, receiving scholarships and mentoring are likely to succeed in STEM related disciplines in their college education (Doerschuk et al., 2016; Estrada et al., 2018). Comparing the difference between the participation of students in STEM and the real graduation rates in these fields, it is important to recognize the experiences and recent views of underrepresented STEM students. Remarkably, only a few empirical studies addressed questions about how underrepresented STEM scholars navigate their educational careers and remain motivated throughout their professional endeavors. (Estrada et al., 2016; Hernandez et al., 2013; Tyler-Wood et al., 2018). In addition, the graduation rates among under-represented university students in most STEM fields are low (National Science Foundation [NSF], 2010).

According to Crisp and Cruz (2009), mentoring is an outstanding and successful way to help and encourage the success of college students and has a great beneficial aspect for students as they transfer from college to work. Enhanced academic performance, social integration and retention rates are among the major benefits of mentoring STEM undergraduates (Mangold et al., 2002). For underrepresented minorities and first-generation college students, especially women in STEM disciplines, being a part of a trustworthy or credulous mentoring relationship is critical. (Tsui, 2007). Quantitative evaluations of mentored STEM students have shown that mentoring positively influences and shapes scientific identity as mentors link students to career resources and research opportunities, provide emotional support, foster students' confidence and self-efficacy in science, and help them value scientific research (Atkins et al., 2020; Byars-Winston et al., 2015; Estrada et al., 2018). Because mentoring has been identified as an effective and beneficial component of STEM underrepresented college students' success (Fifolt & Abbott, 2008; Fifolt & Searby, 2010) this research study became necessary and centered on a customized mentorship approach for underrepresented groups.

Significance of the Study

Mentoring has been recognized and grown over the past few decades as an important and productive educational model to empower and encourage college STEM students in their early career growth (Atkins et al., 2020; Garcia-Melgar & Meyers, 2020). Research studies and literature reviews have associated mentoring with several positive results for apprentices ranging from self-reported well-being and comfort to unbiased performance metrics (Estrada et al., 2016; Hernandez et al., 2013; Jacobi, 1991). Many scholars have recognized and established mentoring as a promising and capable approach to tackle the absence of diversity in STEM-related fields (Hernandez et al., 2018; Lunsford, 2016). Moreover, undergraduate underrepresented groups tend to gain from a mentor's direction and guidance by contributing to scientific research,

discoveries, scientific identity, and innovations (Hernandez et al., 2018). Therefore, in this study, we add to the growing literature on mentoring under-represented STEM students who achieve the highest level of academic achievement and their career aspirations.

Recent research has shown positive impacts, outcomes, and access to various forms of mentoring STEM undergraduate college students (Estrada et al., 2016; Hernandez et al., 2018). This reflects a documented and understood need to identify and expand on mentoring relationship characteristics that are helpful to STEM underrepresented undergraduate students. Accessibility of such mentoring programs is crucial, and it is important to pay more consideration to mentors and mentees' characteristics (Crisp & Cruz 2009). By examining the measurable, theoretical, and practical nature of mentoring interactions in a customized NSF STEM mentoring program, we highlight the advantages of this type of mentoring and expand on the work of other research studies. In this regard, we examined underrepresented college STEM students mentoring characteristics including goal orientation, instrumental, and socioemotional abilities using statistical and quantitative analyses. Therefore, we carried out this research study to investigate participants' motivation score in STEM at three different points in time (pre-, mid-, and end-year) and report on the quantitative analyses to provide evidence of a customized mentoring model effectively applied in STEM fields with underrepresented students.

Background and Related Literature

Jacobi (1991) has defined successful and productive mentoring to consist of five main elements: (a) a connection or association based on accomplishment or acquisition; (b) it includes care and sustenance, direct assistance, and character modeling; (c) it has reciprocal advantages; (d) the relationship configuration is personal; and (e) in the mentoring environment mentors become experts and impact achievement. Mentoring is the basis for exploring the essential aspects of the individuality and social adaptation of students and their assimilation into college as a group (DuBois et al., 2002) and delivers an important and effective supportive network for students who are underrepresented in STEM fields (Summers & Hrabowski, 2006). Therefore, we developed an undergraduate STEM mentoring program using an empirical-based approach to explore the core components that affect the impact of a customized model of mentoring for underrepresented STEM students.

The important factor about the nature of this research is the conviction that mentoring with a customized approach has the potential to upsurge the achievement of college students with deprived experiences. In this research study, our theoretical framework is based on a customized mentoring program. Research studies on mentoring show that mentoring underrepresented undergraduate students are likely to get better grade point averages (GPAs), excellent graduation rates, and successful professional options in STEM disciplines (Summers & Hrabowski, 2006). According to Nikolova Eddins and William (1997), under the "apprenticeship

model” most undergraduate mentoring programs function by matching a qualified, knowledgeable, and accomplished professors as mentors—a more seasoned or experienced individual—with a student mentee—a less experienced junior colleague (i.e., the traditional model [TM]). However, most research studies have acknowledged the shortcomings of the TM mentoring in STEM fields for undergraduate college students (Eby et al., 2000; Feldman et al., 2013; Kobulnicky & Dale, 2016).

The weaknesses, inadequacies, and limitations of the TM mentoring approaches warrant the development of alternatives to fill this gap, because even well-trained, knowledgeable, competent, and experienced mentors can find themselves unsuspectingly in a relationship that is dysfunctional. For these reasons, our commitment and contribution to the field of mentoring, and coupled with the aim of this article was to examine, explain, and share the impact of a customized mentoring model (CMM) for underrepresented STEM students in an NSF scholarship program. Our CMM has some similarities with other community mentoring approaches but is different from the TM of mentoring. Figure 1 below illustrates how the similarities and discrepancies between the TM and CMM are considered and interpreted.

This CMM paradigm avoids many of the drawbacks that are associated with the TM of mentoring and creates opportunities for entirely new beneficial outcomes to emerge. The CMM sees mentoring as personalized learning for STEM diversity and inclusion in ongoing academic and social support for diverse STEM students. The multidisciplinary nature and value of the CMM is that it creates an environment to facilitate student retention, timely degree completion, and career goal setting for underrepresented minority and female students. The constant pulse-checking mentors do with their mentees in the CMM, allows them to work with the faculty and mentee to customize tutoring and support based on the mentees’ needs.

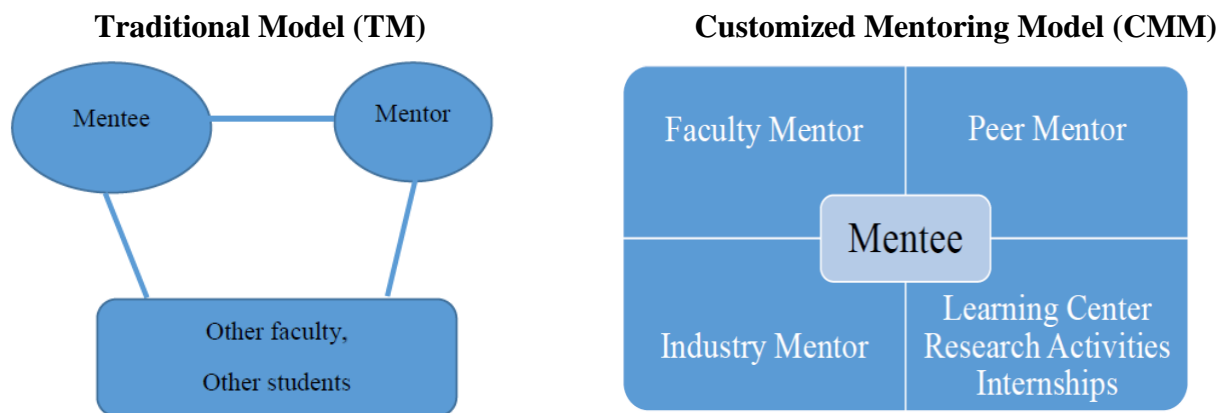


Figure 1. Mentoring models, left traditional model, right customized model

One strategy to assist STEM undergraduates in developing and promoting their scientific identities is through mentoring. So, we believe that through the CMM, student's development of scientific identity (i.e., general sense of self as a scientist) will improve their academic performance, retention and persistence in STEM, and STEM degree completion (Maton et al., 2016; Merolla & Serpe, 2013; Syed et al., 2011). In the next subheadings below, we describe in detail the essential characteristics and activities for each component of our CMM approaches.

Peer Mentoring

Research indicates that peer mentoring is an essential contributor to individual development in academic settings (Eby et al., 2008) and an effective and successful way to help students navigate through college and develop a productive career path (Morales et al., 2017; Kobulnicky & Dale, 2016). For this study, peer mentors were chosen by program chairs and other faculty members in STEM related fields, and we chose to use other STEM students from the Learning Center as peer mentors for our STEM scholars because those students have already received some training in mentoring. Within this customized mentoring program, we matched 15 freshman NSF STEM scholars with a peer mentor with the exact or identical major of the mentee. The peer mentorship groups and teams met on a month-to-month basis without the inclusion and involvement of the STEM faculty.

To develop, improve, and enhance the cohesiveness of the relationship between the mentees-mentors, we motivated and encouraged them to partake in the NSF STEM club events and other STEM related activities on campus. Some of the NSF STEM club activities included the following: (a) area science and engineering fair volunteering, (b) area science and engineering-award ceremony, (c) STEM career launch volunteering, and (d) NSF STEM club talk show on storm and pollutants in areas of water supplies. Additionally, the NSF-STEM club officers offered their services at a food bank through community service. Moreover, fundraising activities were organized, where strong participation was exhibited by recent mentees and other members.

Compared with other forms of mentoring, in a customized setting, peer mentors are capable to draw on more recent and reliable experiences to share with mentees, and mentees are usually more comfortable approaching peers for mentoring needs (Tenenbaum et al., 2014; Holland et al., 2012). Most of the literature on mentoring show that peer mentoring promotes academic, psychological, and career advancement in STEM fields (Anderson et al., 2019; Crisp et al., 2017). In particular, customized peer mentoring when designed effectively can and do impact learning in the STEM disciplines (Tenenbaum et al., 2014). Research studies have shown that college students who experience customized or near-peer mentoring show increase outcomes in program satisfaction and affective commitment to the university (Crisp et al., 2017; Holland et al., 2012). Tenenbaum et al. (2014) explained that customized peer mentoring supports mentees and mentors' development, incorporates established mentoring guidelines, and offers unique

opportunities for the integration of research and teaching in STEM disciplines. Moreover, customized peer mentoring model provides personal, educational, and professional benefits for mentees and mentors, enhances learning, and increases the interest and engagement of college students pursuing STEM disciplines (Kobulnicky & Dale, 2016; Thomas et al., 2015). Consequently, we believe the customized mentoring approach allows for students to serve as peer or near-peer mentors on projects, which enriches mentor experiences and contributes to many learning benefits and opportunities for peer mentors themselves (Holland et al., 2012; Sales et al., 2006).

Faculty Mentoring

Research suggests that faculty mentoring plays an important role in the learning and success of most college students (Chelberg & Bosman, 2019; Fifolt et al., 2014). In particular, faculty engagement with underrepresented STEM college students helped such students to develop effective working skills and grow as experts in their field. Through this customized mentoring program, we established a faculty-to-mentee mentoring strategy to assist the STEM scholar's engagement in the program. Each STEM scholar was matched with the most suitable or appropriate faculty mentor in the first semester of their first year. We deliberately included both men and women faculty mentors from diverse backgrounds and with varied expertise in STEM fields as supported by other studies (Gilmer & Martinez, 2014; Thomas et al., 2015). Other mentors if possible were included from areas closely related to the STEM scholars' field of study because they had wonderful rapport and relationship with the assigned scholar.

We aim at continuing the faculty mentoring component as part of our customized mentoring model for our STEM scholars in the coming years, and with only minor changes that we deem effective and appropriate. The faculty mentoring factor has continued to provide support, encouragement, and motivation for most of the STEM scholars. Additionally, we have proposed a plan that will give mentees the choice to change or self-select faculty mentors to promote and support strong relationships and collaboration, which we believe has the potential to improve or increase mentor-and-mentee relationships and appointments. Overall, the faculty mentoring program enhanced the self-esteem of the mentees, provided opportunities and resources for the STEM scholars, and brought about an increase in the academic achievement of the scholars.

Industry Mentoring

We believe industry mentoring provides college students with the opportunities to learn from experienced professionals and is an essential component for the STEM education. Additionally, industry mentoring helps college student broaden their network, advance their professional skills, and expand their insight of career opportunities. According to Veenstra (2014), industry

mentoring is a backbone to STEM education, and it is the conduit for college students to successfully transition to a career in a STEM related field. Because industry mentoring supports STEM education, we purposefully linked our STEM scholars with industry mentors and invited knowledgeable industry speakers to campus to share their experiences with our scholars. We fully embraced the industry mentoring concept and STEM scholars had the opportunity to interact and learn from industry leaders or workers who had a better understanding of what was required to be successful in a STEM field.

The STEM scholars had the chance to visit companies and met with varied professionals and scientists with diverse backgrounds. The selection of industry mentors was based on their expertise, experience, skill set, and relevance to our STEM scholars. The industry mentors were mostly from firms, corporations, and establishments that were in partnership with our NSF-STEM programs. We expect the industry mentoring program to continue because of its effectiveness and relevance to our STEM scholars and the overall program. The continual commitment of the industry mentors sharing their time, knowledge, and experiences with the STEM Scholars has been priceless and extremely useful. This relationship with our industry partners, has provided the STEM scholars the opportunities for internships, connect or network with local companies, and occasionally securing full-time jobs after completing their programs. Other industrial mentoring activities included talks at different stages in the program.

Learning Center and Other Activities

Most mentoring programs do not operate independently or in silos but many of them share and collaborate on information and are interwoven with numerous academic and professional programs including learning centers (Pleschová & McAlpine, 2015; Tolbert, 2015). As a result, we decided to include the university learning center facility in our CMM for the STEM scholars. We solicited the help of tutors with careers in STEM fields and in the STEM tutoring-only group from the learning center for the mentoring program. The learning center was equipped with standard resources to engage the STEM scholars in various activities for their academic and professional growth. All the STEM scholars who engaged in the tutoring activities during the mentoring program met frequently with their tutors for at least a minimum of four sessions. During these tutoring sessions, some of the STEM scholars got the opportunity to learn about study skills and time management. Additionally, the learning center continued to offer workshops and seminars for the NSF-STEM scholars in special topics including students' readiness level, learning profiles, test preparation, and interests. Overall, the learning center activities or interventions and coupled with the mentoring program, had a positive impact on the STEM scholars by providing support to a wide range of academic enhancement, career opportunities in STEM fields, learning profiles, and personal accountability. In the next two

subsections, we discuss the relationship between mentoring and retention, and the benefits of mentoring.

Retention and Mentoring

Research studies indicate that retention connects carefully to issues regarding students' perseverance, withdrawal, and attrition (Braxton et al., 2007). Based on the literature, one can define *retention* as incessant enrollment of students from one academic year to the other without any break (Braxton et al., 2007; U.S. Department of Education, 2010). Research shows that mentoring has the potential to be an effective tool and approach to boost the representation of STEM college students where systematic under-representation has happened. Additionally, prior research has revealed that mentoring enhances and promotes growth in underrepresented students in the areas of academic achievement, enrollment, and retention (Wilson et al., 2010). Designing programs to recruit and retain individuals into STEM majors in college, requires individual STEM identity, persistence, and institutional traits (Vincent-Ruz & Schunn, 2018). This is crucial because if one cannot see or perceive themselves in that capacity with such a character, then choices leading to a STEM career will be less likely, regardless of the motivating or engaging nature of STEM activities.

According to Fifolt and Searby (2010), completion rates for STEM and related degrees by students in the United States (U.S.) is expected or anticipated to be lower as compared to students in other countries. For this reason, it is important to attract and retain more diverse people (mentors) among economically disadvantaged STEM worker communities, so we can maximize invention, creativity, and competitive capacity of STEM mentees in the world. Moreover, it is essential and important for researchers to develop and engage students from diverse backgrounds and support their efforts through prescribed and recognized mentoring programs. The idea of specialized mentoring programs associates with improved retention rates of students seeking degrees in STEM fields (Packard, 2004). Therefore, engaging college underrepresented STEM students in the CMM is imperative and timely.

Benefits of Mentoring

Mentoring is a two-way street and can be described as a relationship involving mutual actions. Research indicates mentoring relationship promote growth and development in both mentors and mentees through the experiences and opportunities, and individuals without mentoring experiences demonstrate lower expectations and less satisfaction with their work. Several research studies allude to the importance and benefits of mentoring especially in college education and its effectiveness and positive impact on the educational achievement of minority undergraduates (Girves et al., 2005; Kendricks et al., 2013; Lunsford, 2016). Additionally, we agree that mentoring is a significant factor to the growth of an individual in an academic environment

and the workforce (Carmel & Paul, 2015; Eby et al, 2008). Russell and Adams (1991) explained that mentoring is a strong and forceful relational mentor interaction with mentee, where the mentor offers guidance, support, and constructive criticisms concerning career paths and personal growth or development.

This relational exchange or discussion between the mentor and the mentee may include academic support, behavioral support, funding opportunities, skill-development, and participation in professional associations (Cargill, 1989). Research shows that mentors play a significant role in the lives of their mentees and this influential behavior usually have positive influence on the STEM identity of students (Robnett et al., 2018). Therefore, developing customized mentoring programs for underrepresented STEM students is important and cannot be over emphasized. For the past few decades, mentoring has shown to be an effective approach or strategy for guaranteeing student achievement in the areas of STEM (Carmel & Paul, 2015; Kendricks et al., 2013; Robnett et al., 2018). Mentoring is a strategic enterprise that provides mentees from underrepresented clusters with experience and the exposure to positive role models, supportive networks, and relational collaboration with knowledgeable professionals for their success.

Especially, a college setting is the perfect, central, and ideal place for STEM students during their academic career to observe and experience for the first time in their lives, role model relationships. Robnett et al. (2018) studied instrumental (task-based, skill-oriented instruction) and socioemotional mentoring (specific advice and assistance) relationships between mentors and mentees. Instrumental mentoring is task driven, and it includes assigning the mentee with certain skills and resources to progress in a particular situation. On the other hand, socioemotional mentoring pertains to the provision of interpersonal backing system for the mentee. Robnett et al. (2018) found that those mentorship relationship or types positively affected undergraduate college students academic and career paths. Moreover, strong positive effects were established between the mentor-mentee relationships on both instrumental and socio-emotional types of mentorships (Robnett et al. 2018).

Research Aim

The aim of this study was to explore a customized mentoring program with underrepresented undergraduate students in STEM fields that employed both instrumental and socioemotional techniques through peer mentoring, faculty mentoring, and industry mentoring. Because of the nature of our research design and data, the following research questions were examined:

Research question 1(RQ1). What descriptive information does the survey reveal about the NSF Scholars in this customized mentoring program?

Research question 2 (RQ2). Is there a difference in motivation of undergraduate STEM students between the before, during, and after conditions of the programs?

Methodology

The aim of this study was to identify key and relevant factors that contribute to the achievement and success of under-represented STEM undergraduate students utilizing a custom mentoring model (CMM) in a mentoring program. Under our NSF STEM program, the STEM scholars were offered a three-prong mentoring environment: peer, faculty, and industry. One of the researchers developed a mentoring handbook for the three types of mentoring, which included mentor training. Students customized their mentoring by selecting the appropriate peer mentors, based on mentor backgrounds and demographics. Peer mentoring was highly encouraged by the researchers to ease the transition to college life, which is critical for incoming scholars.

Once the transition to college was successful, STEM scholars were asked to choose faculty and/or industry mentors. We focused on customized mentoring, more-specifically near-peer mentoring (Anderson et al., 2019; Holland et al., 2012; Tenenbaum et al., 2014), where slightly older students' mentor younger STEM scholars, in the critical first semester of college. Therefore, the methods utilized in this study were mainly on quantitative approaches that examined the experiences of underrepresented undergraduate STEM scholars from a customized mentoring program perspective.

The customized mentoring program was led by six STEM faculty members with diverse experiences and backgrounds and one administrative or supporting staff. The six faculty members specialty include electrical and computer engineering, electronic engineering, mathematics and computer science, civil engineering, mathematics education, and geosciences. Their contributions and tasks in the program included recruitment and retention plans, mentoring plans, STEM club and career activities, and tutoring programs. The NSF Scholars program was implemented at the beginning of the academic year to help the smooth transition of scholars throughout the first year of college.

Because of the customized nature of the mentoring program, each faculty member was matched with a STEM scholar majoring in an area closely related to the mentors' area of expertise and experience. On average, there were about four to five scholars being assigned to one faculty member. Throughout the mentoring program, activities that were emphasized included: (a) learning community practice—STEM scholars were required to register at least two courses with a peer mentee; (b) mandatory mentoring meetings—scholars were mandated to attend the usual monthly program meetings with their mentors; and (c) undergraduate research projects or creativities—where all STEM scholars were required to apply for an internship on or off campus.

Participants and Context

The participants involved in this study were 34 undergraduate students studying in STEM fields at a university in the northeastern part of the U.S. To recruit student participants, we reached out to students that fit our participation criteria: (a) majoring in a STEM field or discipline, and (b) are part of an ethnical minority federal group. Major STEM disciplines or fields at the institution of interest include biology, biochemistry, molecular biology, civil engineering, structural design and construction engineering, computer science, mathematical sciences, electrical engineering, mechanical engineering. Of these 34 students, about 45% identified themselves as females and 55% self-identified as males. Regarding the issue of race and ethnicity, about 10% identified themselves as Hispanic or Latino; 60% as White American; 18% as Black or African American; 7% as Asian and Pacific American; and 5% as other. After reading, understanding, and signing the informed consent forms, participants were given paper or print versions of the surveys where they completed them in person. The response rate of 100% exceeded the general expectation for collecting survey data because of the small sample size (Miller & Salkind, 2002).

Data Collection and Analysis

Data was collected during one academic year of the NSF Scholars program from the participants at three different stages (pre-year, mid-year, and end-year) using surveys. The component categories of questions or items on the survey comprised of goal orientation, instrumental, and socioemotional abilities. In a broader context and to understand what factors influence customized mentoring of underrepresented students in STEM fields, we created an assessment survey tool to collect data for this research study. Items on the assessment survey tool were selected from the Assessing Women and Men in Engineering [AWE] (AWE, 2008) tool and the Motivated Strategies for Learning Questionnaire [MSLQ] (Pintrich et al., 1991) designed to measure the learning motivating strategies of STEM students.

Sample items on the survey tool include: (a) I feel very much part of the STEM scholars community, (b) I have a regular place set aside for studying, (c) when I participate in STEM professional societies or other extracurricular activities, I feel welcome, (d) my academic program offers me the support and help when I need it, (e) I try to identify students in my classes whom I can ask for help if necessary, (f) this STEM program provides opportunities for me to meet with other faculty and peers, and (g) I enjoy working with other students on group work outside of classes. The mentoring assessments and evaluations were conducted once a new cohort came into the NSF Scholars program.

We evaluated the effectiveness of the NSF Scholars program through an assessment survey tool created from a combination of the AWE and MSLQ items. Statements from the survey

tool were on a Likert's scale with a value of 1 as minimum and 6 as maximum. The rating was on a 6-point scale where 1= strongly disagree to 6 = strongly agree. These anonymous surveys were administered to both mentees and mentors before the start of the mentoring program, mid-way through the program, and at the end of the mentoring program. To examine the effectiveness of the mentoring program, data were collected at three different stages: pre-mentoring, mid-year, and end-year. The data collected were examined and analyzed using descriptive statistics and a one-way repeated measures ANOVA. All, analyses were considered statistically significant with $p < .05$, and the SPSS 25.0 statistical software was used for all the analyses.

Results and Discussion

To evaluate the success and effectiveness of the customized mentoring model in the NSF STEM scholar program, we focused primarily on the scholars' survey data and a few testimonials to answer the research questions. As already discussed, the survey data collected were quantitatively analyzed using descriptive statistics and one-way repeated measures ANOVA. The results related to research question 1 (RQ1) is presented first based on the items on the survey that were coded with numerical values to support the quantitative analysis of the data. Finally, the results of research question 2 (RQ2) is also presented and discussed based on the analyses performed on the data in answering the research question.

Research Question 1(RQ1)

RQ1 sought to investigate the descriptive information revealed by the survey data regarding the STEM scholars in this form of customized mentoring. Overall, the mentee participants reported relatively higher scores on most of the survey items from the pre-year data to the end-year data. Examination of the averages from each learning component strategy showed a slight decrease in mentee pre-mentoring and mid-mentoring scores as displayed in Table 1. We assumed that the pre-mentoring mean scores were artificially inflated scores owing to freshman being ambitious about their perceived study strategies for the upcoming college year.

Table 1.
Mentees Responses to Selected Survey Questions

| | Pre-Year | Mid-Year | End-Year |
|---|----------|----------|----------|
| 1. When I participate in STEM professional societies or other extracurricular activities, I feel welcome. | 5.75 | 5.67 | 5.81 |
| 2. I enjoy working with other students on group work outside of classes. | 4.50 | 5.44 | 5.38 |
| 3. I attend (or intend to attend) faculty office hours at least once a week. | 4.67 | 4.22 | 4.00 |

| | | | |
|---|------|------|------|
| 4. My academic program offers me the support and help when I need it. | 6.00 | 5.44 | 5.63 |
| 5. I have many friends who are studying in my field. | 4.25 | 5.11 | 5.50 |
| 6. Some faculty members know me by name. | 5.00 | 5.25 | 5.88 |
| 7. I have family members or close family friends who are engineers or scientists. | 4.75 | 4.00 | 4.00 |
| a. Value Component: Intrinsic Goal Orientation Average | 5.50 | 5.11 | 5.22 |
| b. Value Component: Extrinsic Goal Orientation Average | 5.94 | 5.69 | 5.58 |
| c. Expectancy Component: Control of Learning Beliefs | 5.31 | 5.08 | 5.00 |
| Averages | | | |
| d. Resource Management: Help Seeking Averages | 4.75 | 4.58 | 4.63 |
| e. Resource Management: Peer Learning Average | 4.83 | 4.67 | 4.92 |
| f. Resource Management: Time and Study Environment | 4.90 | 4.47 | 4.63 |
| Averages | | | |

Note: The numbered list are samples items from the survey and the letters list are averages of each learning component

For the mentee assessment scores, we see an increase in almost all categories (with the exception of extrinsic goal orientation) between mid-year and end-year scores. At the end of the program, the mentees average mean scores from Table 1 indicated that mentees in this customized mentoring program were more likely to value their classes without peer influence. The mentees felt that they were able to achieve the grade desired based on their abilities and were more likely to ask for help from peers and faculty, and had improved their time management skills in regard to classwork and studying. This increase in mentees' average mean scores by the end of the year suggests that the customized mentoring model positively impacted the freshman mentees in the NSF Scholar program. Likewise, examination of mentee participants assessment averages as indicated in Table 2, shows an increase in peer learning categories, suggesting that the mentoring model also had a positive impact on the mentees by connecting to peer mentors.

Table 2.

Summary of mean scores on the overall scale and sub-categories

| Survey Sub-Categories | Pre-Year | Treatment Times | |
|-----------------------|-------------|-----------------|-------------|
| | | Mid-Year | End-Year |
| VC: IGO | 5.50 | 5.11 | 5.22 |
| VC: EGO | 5.94 | 5.69 | 5.58 |
| EC: CLB | 5.31 | 5.08 | 5.00 |
| RM: HS | 4.75 | 4.58 | 4.63 |
| RM: PL | 4.83 | 4.67 | 4.92 |
| RM: TSE | 4.90 | 4.47 | 4.63 |
| Overall Scale | 5.21 | 4.93 | 4.99 |

Note: VC: IGO = Value Component: Intrinsic Goal Orientation; VC: EGO = Value Component: Extrinsic Goal Orientation; EC: CLB = Expectancy Component: Control of Learning Beliefs; RM: HS = Resource Management: Help Seeking; RM: PL = Resource Management: Peer Learning; RM: TSE = Resource Management: Time and Study Environment.

Research Question 2 (RQ2)

RQ2 explored the difference in motivation of undergraduate STEM students between the before, during, and after conditions of the programs. Participants' motivation score in STEM was measured at three different points in time (pre-year, mid-year, and end-year) as shown in Table 2 during the program using the data from the motivated strategies for learning survey items. We performed a one-way repeated measures ANOVA to determine whether there was a statistically significant difference of motivation in STEM between the pre, mid, and post conditions. A repeated measures ANOVA was employed here because we wanted to compare the means scores across the participants based on their repeated observation in the program.

All the assumptions of repeated-measures ANOVA were tenable in this data set. Mauchly's test of sphericity indicated that the assumption of sphericity was not violated, $\chi^2(2) = 2.179, p = .336$. The results of the one-way repeated measures ANOVA with a Greenhouse-Geisser correction determined that the observed F value was not statistically significant, $F(1.615, 53.310) = 3.280, p = .06$, partial $\eta^2 = .09$, which indicated no statistically significant differences of mean motivation scores in STEM attributes over the course of the program. Additionally, the post hoc tests using the Bonferroni correction revealed no statistically significant differences in the training in the STEM attributes from the pre-training to post training of the program. The estimated marginal means for the pre, mid, and post-training data from the one-way repeated measures ANOVA were 5.14, 5.31, and 5.38, respectively. These results showed that the effect of the customized mentoring program was not statistically significant on this group of STEM scholars, which could be due to the sample size. However, the overall mean scores from Table 2 and the one-way repeated measures ANOVA marginal means suggest an increase in mean scores from the pre-training to the post-training of the program. Therefore, we can conclude that the customized mentoring program to an extent had some effect on the students in the area of their instrumental and socioemotional mentoring abilities.

In addition to the quantitative analyses, selected testimonials by the NSF scholars offers additional support to the perspective of the importance of customized mentoring (Morales et al., 2017). For example, one NSF STEM scholar wrote:

“Being an NSF STEM Scholar is something I am proud of, the club has helped me in many ways my first semester of college. My first semester was pretty rough for me, my biggest problem was adjusting to online work and quizzes, missing a deadline on an online quiz tanked one of my grades this semester but I was lucky to find somebody in the STEM club who has taken the class and helped me with the remainder of the material, and I was able to finish the class with a B+.”

Another stated

“While the financial aid I have received for being a STEM scholar is vital to me attending this university, the opportunities that comes with being in this program is invaluable. The STEM club

has been very important to my success at this university. I have met several students in this program that I also share classes with. Being involved in this program has only propelled my interest in STEM and computer science.” One more wrote “The STEM scholarship club has provided me with countless opportunities to further enhance my education experience at this university that would be impossible to receive elsewhere. From field trips and guest speakers to fundraisers and volunteering, I could not be more amazed with everything that has been offered to me through the STEM program.”

Limitations and Future Research

There were some limitations associated with this research study. First, it is obvious that we worked with a small sample size. The nature of the small sample size restricted us to the kind of analyses that could be performed quantitatively and generalizability of the results or findings. This could be due to social desirability bias, which is usually associated with survey studies (Tourangeau et al., 2000). We could not generalize the findings to a wider population as the sample included only peer mentors and STEM scholars from a single university in a Northeastern part of the U.S. Moreover, this research study provided less details about the CMM experience; and there was less information regarding the long-term educational experiences and professional career paths for the study participants.

Regarding directions for future research on mentoring STEM underrepresented college students, we recommend examination of this customized model at different university or research sites and with diverse populations. Additionally, it would be of more interest to determine if the CMM can effectively and efficiently incorporate recognized and conventional mentoring programs including undergraduate research assistant positions. According to Thurgood et al., (2010), most STEM scholars get the opportunity to serve as undergraduate research assistants during college years and integrating innovative and authentic models of mentorship such as the CMM has the possibility to offer significant changes and benefits to the educational, professional and career paths of participants. Finally, we recommend an examination of a long-term study associated with the CMM with STEM scholars in summer internships. In the long run, we anticipate it would be noteworthy to understand how participants involvement and participation affected their personal growth, continued education, and professional aspirations in STEM related fields.

Implications and Conclusion

The number of STEM professionals and academics in the United States (U.S.) is now low, and this does not meet the needs of a growing global economy (National Academy of Sciences, 2007). As the supply of qualified and competent STEM professionals continues to shrink, the

demand for these individuals is on the rise (Wilson et al., 2012). It is important that employers take advantage of this unique opportunity to recruit, train, and retain a STEM workforce before college students graduate through research projects and internships, and the literature supports mentoring as a positive component of these STEM programs (Estrada et al., 2016; Hernandez et al., 2013). There have been some factors that have helped NSF STEM scholars boost their academic achievement in the courses they have taken during this program. The STEM scholars acknowledged and professed that overall, the mentoring program was helpful and beneficial, and the most significant contributing factor to their academic development, performance, and retention in college was the nature and scope of the customized mentoring. Moreover, the mentoring program assisted students in discussing many issues from scholarly to professional and focused on the expectations of each and every student. Overall, from the data analysis, it was clear that most of the STEM scholars perceived and noticed that their personal development and academic success was supported by the customized mentoring model practices.

In summary, despite no statistically significant differences found with the one-way repeated measure ANOVA, our findings suggest a steady increase in the mean scores of mentees learning categories and mentoring characteristics. We believe interpretations and implications can be drawn about effective practices and benefits associated with mentoring underrepresented college students in STEM fields. Our findings suggest that the customized mentoring model and the overall program activities had some positive impact on the mentee participants. Research suggests that mentoring as a pedagogical approach has the ability or efficacy to enhance academic growth and success for students (Kobulnicky & Dale, 2016; Wilson et al., 2012). The NSF-STEM scholars enjoyed the mentoring activities they encountered throughout the customized mentoring model and the present study provided recommendations to researchers and mentors seeking ways to develop and enhance the efforts of their mentees in STEM fields.

The customized NSF-STEM mentoring program has continued to be successful and a tool for recruitment, as enrollment trend for STEM related fields has shown growth for our university. The customized mentoring model had a positive effect and impact on the NSF-STEM scholars in the areas of academic, personal, and social life. As indicated by the STEM scholars' testimonials, the CMM program coupled with other program activities helped the scholars complete their undergraduate studies, continued their education in graduate schools, or even pursued their careers successfully. We believe the scholarships and mentoring support provided to the underrepresented STEM scholars assisted them to succeed in their endeavors and the CMM has the prospect to expand to other settings to provide guidance and growth to underrepresented college students in STEM related fields.

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