Impact of Shared Values & Power on Successful Mentoring for Minorities in STEM

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The study aimed to identify characteristics of mentoring programs that benefit (or do not benefit) women, Black, Indigenous, and people of color, and first-generation college students and increase their retention and continuation in STEM. The hypothesis was that shared values and power dynamics can drive the success (or failure) of mentoring these students in STEM. Specifically, we studied the impact of patented technology "Epixego" – an online mentoring and employment ecosystem – and the accompanying training program that both explicitly incorporate shared values and account for power dynamics in mentoring.

The research was an intentional collaboration across UC Davis, UC Merced, and UC Berkeley, with the former two having the distinction of being Hispanic-Serving Institutions (HSI) in a near-peer mentoring model. Research indicates that access to social capital via mentoring is critical for historically excluded students' sense of belonging, self-efficacy, and retention (Holloway-Friesen, 2019). The research used a mixed-method approach consisting of a quantitative assessment of the mentoring intervention using pre- and post-intervention surveys and qualitative data from focus groups.

LITERATURE REVIEW

"Academia needs a much more evidence-based, inclusive and intentional approach to mentoring, especially if it hopes to engage and retain a diverse group of students, was the finding according to a recent report on improving diversity and inclusion in STEMM (Science, Technology, Engineering, Math, and Medicine)" (NAS, 2019). The report looked beyond degree attainment to retention, career success, and satisfaction, and raised the alert about a gulf between what is known about mentoring and how it is practiced in the country's Institutes of higher education.

Today, mentorship operates provides sponsorship, career guidance, and skill development; and in some contexts, psychological and social support functions (emotional support, role modeling) for the mentee in academic STEM settings They are complementary to coaching or teaching and essential to developing a deeper STEM identity and professional self-efficacy. Despite improvements, representation disparities continue to persist at undergraduate, graduate, and postgraduate levels (Estrada et al., 2018; Ciocca Eller and DiPrete, 2018). Such disparities continue to impede the U. S's long-standing goal of improving diversity in STEM.

An evidence-based method requires exploring the characteristics of effective and ineffective mentorship programs to understand the factors that influence successful and failed mentoring relationships. For example, systematic reviews highlighted the characteristics of good mentors and mentoring programs (Cho et al., 2011; Straus et al., 2009). However, the characteristics of what constitutes a successful or failed mentoring program are far fewer (Straus et al., 2013).

Scandura. 1998 was among the first to define negative mentoring experiences, which she termed "dysfunctional mentoring", followed by Eby (Eby et al., 2000) who generated a taxonomy of 15 types of negative mentoring, including mentor-mentee mismatch. According to one study, mentoring when not done right can have damaging consequences, whereby the mentees may have been better off if they had no formal mentor at all (Ragins et al., 2000). The relationship between negative mentoring and undesirable mentee outcomes (e.g., intentions to leave a STEM graduate program or a job) is strongest for formally initiated mentoring relationships—those where mentors are "assigned.", and tend to have an implicit power imbalance because mentees will not always feel comfortable giving honest feedback to someone who is in a position of power, like faculty directors, department heads, etc. This is particularly relevant because mentoring relationships in academia are typically formed through a formal process, where a faculty member assigns an undergraduate or graduate student to a postdoctoral mentor or a faculty member's research group or department in a formal program (Limeri et al., 2019). The characterization of negative experiences by Limeri, suggests a nuanced framework to enable effective mentoring should have the following characteristics: (1) mentoring consistently with social cognitive career theories of self-efficacy, identity development, and social capital in career decision making (Lent et al., 1994; Bandura 1986, 1997); (2) deliberately expands social capital across department/institutional boundaries for access, information, and knowledge about the post-secondary academic-career process (Glass, 2022); and (3) adapts existing mentoring measures to specific outcomes of mentee self-efficacy, occupational identities and access to bonding and bridging social capital (Beugelsdijk et al., 2009; Scales 2020; Charania et al., 2020; Berríos-Allison., 2005; SEI 2020; Melgosa 1987; Skorikov 2011; Dreher 1990).

This study begins with a pilot of an evidence-based approach to understanding the characteristics of mentoring programs for their impact on underrepresented students in STEM, using specific outcome measures to evaluate the underlying focus of mentoring effectiveness, rather than using proxies such as attendance, length of engagement, etc. (Kerr, 1995).

CONTENT

A Case for an Evidence-Based Mentoring Study

There is a large body of research on career navigation- especially how post-secondary education, career readiness (discovering and understanding viable career paths), and its interconnectedness are important for a growing number of first-generation, low-income, and underrepresented students. Today, typical students' access to explore the interconnected focus of education and work begins via family, counselors, and career centers in high school and post-secondary education. Counselors and career centers are focused on either college-going or career-prep, rather than both. Counselors today are ill-equipped to help every student navigate, with an average student-to-counselor ratio of ~500:1 in high school, and ~1,800:1 in college (Salisbury, 2020). Career navigation and guidance consist of three interrelated pillars of career essentials- Social Capital, Occupational Identity, and Skills (Fisher, 2018). While these 3 pillars are interconnected, most mentoring and career development programs focus on skill acquisition, while ignoring the other two. The rise of digitization and the ubiquitousness of social media platforms has accelerated changes to social

networks and access to social capital. This is especially true for mentoring and career development disparities across institutional boundaries. For example, alumni outcome data from the University of California points to the lack of mentoring and access to social capital caused by institutional boundaries. Two UC campuses (Merced and Berkeley) that are geographically only ~100 miles apart, with presumably equal access to employers, show a 55% difference in post-secondary employment rates and annual income 2 years after graduation from the same field of study- engineering (UC, 2021). We hypothesized that this gap was due to the differences in access to social capital (which in turn informs occupational identities) between campuses, rather than the skills gained, given their distinctly different student demographics. Social capital plays a pivotal role in promoting equitable educational opportunities and outcomes, especially in postsecondary institutions; and can significantly impact a student's access to resources and opportunities for education and economic mobility (Reeves, 2022). This finding was supported by a study that found that friends and peers/near-peers are the single best predictor of college graduation rates, even after controlling for a range of variables that affect college going (Sokatch, 2006).

The research aimed to study (a) the role of shared values (using deeper level similarities to suggest near-peer role models, rather than assigning mentors), and (b) decrease power dynamics (with peers and near-peers across campuses) to minimize the power barriers mentioned above, while also expanding access to social capital through a fit-for-purpose mentoring-specific online social-networking platform, Epixego, from Berkeley, CA, part of University of California accelerator for founders building deep technology startups.

METHOD

Participants

Students across the three University of California campuses (Berkeley, Davis, and Merced), who identified themselves as historically under-represented, were invited to apply for a paid 10-week STEM mentoring fellowship, for an opportunity to learn mentoring best practices, expand their mentoring network, support and reinforce, STEM identity, and STEM self-efficacy. Each applicant submitted two short essays on why they identify themselves as historically under-represented (in STEM), and what they hope to get out of the mentoring fellowship. Student applications were reviewed by at least two faculty and scored independently to determine the final participants. A total of one hundred participants were selected using a stratified sampling methodology to ensure equal participation from undergraduate, graduate, and doctoral students across all three campuses. Each PI from the campus worked with the respective Research Offices' IRB (Institutional Review Board) to conduct the study.

Undergraduate participants were mentees, doctoral participants were mentors, and graduate participants were both mentors (to undergraduate students) and mentees (to doctoral students). To be eligible for the fellowship, participants needed to attend a 90-minute weekly online meeting over 10 weeks. One-third of the time was spent on group discussions with guest speakers and/or best practices, and two-thirds were spent in dyad and small group mentoring sessions in breakout rooms with informal themes and guided conversations.

The key features distinguishing the mentoring intervention were as follows:

a) A mentoring fellowship with content over 10 weeks specifically tailored to equip participants with the latest research supporting (i) self-efficacy, identity development, and social capital in career decision-making, and (ii) increasing importance of expanding social capital at Institutions of Higher Education (IHE) across department/institutional boundaries for access, information, and knowledge about the post-secondary academic-career process. (iii) navigating resources to nourish a network of mentors across campus boundaries
b) No assigned mentors. Mentees curated a short list of desired mentors based on Epixego profiles and suggested matches. The study organizers then consulted with participants to select final mentor/mentee matches, in the co-design of the mentoring relationships and activities.
    i) Shared Values: At the beginning of the 10-week fellowship, which was conducted digitally due to COVID-19 conditions, each participant filled out their Epixego profile.

This profile, unlike their resume, prompts students to answer questions about 'flow', 'purpose', 'aspirations', and their learning experiences beginning in High School; questions aimed at self-efficacy, and no information about GPAs, or test scores was gathered. The profile information generates a 'competency fingerprint' unique to the individual and evolves with learning and signals self-efficacy. Epixego surfaces peers and near-peers as role models based on overall similarities in the competency fingerprint (Figure 1). This is the basis for shared values based on deeper-level similarities, rather than only surface-level similarities like gender, race/ethnicity, or major.

ii) Co-designing mentoring with near-peer mentors: Mentees were asked to co-design their mentoring experience. This meant that purpose was prioritized over the process. Mentees were encouraged to 'discover' peers and near-peer role models suggested based on competency profile matches. Through the profiles of peer and near-peer role models, mentees provided their preference for mentors, who were not necessarily from their university. The peer/near-peer being across institutions was designed to reduce power barriers and decrease the risk of failed conversations. Mentees' preferences for mentors were honored for the 10 weeks of the mentoring program.

Data Collection and Analysis

While the number of participants in the mentoring intervention was almost one hundred (split evenly between mentors and mentees), participation in the survey was optional. Participants included undergraduate and graduate students (including doctoral and post-doc) in STEM areas from the 3 campuses.

A survey was conducted pre-intervention and post-intervention (pre/post) with mentors and mentees. The pre-intervention survey focused on participants' prior mentoring experience, and their experience was noted as a mentor, and/or mentee. The post-intervention measured their experience as a mentor and/or mentee based on the 10-week mentoring fellowship program, also with their role as a mentor or mentee.

Survey data consisted of 2 sets of question types:

1. 5-point Likert scale responses for questions about the following categories:
    a. S- Skills (3 questions, e.g. I see how my academic skills and work experiences translate to my career goals.)
    b. OI- Occupational Identity (4 questions, e.g. I am aware of possible career paths available to me and feel confident about the resources that can provide me guidance.)
    c. SC- Social Capital (9 questions, e.g. The people in my network have information and/or relationships that can help me in becoming a professional in a STEM field.)
2. 5-point Likert Scale responses modeled after GMMP (Global Measure of Mentorship Practice), a comprehensive assessment of mentorship support received, adapted for use in a post-secondary STEM context (NAS, 2019). These are paired surveys of mentor-mentees, and mismatches in responses to mentoring relationships are measured. A mismatch between mentor and mentee responses to the paired questions is indicative of a lack of shared values, and therefore lack of career and psychological support between mentors and mentees. (4 questions).

In selecting appropriate survey measures, there were at least three important questions to consider:

1. Quantifying the "quality" of mentoring relationships and programs—and at what time and from whose perspective? Similarly, what are the indicators that prevailing evidence suggests constitute quality in mentoring relationships?
2. What measures assess effective mentoring relationships in STEM fields that allow for multiple mentoring relationships at one time?
3. What outcome measures are useful in assessing the most successful characteristics of mentoring relationships and programs?

In this context, the measures were aimed at testing the mentoring intervention weighted toward the mentee's perspective in a mentoring intervention program, relative to their past mentoring experiences. The outcomes measured include self-efficacy, as indicated by social cognitive career theory (Bandura, 1986;

Lent, 1994), concerning social and occupational identity, and social capital. The survey measures for shared values, self-efficacy through skills, and occupational identity were adapted from prior work on social cognitive career theory, social capital theory, social network theory, and social exchange theory (Scales et al., 2020; Charania, 2020; SEL, 2020; Berríos-Allison, 2005; Melgosa, 1987; Skorikov, 2011).

Paired pre-and post-surveys were then analyzed for differences in the mean scores for each question using a two-tailed Student's t-test in SPSS software (IBM SPSS Statistics. v.27). Differences between pre-intervention and post-intervention groups were considered significant at an alpha level of 0.05. The percent difference between pre and post was also calculated.

Students also participated in voluntary pre-and post-intervention focus groups. Six focus groups were held pre-intervention and six focus groups were held post-intervention, both with three to six participants each. Focus groups were conducted via zoom. The conversation was transcribed, anonymized, and coded for relevant themes. Relevant themes in the pre-intervention focus groups included past mentoring experiences, belonging, and ideal mentoring relationships.

RESULTS AND DISCUSSION

Of the 100 participants, 42 mentees and 33 mentors completed the pre-survey. 30 mentees and 33 mentors completed the post-survey. Mentee and mentor race/ethnicity and gender are presented in Figure 2. More than 50% of mentees and mentors were non-White/Caucasian/Asian, and the gender split between mentors and mentees was similar

Social capital and occupational identity were the factors that showed some of the largest changes (~20-35%) pre vs. post in mentees, and based on GMMP, the shared values showed significant changes.

For example,

a) Social capital measure: "The people in my network have information and/or relationships that can help me in becoming a professional in a STEM field." There was a 35% increase in a mentee's social capital measure, statistically significant post-intervention (difference = 35.15%, p =0.000011*).
b) Social capital + occupational Identity: "I understand how to develop and translate my skills into the language of STEM higher education and the labor market." This measure saw a 23% increase in a mentee's STEM occupational identity and access to social capital that supported that identity (difference = 23.19%, p = 0.0023*].
c) Shared Values: "My mentor encourages me to talk about my anxiety and fears and relates to me in a way that helps me to address them." This is an adapted GMMP measure where the mentee's assessment of their shared values with their near-peer mentor increased by 27% (difference = 27.03%, p = 0.036*).

See Figure 3 for the complete information on measures of pre- and post-intervention for mentees.

The results of the GMMP (see table below) indicate an overall decrease in the mismatch between mentee and mentor on all responses, indicative of shared values. While the mismatch in the mentee-mentor response to the question, "I can relate to the experience of my mentor/mentee" decreased (as a %) from 35% to 10%, it is directionally noteworthy, albeit not statistically significant at the study's a prior alpha level.

TABLE 1

Question	Mean (Pre)		p-value	Mean (Post)		p-value
	Mentee	Mentor		Mentee	Mentor	
My mentor conveys feelings of respect for me as an individual.	4.07	4.7	**0.004229***	4.48	4.72	0.174
My mentor helps me meet other people in my field at the University or other people in my field elsewhere.	3.17	3.54	0.247	4.05	3.64	0.169
I can relate to the experiences of my mentor/mentee.	3.22	4.35	**0.0001***	4.17	4.6	**0.021***
I feel comfortable proposing alternative ideas and solutions to my mentor.	3.37	4.08	**0.0066***	4.22	4.4	0.32

It is also notable that the mentee's preference for 'near-peer' mentors increased from less than a third pre-intervention to nearly half, post-intervention (Figure 4).

The focus group data (qualitative data) gathered as part of this research covered three key topics in the pre-intervention phase: (1) past mentoring experiences, (2) belonging, and (3) ideal mentoring relationships. The focus group data gathered post-intervention covered the following three key topics: (1) preparation for mentoring relationships, (2) belonging, and (3) ideal mentoring relationships.

Increasing STEM identity is a salient point in most mentoring programs, from the assignment of the meaning of a student's role (in STEM), their membership, personhood, and eventually leading social interactions that translate to persistence (in STEM). This identity process includes first seeing oneself as having a particular identity through a variety of learning experiences, then experiencing verification from a near peer's identity, and gaining clarity in outcome expectations, thereby gaining prominence from the identity (Burke and Stets, 2009; Stets et al., 2017). Several studies have outlined characteristics of mentoring, and characteristics of good mentoring programs. This study provides rich details in combining the best practices (shared values based on deeper level similarities), while avoiding inherently problematic ones (e.g., power barriers), and quantifying the quality of a mentoring program from an interdisciplinary (cognitive social sciences) perspective of a mentee. There are current gaps in the literature regarding effective mentoring strategies, from measuring the impact of mentorship on educational interventions, to how to 'reduce fear of failed conversations' through the co-design of a mentoring program by mentees. This study provides an important first step toward those directions.

CONCLUSION

Science and technology touch nearly every aspect of innovation in our lives today. Institutes for Higher Education (IHE; colleges and universities) play a crucial role in the development and dissemination of science, technology, and innovation. The capable workforce created by IHE is critical to the creation of an innovation-driven economy, with a very real economic upliftment. The demand for STEM occupations is expected to grow faster than any non-STEM occupation, by 10.5% to 11,278,000 jobs by 2030, with median wages for STEM occupations today being 137% higher than non-STEM occupations (BLS, 2021). Yet, despite the potential for economic upliftment, the stark under-representation of Black and Hispanic students in STEM with undergraduate, graduate, and postdoctoral degrees in Science and Engineering remains at 25%, 22%, and <20% respectively (NSB, 2022). According to a recent study by the Brookings Institute, social capital plays a pivotal role in promoting equitable educational opportunities and outcomes, especially in postsecondary institutions; and can significantly impact a student's access to resources and opportunities for education and economic mobility (Reeves, 2022). This finding was supported by a study that found that friends and peers/near-peers are the single best predictor of college graduation, even after controlling for a range of variables that affect college going (Sokatch, 2006).

This study has attempted to measure self-efficacy, shared values, and power dynamics in mentoring based on existing social sciences research. The findings indicate a clear decrease in power dynamics between mentors and mentees based on GMMP measures and a statistically significant increase in shared values between mentors and mentees. This study also lays the foundation for measuring social capital- an expanding research theme in economics that is becoming more important to explain educational and career outcomes. Creating and cultivating mentoring networks for students across institutional and program boundaries with an explicit objective to expand social capital and occupational identities showed significantly promising results in this study. In the past, there have been vast varieties of proxies for social capital and occupational identity. However, in this study, we adopt explicit measures of social capital and occupational identity to quantify the social and political aspects of human agency and capture the way that shared identity and commitment to social values can contribute to social welfare. The concept of social capital is useful in economics, but not commonly used to measure educational outcomes. We believe it must be incorporated into social and emotional learning outcomes to bridge the theoretical and empirical divide; social capital (and occupational identities) are both an input to and an output from social and economic processes and requires additional research.

Mentorship in IHE serves an essential role in the process of enabling undergraduate, graduate, and postdoctoral students to become valuable professionals in an evolving talent marketplace. Despite the influential role that mentorship plays, it rarely receives the focused attention, evaluation, and recognition that other aspects of the professional development process, such as learning, skills development, or research garner. Recent events due to the global pandemic have brought additional stressors to the fore as our society continues to grapple with structural racism. The higher education community must remain vigilant for potential inequities in educational outcomes across the education continuum. Diversity efforts are particularly vulnerable during times of disruption; hence institutions must heighten their commitment to attention and resources. The pandemic creates another leak in the STEM pipeline as it pertains to underrepresented students. These circumstances create an opportunity to build on the results of this project, within the University of California, and externally.

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APPENDIX

FIGURE 1
EPIXEGO PROFILE WITH COMPETENCY FINGERPRINT AND ROLE MODELS SUGGESTED BASED ON MATCHED COMPETENCY FINGERPRINT

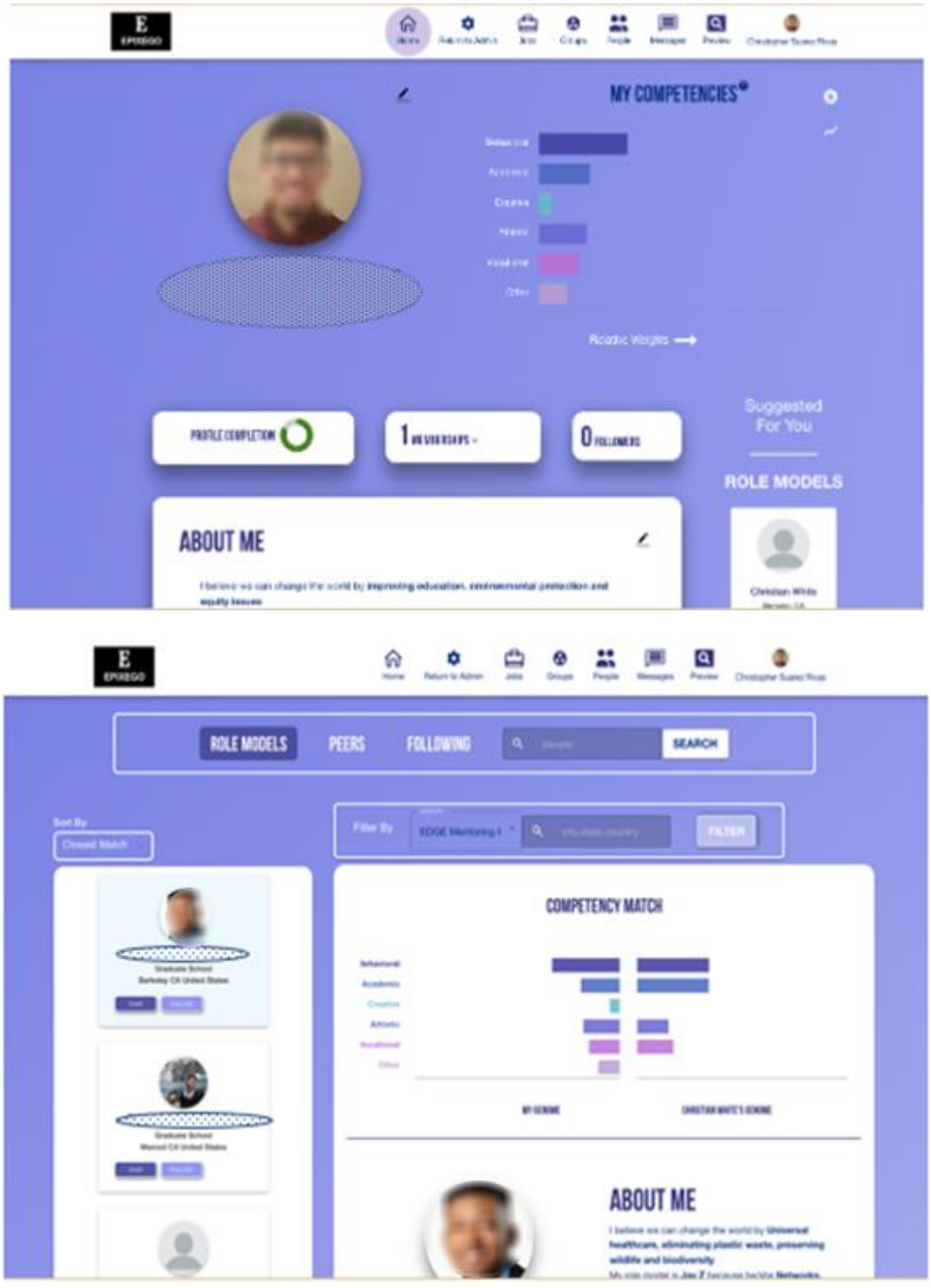
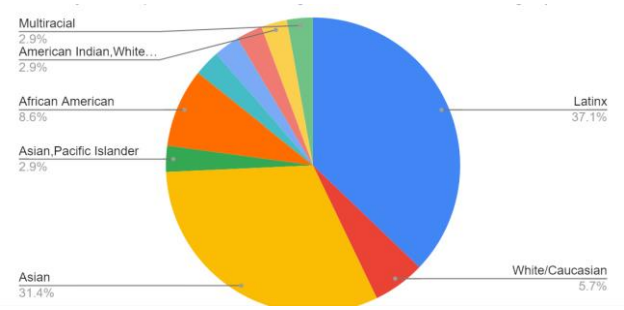
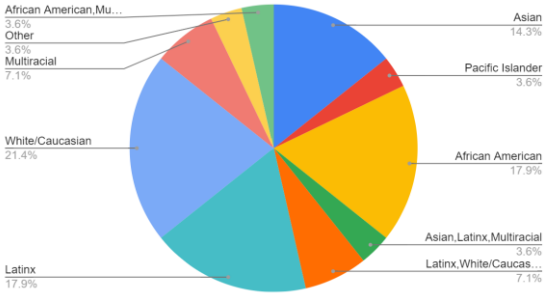


FIGURE 2
MENTORING FELLOWSHIP PARTICIPANT CHARACTERISTICS

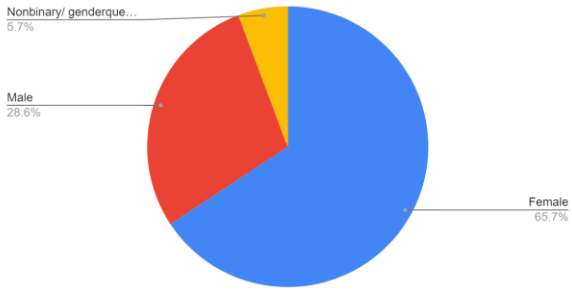
Mentee Race/Ethnicity



Mentor Race/Ethnicity



Mentee Gender



Mentee Gender

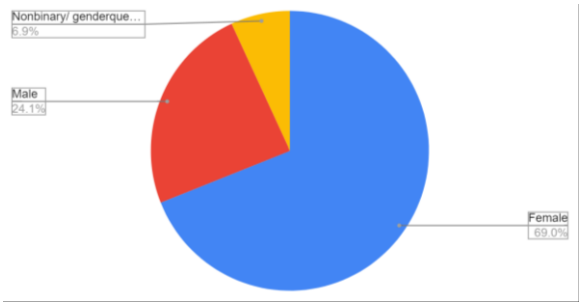


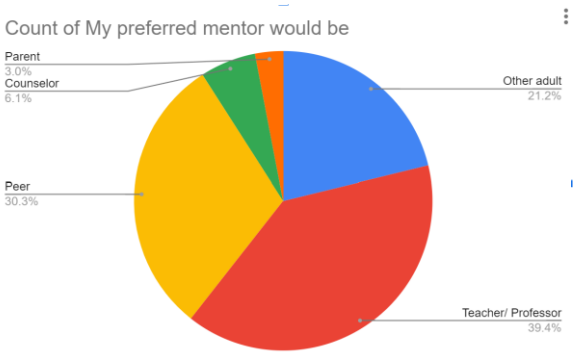
FIGURE 3
QUANTITATIVE MEASURES OF MENTORING INTERVENTION FOR MENTEE (PRE VS POST)

Category	Question	Pre-mentee (avg)	Post-mentee (avg)	% change	p-value (2-tailed t-test)
OI	I am clear about what I want to do 5 years from now	3.18	3.46	8.69%	0.31
S	I see how my academic skills and work experiences translate to my career goals	3.33	3.83	15.00%	*0.002
SC	I feel comfortable discussing my career interests and aspirations with - Family	3.67	3.67	0.00%	
SC	I feel comfortable discussing my career interests and aspirations with - Other adults in my community	3.39	3.75	10.49%	0.17
SC	I feel comfortable discussing my career interests and aspirations with - Peers	4.03	4.25	5.45%	0.21
SC	I feel comfortable discussing my career interests and aspirations with - Counselors	3.79	4.25	12.20%	*0.015
SC	The people in my network can speak to the quality of my accomplishments, attitude, and work ethic.	3.94	4.08	3.65%	0.39
SC	The people in my network have information and/or relationships that can help me in becoming a professional in a STEM field.	3.06	4.14	35.15%	*0.000011
SC	I understand how to develop and translate my skills into the language of STEM higher education and the labor market.	3	3.7	23.19%	*0.0023
SC	Please reflect on your experience as a mentee to answer the following questions. - My mentor provides effective advice and/or resources in support of my goals and ambitions.	3.85	4.48	16.26%	*0.0067
SC	Please reflect on your experience as a mentee to answer the following questions. - I see my mentor as a role model.	3.78	4.13	9.34%	0.15
SV	Please reflect on your experience as a mentee to answer the following questions. - My mentor conveys empathy for the concerns and feelings I discuss with them.	3.93	4.43	12.96%	*0.037
OI	Please reflect on your experience as a mentee to answer the following questions. - My mentor has encouraged exploring career options and helped me to prepare for the next steps in my career.	3.38	4.32	27.58%	*0.0013
SV	Please reflect on your experience as a mentee to answer the following questions. - My mentor encourages me to talk about my anxiety and fears and relates to me in a way that helps me to address them.	3.32	4.22	27.03%	*0.036
OI	I am aware of possible career paths available to me and feel confident about the resources that can provide me with guidance.	3	3.74	24.64%	*0.0068
S	I can see how my non-academic learning (hobbies/sports/jobs) may contribute to my ability to reach my career goals.	3.3	3.65	10.57%	0.52
S	I feel confident about my skills and feel competent in areas where I can apply them.	3	3.57	18.84%	0.07
OI	I am upbeat/confident about my post-graduation career prospects	2.7	3.43	27.36%	*0.030

OI = Occupational Identity | SC = Social Capital | S = Skills | SV = Shared values
* Statistically significant at p = 0.05

FIGURE 4
MENTEE'S MENTOR PREFERENCES

Pre-Intervention



Post-Intervention