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Using Self-determination Theory to Guide Mentoring Activities for Underrepresented Students in Engineering Technology Programs

Prof. Elizabeth Dell, Rochester Institute of Technology

Professor Dell is a Professor in the Manufacturing & Mechanical Engineering Technology department at RIT. She is the Director of the AdvacneRIT office which supports the retention, recruitment, and advancement of women faculty. Senior Faculty Associate to the Provost for Women Faculty. Her research interests include characterization of biodegradable plastics and environmental consideration in materials selection for production design, the impact of technology paired with active learning pedagogies on student learning, and effective strategies for increasing gender diversity in STEM disciplines.

Prof. Jeanne Christman, Rochester Institute of Technology

Dr. Jeanne Christman is an Associate Professor and Associate Department Chair in the Department of Electrical, Computer and Telecommunications Engineering Technology. She holds a BS in Electrical Engineering, an MS in Computer Science and a PhD in Curriculum, Instruction and the Science of Learning. Utilizing her educational background, her teaching specialty is digital and embedded system design and her research areas include engineering education culture, equity in engineering education and increasing diversity in STEM through transformation of traditional teaching methods.

Dr. Jennifer A. O'Neil, Rochester Institute of Technology

Jennifer A. (Mallory) O'Neil received her B.S. and Ph.D. in Mechanical Engineering from the Rochester Institute of Technology in 2008 and Purdue University in 2012, respectively. In 2016 she joined the faculty of the Rochester Institute of Technology, where she currently holds the position of Assistant Professor of Manufacturing and Mechanical Engineering Technology. She currently teaches undergraduate courses in the thermal fluid sciences and introductory engineering courses. Her research interests are in the area of spray physics, focusing on pediatric nebulizer devices, and in engineering education, focusing on mindset.

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Abstract

Self-Determination Theory (SDT) posits that when three basic psychological needs-competence, relatedness, and autonomy-are met, individuals will be intrinsically motivated to support their own personal growth and well-being. Using self-determination theory to inform practice, the Self-Determined Critical Mass of Engineering Technology Scholars (SD-CoMETS) project at RIT seeks to build a more diverse student population through the recruitment and retention of students to the Engineering Technology (ET) programs within the College of Engineering Technology (CET) at the Rochester Institute of Technology (RIT). This project is funded by a National Science Foundation Scholarships in Science Technology & Math (S-STEM; NSF Award No. 1930313) awarded in 2020. The SD-COMETS program is a comprehensive program aimed at increasing enrollment of economically disadvantaged, academically talented students in ET academic programs at RIT, with targeted recruitment of underrepresented groups. The project is designed to increase first and second year persistence, known to be the critical years for degree completion. Using a research based approach, factors in the engineering education environment that contribute to the underrepresentation of women; First Generation; African American, Latin American, and Native American; and Deaf or Hard of Hearing students in these programs, are addressed. The scholarship program includes the development of a comprehensive Scholar Support Network (SSN) and activities to promote inclusive pedagogical practices that engage a broader spectrum of learners and support competence, relatedness, and autonomy. SD-CoMETS scholars will work with a faculty mentor to develop their personalized SSN and be provided guidance in how to make best use of it. This paper presents the Faculty Mentoring Protocol developed to guide mentoring practice and evaluation of mentoring activities for the SD-CoMETS program.

Introduction

The National Science Foundation Scholarships in Science Technology Engineering & Math (NSF S-STEM) address the need for a high quality workforce to ensure the nation's competitiveness in the global economy is maintained [1]. The S-STEM program aims to increase the number of students with demonstrated financial need obtaining degrees in STEM fields, improve STEM undergraduate education, and advance the understanding of best practices for the retention and graduation of low-income, academically talented students in STEM. Funding for these projects supports scholarships and curricular and co-curricular activities that support student success.

The Self-Determined Critical Mass of Engineering Technology Scholars (SD-COMETS) program is a comprehensive program aimed at increasing enrollment of economically disadvantaged, academically talented students in ET academic programs, with targeted recruitment of underrepresented groups. SD-COMETS aims to increase diversity in ET by addressing factors in the engineering education environment that contribute to the underrepresentation of women; African American, Latin American, and Native American

(AALANA); First Generation (FG); and Deaf and Hard of Hearing (D/HH) students in these programs. The proposed work is informed by findings from a previous NSF S-STEM project (CoMETS, NSF Award #1060136), which indicated that retention of women in ET was supported through specific initiatives based on Self-Determination Theory [2-4]. Self-Determination Theory (SDT) posits that when three basic psychological needs-competence, relatedness, and autonomy-are met, individuals will be intrinsically motivated to support their own personal growth and well-being [5]. The program initiatives include a comprehensive Scholar Support Network (SSN; Figure 1) and activities to promote inclusive pedagogical practices that engage a broader spectrum of learners and support competence, relatedness, and autonomy. Each SD-COMETS scholar will work with a mentor to develop their personalized SSN and provided guidance on how to make best use of it.

Figure 1: SD-COMETS Scholar Support Network

The objectives of the SD-COMETS program are:

1. Develop relatedness through a supportive environment for scholars by engaging them in a multidimensional Student Support Network (SSN).
2. Nurture intrinsic motivation, voice, and agency to develop autonomy.
3. Promote competence by identifying academically struggling scholars and providing proactive academic support.
4. Develop scholar's identity as a member of the professional engineering community and prepare them for the workforce or graduate school.
5. Leverage scholarship support for academically talented, economically disadvantaged students to improve retention and graduation rates for women, AALANA, FG, and D/HH students.
6. Contribute to the knowledge base on best practices for the effective college retention and success of marginalized populations in ET.

One critical component of the SD-COMETS program is faculty mentoring. To support effective

mentoring and robust evaluation of the impact of the faculty mentoring, the SD-COMETS Faculty Mentoring Scholars Protocol (FMSP) was developed. The focus of this paper is to describe the mentoring FMSP.

The Importance of Mentoring

The underrepresentation of women and minorities in engineering and engineering technology is an issue that has been well documented for decades, yet there is still a lack of consensus among researchers on how to increase their numbers and thus, the diversity of the field [6-8]. Despite the many programs that have been put in place to recruit and retain women and AALANA students, barriers to persistence in engineering and engineering technology degree programs still exist. These include masculine culture [9], gendered interactional norms [10], and traditional pedagogical methods [11], which combine to form a learning environment that many have described as "chilly" towards underrepresented populations [12-14]. Long-standing and pervasive hegemonic practices in engineering have led to the identification of engineers as masculine, white, and middle-class [15]. As such, even in Engineering and Engineering Technology departments that have made changes to increase diversity, deep-rooted traditions such as discourse [16], hard work and challenge [17], and competition [18, 19] in the discipline serve to erode the sense of belonging. This leads to burnout and attrition for those students who do not identify as the "typical" engineer [20]. Women and minorities leave engineering and engineering technology, not because they cannot do the work, but because they feel isolated and unwelcome.

Through previous research, mentoring has been found to help combat feelings of isolation and promote a sense of fit for women and minorities in STEM. This has held true at the faculty level [21, 22] and for students as well [23-25]. As evidence has shown, the academic and social support provided through mentoring can improve retention rates of underrepresented students in engineering and engineering technology. While this project does include activities to educate the faculty on inclusive pedagogy, we know that teaching beliefs are well established and resistant to change [26, 27]. Solely depending upon instructors to change the environment for underrepresented students was not going to be sufficient to meet our objective 4 (above) and help students to form an engineering identity. As such, an important part of this project is the assignment of both a peer and faculty mentor for each scholar. This paper focuses on the faculty mentors and their role in supporting the scholars in developing relatedness, autonomy, and competence.

Faculty Mentoring Scholars Protocol

The SD-COMETS Faculty Mentoring Scholars Protocol (FMSP) was developed to outline the parameters that must be addressed in conducting a robust study on the effectiveness of the S-STEM faculty-scholar mentoring program, based in self-determination Theory. The questions guiding this investigation are:

- Does the individual definition and utilization of a Scholar Support Network improve retention of Engineering Technology students, particularly women, AALANA, Deaf/Hard of Hearing, and First Generation students?

- Does programmatic implementation using an SDT framework improve student retention by attending to the basic psychological needs of autonomy, competence, and relatedness?

To determine mentoring program success the parameters outlined below will be evaluated. To ensure a robust study, a quasi-experimental design will be done by comparing outcomes of a control group (scholars) to a comparison group (a random group of freshmen). The impact of mentoring on different types of students (i.e. women, minorities, 1st gen, etc.) will be considered. A combination of techniques such as focus groups, surveys, and /or quantitative outcomes, will be used to evaluate the parameters outlined below, and therefore the effectiveness of the program.

1. Define mentoring and provide a clear operational description.

Although all mentorships involve the attainment of knowledge, most definitions of mentoring combine it with teaching. These definitions miss the distinctive components of mentorship that range beyond what is normally expected from classroom teaching, in both form and content.

Mentoring relationships, both informal and formal, should be defined as an interpersonal exchange between an experienced (mentor) and less experienced (mentee) person in which the mentor provides support along three dimensions: career functions, emotional/psychosocial functions, and role modeling functions [28].

Career functions encompass activities such as academic support, exposure and visibility, and coaching and feedback. Psychosocial functions include activities such as acceptance and confirmation, friendship, and counseling. Role modeling is looking to the mentor as a source of guidance in shaping the mentee's behavior, values, and attitudes [29].

Mentoring is a process, defined by the types of support provided by the mentor to the mentee. These relationships are also dynamic, changing over time, and increasing in impact. The FMSP was founded on the principles of a formal mentoring relationship between the faculty mentor and scholar.

2. Elements of the mentoring relationship that should be detailed.

When developing a mentoring framework like the FMSP, it is critical to its success to have clearly defined mentoring elements. This has been a shortfall in previous and much needed when determining the success of a mentorship. The key elements of the FMSP are detailed next.

a. Role: Clearly define roles in the mentor/mentee relationship. [30]
   All assumptions in the mentor/mentee relationship need to be made clear by specifying who is involved and what exactly their responsibilities are. This includes:
   - Number of students who access mentoring;
   - Number of faculty who serve as mentors;
   - Nature of the mentoring partnerships; and
   - Characteristics of both the mentors and mentees.

   Another consideration in the degree of formality is the extent to which guidelines for the mentorship roles are outlined, including relationship goals, how and when to interact in

the mentorship, and a prearranged length for the mentoring relationship.

b. Tie strength: Intended closeness of the mentoring relationship. [30]
   The concept of tie strength can be used to define how close a mentoring relationship is, i.e. strongly or weakly tied. Typically formal faculty-student relationships evolve to strongly tied relationships, but ultimately it is a function of breadth, intensity, and duration of interactions.
c. Time: Length of the mentoring relationship, the regularity of contact, and quantity of contact. [30]
   The time spent in a mentoring relationship is not inconsequential. Formal mentoring models, like the FMSP, need to clearly specify the time commitments of both the mentor and mentee.
d. Where: Where the mentoring was done.
   The location in which the mentoring takes place is also of significance and needs to be noted. Was it in a casual or more formal environment? Was it in a commonplace or a faculty office? This location may contribute to the overall mentoring relationship and how successful other elements of the FMSP are, like tie strength.
e. How: How did the interactions occur?
   As previously mentioned, the FMSP is based on a formal mentor-mentee relationship. An additional consideration in the success of the program is how the interactions took place. For example, were they informal meetings with casual conversation, or more formal with a pre-determined agenda?

3. Matching of mentor and mentees

The initiation of the mentoring relationship is an important aspect to consider. Effective mentorship is based on the ability of mentors and mentees to trust, share strengths, identify with, and authentically engage with one another.

The extent to which individuals have personal choice and voice in determining their mentor is likely to influence subsequent relational processes. For example, perceived similarity and liking are probably greater when the mentee has input into the mentoring match since these perceptions influence partner compatibility and relationship initiation [31].

Relationships built on a foundation of perceived similarity and liking may foster the development of important relational processes such as trust, disclosure, and commitment. This may be particularly important in settings where “at risk” individuals are targeted for mentoring, as is the case with the SD-COMETS scholars.

Research is ambiguous on the value of same-race and same-gender mentoring relationships. There is research to indicate that receiving support from same-gender mentors and role models is particularly important for women in STEM [28]. There is also research that identifies mentors from similar backgrounds as particularly important to students of Color because they represent prototypes that enable students to gain a sense of academic self-efficacy [32]. This understanding of shared experiences for underrepresented students in STEM may be critical for providing the necessary psychosocial support, resulting in the ability of the student to better engage.

At an emotional level, it may feel comforting to have the guidance of someone who has already solved some of the problems confronting one's own demographic group, and it may be less difficult to trust “one's own” than to trust someone who seems to resemble “the other.” In contrast, a mentee may see significant advantages to being mentored by an individual from a different demographic group. For example the perceptions of power, i.e. the more the mentor has access to power and the predominant cultural norms, the greater might be the rewards for the mentee [28].

Even though some studies of racial matching show no more consistency than studies of gender matching, there is evidence that mentees benefit from mentoring relationships matched on both deep and surface levels regardless of gender or race [28, 32]. Deep-level similarities include shared attitudes, goals, interests, values, and even perceived similarity in problem-solving style. Surface-level similarities include normally readily detectable attributes such as race, ethnicity, gender, and age.

What is ultimately important is the mentor’s acknowledgment of the role of students’ social identities in their career development [33]. Given this, it may be worthwhile to form mentor-mentee relationships based on scholar survey responses to questions such as:

> “What was their biggest challenge been prior to college?”
> “What do they foresee their biggest challenge to be in college?”
> “What are they most worried about for their college/future career?”
> “What do they hope to get out of the mentoring relationship?”
> “How important is it to have a mentor who is the same gender as you?”
> “How important is it to you to have a mentor who is the same race/ethnicity as you?”
> “In order to complete your academic studies, how important is it for you to have someone who understands how your background (e.g., gender, race/ethnicity) may affect your experiences of being a student in your field of study?”

Research has determined motivational similarity to be most important, with relationship satisfaction being highest when the mentor and mentee have similar levels of commitment to the relationship.[34] This may indicate that the match between the mentee and mentor, in terms of either demographics or attitudes, may not be the most important element for a positive mentorship outcome. More importantly, may be matching based on what the mentee needs and what the mentor can provide.

4. Characteristics of a good mentor.

While there is great importance in how mentors and mentees are matched, it is equally important that the mentor has the right attributes, which include: [34]

a. An underlying helping, teaching-learning, reflective, and desire-to-mentor nature.
b. Identity as a coach/sponsor/role model.
c. Character that is respectful, tolerant, non-judgmental, and trustworthy.
d. Ability to provide emotional and psychological support.
e. Academic knowledge, which enables them to connect the mentee with resources on campus for academic success.

Some characteristics that have been documented in the literature to lead to poor mentorship are: dissimilar personalities and habits, self-absorption, manipulative behavior, the delegation of duty, intentional exclusion, self-promotion, incompetence, sabotage, general dysfunctionality and deception. Additionally, the relationship can break down due to feeling that trust in the mentor has been breached, mentor unavailability, feeling unable to meet mentor expectations, and problematic mentor personality traits[34]. Great care should be taken when matching mentors and mentees to form relationships by avoiding these.

5. Responsibilities of the mentor.

Once a mentor and mentee relationship has been established the mentor should take responsibility for the following [28]:

a. The mentor and mentee make their expectations explicit, with the mentor creating a safe space for the mentee to feel comfortable doing so.
b. The mentor works with the mentee to understand what the mentee knows and is capable of, and considers what the mentee can do to further develop and achieve success.
c. The mentor engages in active listening with the mentee, provides timely and constructive feedback, recognizes that communication styles differ, and works with the mentee to accommodate their personal communication styles.
d. The mentor reflects on and accounts for the biases and assumptions they may bring to a mentoring relationship and acknowledges and accounts for how their background might differ from the background of their mentees.
e. The mentor helps the mentee to set career goals, develop and refine plans related to career goals, develop a professional network, and access resources that will be helpful in their professional development. The mentor also recognizes the impact they have as a professional role model.
f. The mentor works to motivate the mentee, build their confidence, stimulate their creativity, acknowledge their contributions, and navigate their path toward independence. There is documented evidence that providing social support to mentees positively influences GPA.
g. The mentor provides support through formal and informal frequent contact and interaction.
h. The mentor will help the mentee establish several networks, social and academic, within the RIT community, creating their SSN. There is evidence to indicate that having a broad network with multiple developmental mentoring relationships can be particularly important and helpful for women pursuing scientific and professional careers.

6. Activities and training in the mentoring relationship.

Defining formal mentor/mentee activities that support Self-Determination Theory is important in that most of the mentors have had limited training and experience in being a mentor and, in order to be effective, the relationships need to be more than just a friendship. While informal meetings are encouraged, mentors are also provided with structured meeting formats. The discussion questions below, which can be revisited every semester, were developed to specifically address SDT and assist the mentor and mentee determine together what support services may be needed.

Relatedness	Competence	Autonomy
Initial: Why did you decide to attend RIT? Follow-up: How do you feel about your decision to attend RIT? Initial: Why did you choose the ET major? Follow-up: How do you feel about your decision to major in ET? What student clubs have you joined? Student organizations related to student demographics and/or interests How are you adjusting to life at college? Can I connect you with an alumni/upperclassmen/faculty related to your career interests?	How are your classes going? What is/was your favorite class and why? What is/was your most challenging class and why? Faculty Research Opportunities Co-op, Internships and Research Experiences for Undergraduates (REU's) Understanding the difference between Engineering and Engineering Technology	What worked/did not work for you this month/semester/year? What will you do differently next month/semester/year? What approaches do you use to address challenges you have in your coursework? Follow-up: Have you met with your professor? Used the academic support center? Formed or joined a study group? Used the department tutors? Why/why not?

Table 1: Faculty Mentor Questions and Discussion Topics Related to Self-Determination Theory

Progress

The SD-COMETS program launched the fall semester of the 2020 academic year. The first cohort of scholars consisted of twelve freshmen. All of the scholars were surveyed as to their mentoring needs per the Faculty Mentoring Scholars Protocol and Faculty Mentors were assigned based on the responses to the survey. A total of eight faculty are participating as SD-COMETS mentors. Scholars were notified of their faculty mentors via email. The social distancing required by the COVID-19 pandemic made hosting in-person group mentoring functions challenging. Mentors met with their mentees individually in person or on Zoom to introduce themselves and discuss the goals for the mentoring relationship. Additional meetings were held over the semester to check on the students' progress, with particular attention paid to supporting the three psychological needs described in Self-Determination Theory: relatedness, autonomy, and competence. The mentors also assisted the scholars with the development of their individual Scholar Success Network (Figure 1).

Mentoring Workshop

After the mentor/mentee relationships were formed and initial introductions were made, the eight mentors and 12 mentees participated in a workshop focused on inclusive mentoring. While all of the mentors and mentees are women, it was still important to bring inclusiveness in mentoring to the forefront. Research has shown that, despite being underrepresented themselves, the enculturation process that is necessary for marginalized faculty to find success in STEM fields often results in repeated patterns of inequity [35]. Women faculty have to push back against this phenomenon that occurs, not from any conscious intent, but as a result of socialization.

In addition to faculty being introduced to the framework for inclusive mentoring, the workshop allowed the scholars to better define what they needed from the mentoring relationship. The importance of including mentees in the planning stages was made evident from the start. When asked what kind of mentor, (learning consultant, coach, counselor, advisor, role model, or critical friend) the faculty members saw themselves as, they unanimously agreed that role model was number one followed by an adviser, coach, counselor, and learning advisor. In contrast, when asked what they were looking for in a mentor, the mentees ranked coach first with a counselor and critical friend tied for second. Once the expectations were set by the mentees for the role they wanted their mentor to take in the near term, they were able to further define how they believed they would benefit most from the mentor/mentee relationship. As a group, they described a relationship where the mentor is a guide that they can go to with issues/problems and will provide tools for finding the solution. From the mentees' description of what they wanted, the mentors had clarification that their job was not to solve problems (a role engineers naturally fall into) but to empower their protégé.

The 2020 Academic Year was the first year of the SD-CoMETS program. In addition to faculty mentoring of the scholars; other major initiatives that were launched include the SD-CoMETS Seminar, Parent Orientation, industrial networking events (held virtually due to the pandemic), and social gatherings, such as movie night. A part-time staff program coordinator was hired.

The SD-Comets seminar is a one-credit course required for all first semester scholars. It is designed to aid students in the transition from high school to RIT and Engineering Technology. The goals of the seminar are to engage students in campus life, to assist students in developing academic and personal success strategies, to provide professional development, to build an understanding of the field of engineering, and to promote awareness and utilization of campus resources.

Using a combination of speakers, panel discussions, and interactive workshops, the first offering of the seminar in the fall of 2020 successfully met its intended learning outcomes. Scholars participated in workshops focused on assertive communications skills, success strategies, growth mindset, stress mindset, metacognition, professional communications, and the importance of soft skills. Each of the aforementioned workshops included a guest speaker with in-depth knowledge of the topic. Additional speakers included an alumna from the college, advisors, representatives from the university's Center for Women and Gender, Spiritual and Religious Life, Academic Support Center, and Counseling and Psychological Services.

In the process of meeting its learning goals, the seminar also helped to create a community of scholars. Especially in a time of social distancing, the weekly class, which met in-person 50% of

the time, provided a safe and comfortable environment for the students to bond as part of a group. We realized the importance of this unexpected benefit of the seminar during the spring semester when the scholars asked for additional social events to be planned so that they could have the same collaborative experience they had during the seminar. Not only did this lead to the implementation of group mentoring and a movie night, we plan to include opportunities for the first cohort of scholars to participate in some of the workshops during next fall's seminar.

To provide additional support from outside the program and the university, we felt it was important to include parents and other support givers. An SD-CoMETS Parents and Supporters Orientation was held virtually in October of the 2020 fall semester. The session was held on Zoom. Scholars were asked to share contact information for parents, guardians, or other supporters. During this orientation, we provided parents with an overview of the SD-COMETS scholarship and SD-COMETS Team. More importantly, we introduced them to the SD-COMETS Program Support Network, Program Activities, Scholarship Requirements, and ways to Support their Scholar. As some of the scholars are first-generation college students and others have parents unfamiliar with RIT, having information about support services available, allows them to assist us in encouraging their scholar to take advantage of their individualized support network. The orientation concluded with a list of other financial aid resources and time for questions and answers. The participants expressed appreciation for the information about the scholarship program and for getting an opportunity to meet other supporters.

The final initiative that we started this year was industrial networking. Due to restrictions because of the pandemic, the students were not able to tour local facilities to see engineering in action. However, we held a virtual panel discussion with Texas Instruments in which the panel members discussed their experiences in college and how those experiences shaped their careers. In addition to presenting the many opportunities available for each type of engineer at Texas Instruments, they answered questions and offered advice for the scholars. In continuation of this initiative, another virtual event and an in-person tour have already been scheduled for the fall semester.

Next Steps

This paper describes a work in progress, thus several tasks are remaining. In regards to our previously introduced Faculty Mentoring Scholars Protocol, the following components will be addressed in the upcoming year:

1. Resources and tools: technological or other artifacts that assist the pair.
2. Role of technology: how important was this to the relationship.
3. Training: how necessary understandings and skills will be developed in participants.
4. Policy: a set of rules and guidelines on issues such as privacy or use of technology.
5. Monitoring: oversight of the FMSP.
6. Termination: determination of how relationships will end.
7. Evaluation of the mentoring partnerships.
    a. SDT component *relatedness* will be captured by tracking scholar's participation in mentoring (faculty-scholar and scholar-peer), i.e. their Scholarship Support Network (SSN).

b. SDT component *motivation* will be captured by tracking the scholar's career and graduate school intentions.
c. The scholar's GPA, persistence, and academic performance will be tracked and compared with a comparison group (random freshmen in CET).

In addition to the quantitative data described above, which will be collected in support of evaluating the program, an external evaluator will hold focus groups with the scholars to collect qualitative data. The team will analyze transcripts from the focus groups over the summer and the results used to inform mentoring activities for the following year. The twelve mentor/mentee relationships that have already been formed will continue into year two and twelve more pairings will be made with the second cohort of students.

Activities planned for completion during the summer of 2021 include completing the protocol and providing each mentor with more formal activities for their mentoring sessions. These activities, based on the KEEN Reflective Collection [36, 37] are designed for the mentees to consciously connect their thoughts and actions and transform their goals into promises to themselves.

Conclusion

This paper presents the Faculty Mentoring Scholars Protocol developed to guide mentoring practice and evaluation of mentoring activities for the SD-CoMETS program. This work in progress takes the general definition of mentorship, a pairing of mentor with mentee, and enhances it by adding detailed elements intended to improve the effectiveness of the mentoring relationship. This is an improvement on previous work, which tended to keep operational details regarding mentoring and associated elements vague. The next steps will look at starting to evaluate the effectiveness of the current FMSP with intentions for continuous improvement. The evaluation methods outlined here are also an improvement on previous work, which again tended to not keep control variables in mind.

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