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WIP: A Layered Mentorship Program (LMP) for Engineering Student Success and Retention

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Work in Progress: A Layered Mentorship Program for Engineering Student Success and Retention

Abstract

This Work in Progress paper of an Evidence-based Practice examines the impact of a Layered Mentorship Program (LMP) on the retention of first-year engineering students and develops a conceptual model focusing on STEM Identity for conducting further research. The College of Engineering at an urban research university is acutely aware of the increased need for retention programs in engineering colleges across the US. To respond to this need, a unique mentorship program, the LMP, was established as one of the main components of an Engineering Learning Community (ELC) for first-year engineering students. Students self-select into the ELC program and, upon being registered, are assigned a peer mentor. The peer mentors are sophomore through senior-level undergraduate engineering students in the college who hold loosely structured meetings with the mentee students. The peer mentors are in turn supported by multiple "layers", including senior mentors, graduate students, and faculty. A majority, but not all, of the peer mentors and mentees are recipients of scholarship funds from a NSF S-STEM grant.

The researchers focus on the peer mentorship component of the ELC program as a critical and catalyzing practice that promotes STEM identity, which is corelated with academic success and retention. Furthermore, the relational and communal aspects of the mentorship program are posited as particularly critical supports in context of the global pandemic. The researchers hypothesize that participation in the LMP will be correlated with improvements in student retention and academic performance, and that there will be a change in students' STEM identity as they progress through the program. A chi-square test found a statistically significant difference between groups of students who had participated for an entire year in the LMP and students who had not participated at all. An independent samples *t*-test found an observable, but not statistically significant, positive association between LMP participation and GPAs. Emergent themes resulting from a preliminary coding of student interviews pointed to a transition in student behavior and identify as they progressed through the LMP. The researchers conclude by proposing a systemic understanding of mentorship programs as a means to provide dynamic supports that relate to students' dynamic STEM identities.

Introduction

A multi-institutional NSF S-STEM Project is in its second year of researching the impact of STEM identity on student success. Each of the three participating universities have developed and implemented a unique set of supports that are designed to promote STEM identity development and academic success in a population of academically talented students with unmet financial needs. To formatively and summatively evaluate the project as it continues into its second year, project participants had previously outlined the need to determine the effectiveness of the individual project components [1]. With each of the universities designing and implementing a partially unique set of supporting activities and mechanisms, it is difficult but imperative to understand and relate the unique components to student identity development and academic success.

This paper will begin a preliminary examination into how specific aspects of an innovative peer mentorship program at a large urban research university, called the Layered Mentorship Program (LMP), are related to the students' continued academic success and corresponding retention rates. The hypothesis is that as students transition from being mentees to mentors, different aspects of this program will aid in the development of a heightened STEM identity that will, in turn, indicate increased and continued academic success and retention. The relevant research questions are:

- RQ1: How does continued student participation in the Layered Mentorship Program relate to retention in the engineering college and academic outcomes?

- RQ2: How do student identities change as they transition from being mentees to being mentors?

- RQ3: Does a change in student identity correspond with a change in needs that can be supported by the Layered Mentorship Program?

Literature Review

Developing and enacting mentorship programs as a means to promote academic success is an area of rich discussion and research in higher education [2], in STEM education [3], and within the ASEE community (a non-expansive review of the literature yielded over 20 ASEE conference papers in the last two decades). Collectively, this research points to an important (if not obvious) fact: there is great diversity in higher education mentorship models. This diversity of mentorship models needs to be understood in conjunction with another important fact: a recent meta-analysis has evidenced that, broadly speaking, being mentored is not strongly associated with favorable student academic outcomes [4]. This research is not to be understood as being dismissive of the efficacy of all mentorship programs; instead it points to the need to develop and enact specific models based on circumstance and desired outcomes.

To develop, assess, and iteratively improve our mentorship program, the authors have engaged in a review of relevant literature. While there is an expansive corpus relating to all the themes that will be discussed, our team elected to focus on seminal papers, meta-analyses, and ASEE conference papers published in the last 10 years. It is important to note that, while there are many ASEE papers that investigate mentorship programs, there are few that either directly reference or consider research from the existing body of ASEE literature in developing or assessing their programs.

Consistent with the project's forthcoming research [5], the authors have adopted a Communication Theory of Identity (CTI) framework for understanding identity as a multilayered, relational construct. A relevant literature review was grounded in CTI's four layers of identity development [6], all of which were evidenced in ASEE conference papers studying mentorship programs. The language used to describe the CTI layers in these papers will be used in this paper to develop a working construct for STEM identity currently evidenced in the ASEE body of literature. The CTI layers, written in italics, are followed by relevant themes pulled from ASEE conference papers.

- *Personal*: self-efficacy and self-confidence in engineering students [7]
- *Enactment*: the development of professional / authentic skills [8]
- *Relational*: creating interpersonal bonds [9]
- C*ommunal*, specifically community and sense of belonging [2], [9], [10].

Pertaining to the programmatic goals of student academic success and retention, the authors were able to identify relevant literature to guide in the design of the program. Relevant literature fell into three categories: relating mentorship programs to favorable academic outcomes, specifically increases in student GPA and retention [11], [12]; post-secondary STEM and engineering mentorship programs [13]-[18]; and mentorship programs and STEM / engineering identity development [7], [19], [20].

Background

The LMP is a peer led mentorship program that includes multiple layers of support from a small group of multi-disciplinary graduate research assistants and engineering faculty participating in the Project [21]. Being peer led, the primary relationship exists between a first-year undergraduate mentee and a second-year peer mentor who has been selected by Collaboratory faculty. This aspect of the program can be characterized as peer mentorship, a model selected due to its demonstrated relationship with improved mentee GPA and retention rates [11], [15], [16], [18], improved communication and participant satisfaction [6], [11], and perceptions of community development [22] in undergraduate STEM students.

The LMP formally began in the Fall 2020 academic semester, with each of the universities participating in the STEM Project developing largely consistent recruitment practices for identifying and awarding scholarship funds to a population of undergraduate students [1]. Establishing a set of common research goals, the three universities began documenting their specifically devised activities and mechanisms that were (and continue to be) designed to aid student academic success and develop STEM identity [1].

Certain components of the urban research university's STEM Project pre-date its participation in the STEM Project. The Engineering Learning Community (ELC), currently in its fifth year of operation, has provided a voluntary opportunity for all incoming first-year engineering students to participate in a cohort model of learning. Participating students enrolled in a common writing, math, and (devised specifically for the ELC) Introductory Design course. Additionally, the students were asked to participate in a mentorship program (as mentees) during their first year.

Upon inception of the STEM Project, the urban research university elected to keep this voluntary structure intact for all incoming first-year students while requiring students who were receiving scholarship funds from the STEM project (termed "Scholars") to participate. In addition to participating in all aspects of the ELC, Scholars were required to participate in a cross-campus bridge week and participate in a student social networking platform called Course Networking. Importantly, at this time the mentoring program began a transition from being a faculty led mentorship program to a peer led, Layered Mentorship Program that characterize this paper's research.

For the first cohort of STEM Project Scholars, students who had participated in the ELC were vetted as possible mentors and then invited to serve as peer mentors. Mentors met with students (both first year ELC students and Scholars) on a weekly basis for 30 minutes, for a total of 16 meetings. All of the mentors were required to complete a course offered by the principal investigator who, in addition to acting as their instructor, had been advising these students and helping them to connect with the engineering program community. The layered structure was designed to establish a basis for communication, where mentees could communicate comfortably with mentors, and mentors could communicate with faculty and researchers to support students with identified needs.

In each of the meetings, the mentors completed a form that was developed to collect data on the students' current grades, perceived academic needs, and advice offered, as well as general notes. Using this form to guide discussions, the mentors met with one of the researchers to identify students at academic risk and to identify possible resources that might support them. The focus was on identifying specific resources as opposed to generic best practices. An example of this was mentors accompanying students to the writing and math tutoring centers and helping students to navigate the various aspects of these formalized support processes. Mentors also helped to connect students to non-academic resources, such as scholarship workshops.

Methods

A quantitative study was designed to test RQ1, examining how continued participation in the LMP was associated with student academic success and retention in the engineering program. The study compares retention rates and GPAs of engineering students who participated in the LMP in Fall 2019 semester ($n = 8$), Fall 2019 and Spring 2020 semesters ($n = 15$) with engineering students who did not participate in the LMP ($n = 123$) during either of these semesters. Additionally, the use of qualitative analysis (specifically grounded theory), was used to begin preliminary work in the examination of RQ2. These studies were granted approval by the authors' institutional review board (IRB).

Participants

The participating students were all first-year engineering students during the Fall 2019 semester. Enrollment was defined by the following criteria: (1) Students must have been registered in Fall 2019 for at least one engineering-related course offered by one of the following departments: general engineering, mechanical engineering, civil engineering, electrical engineering, computer science, chemistry, or math (2) Having at least one course with any letter grade (A – F) or a W on their transcript, but not all blank grades (indicating they dropped a course before the census date) and (3) Having a declared engineering or pre-engineering major. Students who did not meet all these criteria were excluded from the sample. Additionally, students taking courses as part of the university's high school collaboration project were excluded from our data collection.

Data Collection

The research team collected data from their university's student information system (SIS). Data collected was limited to student course enrollment, GPAs, and declared major during the Fall 2019 and Spring 2020 semesters. Additionally, one of the researchers conducted 10 semi-structured interviews surrounding engineering / STEM identity were first auto-transcribed using the closed captioning feature in TechSmith Relay, and then heavily edited by the authors to ensure accuracy of transcription.

Analysis

In order to answer RQ1, two chi-square tests of association were conducted to compare the frequency of retention between 2 categories of students (those enrolled in the mentorship program and those not enrolled) at the end of the Fall 2019 and the Spring 2020 semesters. An independent samples *t*-test assuming equal variances was used to test for a significant difference between the two categories of students' GPAs at the end of the Spring 2020 semester. Using a single exemplar interview, three members of the research team engaged a process of constant comparison [23], [24], inductively developing codes and then meeting together to discuss and create a collectively agreed upon set of codes that will be used more expansively in future research.

Results

This work in progress investigated the first and second research questions:

- RQ1: How does continued student participation in the Layered Mentorship Program relate to retention in the engineering college and academic outcomes?

- RQ2: How do student identities change as they transition from being mentees to being mentors?

Research Question 1

An initial chi-square test compared first year engineering student retention rates between two groups of students: the first group did not participate in the mentorship program (n= 123) and the second group participated in the mentorship program for either 1 or 2 semesters during the 2019 – 2020 academic year (n= 23). There was an observed but not a statistically significant difference in retention between these two groups with χ^2 (1, N = 146) = 1.7124, p = .189. This test provided weak evidence against the null hypothesis, indicating that there is an 18.9% chance the observed differences in retention between the two groups are due to random chance if there really is no difference between groups.

Extending the perspective, a second chi-square test was used to see if the number of semesters a student participated in the mentorship program was related to student retention by dividing the same population into 3 groups; the first group did not participate in the mentorship program (n= 123), the second group participated only during the Fall 2019 semester (n= 8), and the third participated during both the Fall 2019 and Spring 2020 semesters (n= 15). There was a statistically significant difference between the group of students who had not participated in the

mentorship program and the students who had participated in two semesters of the mentorship program with χ^2 (1, N = 146) = 8.089, $p < .05$. This chi-square test of associate yielded a Cramer's V value of V = 0.235, indicating a medium effect size [25].This test provided strong evidence against the null hypothesis, indicating that there is an 1.8% chance the observed differences in retention between the two groups are due to random chance if there really is no difference between groups

Table 1. Comparing the Retention Rates of Students with No Mentoring to Students with Some Mentoring

	No Participation in the LMP	Some Participation in the LMP (1 or 2 Semesters)
Fall 2019 Starting Population	123	23
Total 2019 - 2020 Attrition	38	4
Total 2019 - 2020 Retention	85	19
Retention Rate	69%	83%

Note: When dividing the population of 2019 – 2020 engineering students at the urban university into two groups based on mentorship program participation, there is an observable, but not statistically significant, difference in student retention rates. 69% of students who did not participate in the mentorship program were retained compared to the 83% of students who received some mentoring who were retained.

Table 2. Comparing the Retention Rates of Students with No Mentoring, Those who Only Participated in Fall 2019, and Those who Participated both Fall 2019 and Spring 2020

	No Participation in the LMP	Only Participated in the LMP in Fall 2019	Participated in the LMP in Fall 2019 and Spring 2020
Fall 2019 Starting Population	123	8	15
Total 2019 - 2020 Attrition	38	4	0
Total 2019 - 2020 Retention	85	4	15
Retention Rate	69%	50%	100%

Note: When dividing the same population of 2019 – 2020 engineering students at the urban university into three groups, there is a statistically significant difference in student retention rates between two of the groups. 69% of students who did not participate in the mentorship program were retained compared to the 100% of students who received two semesters of mentoring who were retained.

To investigate the relationship between mentorship and academic success, an independent samples *t*-test was conducted using the average first year GPAs. There was an observable but not statistically significant difference (t (144) = -1.635, p = .104) between the GPAs of students who had not participated in the mentorship program (3.122) from those who had participated in the mentorship program (3.287) at the end of the Spring semester. While the p-value does not

evidence correlation, it does support a positive association in a mentorship program where participation is not a randomly assigned variable. Together with previous Program research [1] that had evidenced correlation, the researchers interpret these findings to provide supporting evidence of the need to continue the LPM and associated relevant research in this area.

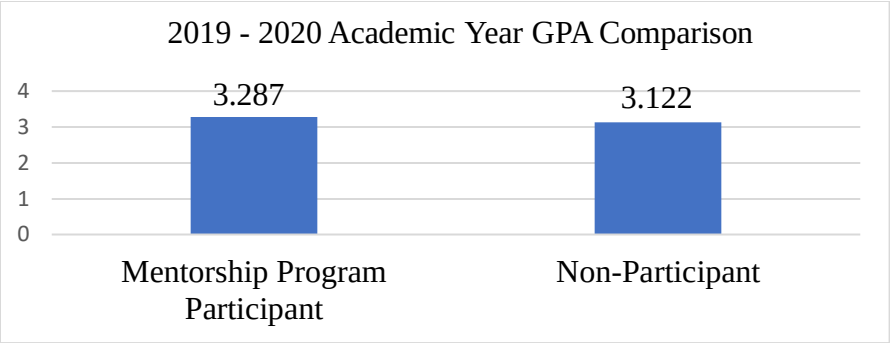

Figure 1. Average year-end GPAs of the two student populations after completing two semesters (both Fall and Spring).

Research Question 2

Participating in a process of constant comparison, three members of the research team achieved consensus on five emergent themes that seemed to capture a narrative arc contained in the LMP. The exemplar interview pointed to an important transitional process as students progress through the LMP, from mentee to mentor. These emergent codes will be used to analyze remaining and forthcoming student interviews to better understand the transitional process in RQ2. Additionally, they are used in the discussion to begin an exploratory research for RQ3. The codes, with a related student quote, are as follows:

- *Behavior as a Mentee* – "So [my] time management was very different after speaking with him."
- *Identity as a Mentee* – "My entire time here, I always asked for help rather than helping."
- *Transition (Between Mentee & Mentor)* – "[However,] being a mentor actually did change the way I viewed myself."
- *Behavior as Mentor* – "I do help out with friends on homework, but that's different from mentoring – [when I'm in the role of mentor,] I'm actually trying to spend that time to mentor someone."
- *Identity as a Mentee* - "[Now, as a result of being a mentor, I view myself as] someone who can be reached out to when you're in need of help. Because I've always been the one to ask for help rather than providing help."

Discussion

The quantitative research analyzed for this paper largely aligned with previous research conducted by the urban research university which demonstrated that students who participated in mentorship program as part of the broader ELC program had both an observable and statistically significantly higher GPAs than non-participating engineering students [26]. It extended the

research in an intriguing fashion by associating longer participation in the mentorship program with a statistically significant increase in student retention. All of the students who participated in both the Fall 2019 and Spring 2020 semesters of the LMP were retained. Conversely, an interesting, but not statistically significant, observation was that half of the students who only participated in LMP for one semester (Fall 2019) were not retained.

While circumstances that lead to student attrition are diverse, it is important to consider the specific supports that were made available to LMP participants during each of the semesters and how these align with (possibly categorizable) changing needs of students as they progress through the program. It is interesting to consider if there are aspects of the program that might be better designed to serve second semester engineering students than first semester engineering students. It is equally interesting to consider how the LMP has possibly continued to meet the needs of these students as 12 of the 15 retained students have continued to participate in the LMP as mentors during the current academic year (2020 – 2021).

A relevant historical element of this research is that these second-year student mentors are scheduled to complete the university's two-year model of providing supports and scholarship funds at the end of this semester (Spring 2021). This marks an important transition for these students, who will no longer formally be associated with the STEM Program. As serving as a peer mentor has been related to academic growth and professional skill development as well as an increased sense of connection to the campus and professional communities of engineers [9, 27], it will be important to contemplate if the supports provided to date will have a lasting effect on these students.

Preparing to Investigate Research Question 3

Tracking these students' developing STEM identities, the most salient indicator of identity *enactment* is likely students' continued enrollment in the engineering program. As students progress though the program, it will be interesting to see how this layer likely changes [17]. Based on initial observations from the exemplar interview, it appears that the role of mentee could promote *relational identity* development as the mentee creates a bond with their mentor, and later on the role of mentor might promote *communal identity* development as the mentor shifts focus to giving back to the community. The researchers plan to further explore these possible relationships as they relate to RQ3, particularly relating to the complexity of developing relationships and community against the backdrop of the global pandemic. In an effort to support mentors and mentees in their academic careers both as they participate within and beyond the container of the Program, future research will begin the consideration of a systemic framework that is capable of registering the relationships between more discrete components. A posited theoretical framework that will be used for RQ3 is shown in figure 2.

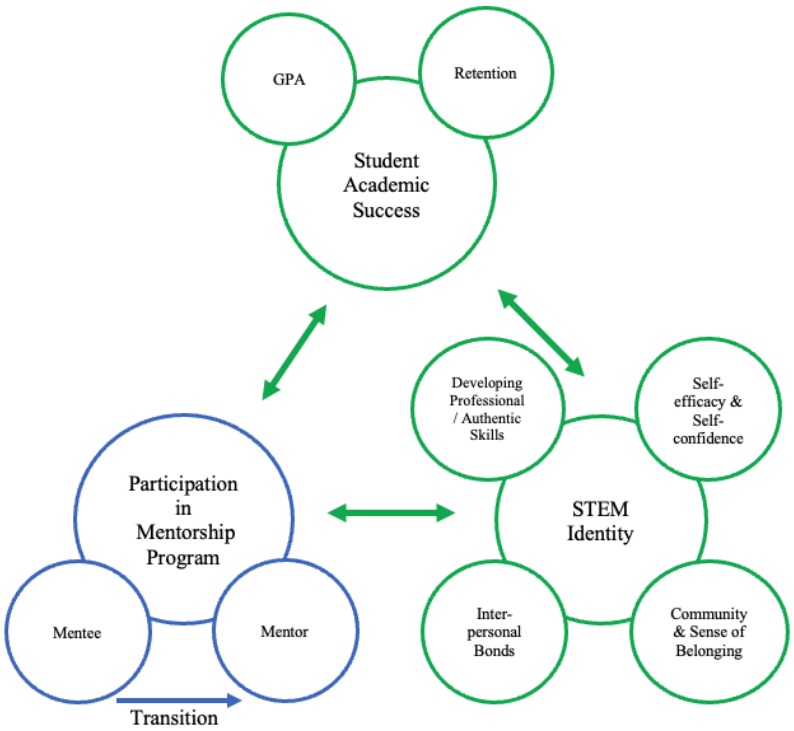

Figure 2. A theoretical framework for understanding the possible relationships between student academic success, STEM identity, and participation in the mentorship program. The specific research focus, pictured in blue, is the transition from mentee to mentor.

In this framework, all of the constructs and their parts are understood as relating to one another systemically. By measuring and instrumentalizing each of the parts of the constructs, the intent is to make these relationships measurable so that the intentional manipulation of a single variable might be registered and measured in the change of different construct's parts. The mentorship construct, pictured in blue, is to be understood as the principal construct to be acted upon. The purpose in developing this theoretical framework is to extend our understanding of the LMP's success by better understanding why it is successful. Using this framework, our future research will attempt develop a deeper understanding of programmatic elements that relate to specific aspects of STEM identity development and, importantly, a student's capacity and desire to graduate with an engineering degree.

Limitations

The sample sizes used in this research limit the generalizability of the findings. While this limitation is common in the ASEE body of research, it is the authors' hope that the research makes a positive contribution to this larger body of research and can exist to further the same meaningful dialogue that has informed the creation of the successful program that has been discussed in this paper.

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