Minority Status and Belonging: Engineering Math as a Vehicle to Build Community

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Janet Y. Tsai is a researcher and instructor in the College of Engineering and Applied Science at the University of Colorado Boulder. Her research focuses on ways to encourage more students, especially women and those from nontraditional demographic groups, to pursue interests in the field of engineering. Janet assists in recruitment and retention efforts locally, nationally, and internationally, hoping to broaden the image of engineering, science, and technology to include new forms of communication and problem solving for emerging grand challenges. A second vein of Janet’s research seeks to identify the social and cultural impacts of technological choices made by engineers in the process of designing and creating new devices and systems. Her work considers the intentional and unintentional consequences of durable structures, products, architectures, and standards in engineering education, to pinpoint areas for transformative change.

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Abstract

This research explored feelings of belonging and engineering identity among entering first year students, within the case study of an engineering math course at a large, public institution. Incoming first-year students who did not place into the traditional Calculus I course or above were co-enrolled in the engineering math (EMath) course. This pilot EMath course was found to enroll a higher percentage of students underrepresented in engineering at the institution, including underrepresented racial/ethnic minorities (URM), first-generation, and low income students. It was unclear the extent to which being at a demographic “critical mass” in the EMath course could provide a supportive community for these students, and potentially counter the institutional message of “tenuous” belonging in engineering due to being unable to place into the typical first semester calculus course. Survey instruments with Likert-type questions were used to measure belonging and engineering identity at the beginning and end of the semester. Course belonging and engineering identity was higher among first-generation and low-income students in EMath on the pre survey. Course belonging and math confidence increased on the post survey. Among students enrolled in an engineering projects course in fall 2018, at the end of the semester students also enrolled in EMath had higher private regard and group identification (two measures of identity) compared to students not enrolled in EMath; the largest difference was among URM students. The results indicate that EMath might provide a supportive environment with benefits to students’ engineering identity, although confounding factors of additional cohort programs and intersectional identities are complications to the study. Further exploration of these ideas is warranted using qualitative methods and longitudinal studies.

Introduction

Student retention in engineering education is an important issue for a variety of reasons. The creative potential of engineering to benefit society is diminished when diverse students fail to graduate. This includes cognitive diversity as well as students with diverse interests, values, and experiences, sometimes termed latent diversity. For example, Haemmerlie & Montgomery [1] found that male students with greater prudence and lower sociability had greater persistence from first to second year. In addition, all students should be provided equitable opportunity to successfully earn engineering degrees. Equitable student outcomes often focus on more visible forms of diversity including race/ethnicity [2]. Engineering commonly uses the acronym URM in reference to underrepresented racial/ethnic minorities in engineering, including Black, Latinx, and Native American individuals. Studies have found that the persistence and retention of URM students in engineering is lower compared to majority white and Asian undergraduates, although this varies significantly among institutions [3].

Feelings of belonging have been linked to student persistence, and minority students may feel a lower sense of belonging [4,5]. Belonging is an individual’s feelings that they fit in and are a member of a group. It is closely related to feeling a sense of community, which implies feeling connected to other individuals within a group. Belonging has also been related to “feeling cared about, accepted, respected, valued by, and important to the group” [6]. Feelings of belonging and
community operate at multiple levels in college, including within a particular class, one’s major, within engineering and/or STEM more broadly, and at the institution. During the transition to college, a sense of community and support may be particularly important elements of persistence and success [7,8]. Sense of belonging may be differentially important to the persistence of minority students, such as women in STEM [5] and non-Caucasians [9]. In contrast, one study failed to find that students’ sense of belonging increased their second-year retention [10].

The theoretical construct of identity was also used to ground this research. Identity has been defined as being recognized as a particular kind of person, with identity being both self-constructed (e.g. recognizing oneself as an engineer) and externally validated (e.g. others recognizing a person as an engineer). Engineering identity has been found to differ among demographic groups, and identity has been linked to retention [11]. In a counter example, a recent study failed to find a difference in engineering identity between male and female students, as well as no link between identity and persistence [12]. Thus, the literature lacks consensus on identity and persistence issues, particularly with respect to demographic factors. This may be due in part to the diversity of operational definitions and measurement methods for identity, which stem from a variety of different theoretical models of identity. For example, Patrick et al. [12] found that self perceived competence in engineering skills, interest in engineering, and recognition as an engineer led to increases in engineering identity. In a study with first-generation college students, Verdin et al. [13] did not find a direct link between competence and identity, but rather that competence impacted interest and recognition and those factors in turn impacted identity. In our study we explored three identity constructs from Chachra et al. [14], including centrality (the extent the student defines themself as an engineer), private regard (student’s positive or negative feeling about engineers and engineering), and public regard (extent student believes others feel positively or negatively about engineers and engineering). Belonging and identity may influence each other. For example, Verdin et al. [13] found a pathway from engineering identity to both belonging in an engineering major and belonging in an engineering classroom, with these two types of belonging being correlated. In our research we explored elements of belonging and identity within specific demographic groups.

The extent of one’s representation or underrepresentation in a particular environment may impact feelings of belonging and persistence. This idea has been termed a “critical mass” or “tipping point”, with mixed support in the literature. Hagedorn [15] found higher GPA and success of Latinx students attending community colleges with a higher percentage of Latinx students (ranging from 20 to 76%). In contrast, Capers [16] found that Latinx peer representation was not a significant predictor for Latinx graduation rates; only in a model that accounted for structural representation (e.g. HBCU) was Latinx peer representation found to have a secondary effect on Latinx graduation. These results indicate that specific institutional characteristics should be considered in studies exploring the experiences of under-represented groups. Institution was also a prominent factor in the findings from Ohland et al. [3]. The representation of women and URM students in engineering vary significantly across institutions [17].

In addition to visible differences (e.g. gender, race/ethnicity) that may impact a students’ sense of belonging, other factors such as income level and first generation status may be important. For example, a recent book documented feelings among low-income students that they did not belong at an elite college [18]. One low income student stated, “if I went to another school where
I was comfortable, I would be more of a leader… this place puts you in a depression… the toxic environment, it’s isolation. You feel like you’re alone, like there’s no one that can relate” [18, pg. 43]. A poor white female student said “I always feel that I don’t belong” (pg. 45), while a poor white male student recounted “alienating moments” (pg. 46). Thus, within a particular institution, having a lower income background was detrimental to students’ feelings of belonging. URM students attending college are on average from lower socio-economic status (SES) than white peers [19], which may exacerbate challenges.

The fact that students are not defined by single categories of demographics is an important consideration, particularly when this includes multiple minority or under-represented attributes. This brings to the fore the notion of “multiple lenses” and intersectionality [20, 21]. For example, Rainey et al. [22] found the lowest sense of belonging in STEM among women of color. Persistence in engineering differs based on intersectional groups of race/ethnicity, gender, and economic status [3, 19, 23]. An individual may feel different than the majority of their college peers in a number of ways, compounding feelings of otherness and diminishing their sense of belonging.

Within engineering, math knowledge and/or course performance has been shown to be a key to persistence and success. Ohland et al. [19] found that SAT math scores were the most significant factor in a model that predicted six-year graduation rates in engineering across multiple institutions. However, institution was the second most important factor in the model, with an interaction between math and institution being the 4th most important factor (following economic status); the model also included a small impact (11th most important) of a factor for the interaction between math and gender. In STEM more generally, persistence was lower for students who were not “math ready” [24]. Math readiness has been found to differ among demographic groups [25, 26, 27] and is thus an important consideration in efforts to broaden diversity, given the “gate keeper” role that passing mathematics / calculus courses often serves in engineering [28, 29].

The importance of mathematics competency has led to interventions to help college students gain confidence and knowledge in their math skills. This research explored a cohort of students participating in a pilot engineering math (EMath) course designed for those who did not place into Calculus I or higher at a large public institution (LPI). While the primary intent of the course was to provide scaffolding for success in math and engineering, it was recognized that the course might also provide an environment where a diverse cohort of students could feel part of a supportive community. This sense of community was described previously in student interviews [30], but quantitative assessment results were not previously examined. The premise for the engineering math course was based on the Wright State Model (WSM) [31], with similar learning goals and course content. However, institutional conditions resulted in the course being implemented very differently. Unlike at Wright State where the course serves all first semester students and is the sole math course in the first semester, at LPI only students not placing into Calculus I were enrolled in EMath. Given this enrollment model, students in EMath may have perceived themselves as outside the norm of the college (i.e. Calculus I ready), which could negatively impact their engineering identity and/or sense of belonging. Although the EMath course was given a 3000-level number so that it could count as a technical elective toward graduation requirements, in some ways the course implementation is similar to “remedial math”
courses and narrowly avoids the stigma of “courses [that] are administered in ways that require students to pay for courses that earn nonadditive credits” [32].

It is likely that one’s ‘mathematics identity’ could influence their engineering identity, given the core and gatekeeper functionality of math in engineering. This aligns with the competence factor explored in previous studies of engineering identity (e.g. [13]). In a qualitative study of two Black students taking a remedial math course, Larnell [32] noted that both students began to “question their mathematics identities”, and despite regarding themselves as high achieving students began to exhibit “behaviors that were misaligned to high-achieving identities.” Specifically, the students shifted from being “academically successful maximizers… to acting as satisficers.” Further of interest in this study were discussions of “cues implicating one’s marginality” as major harbingers of identity threat; “the number one such cue is the number of other people in a setting with the same identity—the ‘critical mass cue’” (p. 140). For one student, the critical mass cue (i.e., noticing “so many black people . . . in the classroom”) was indeed major [32, p. 258, citing 33]. For another student participating in an “institutional support system” for URM students, “senior students were substantiating and transmitting a deficit-oriented and identity-threatening master narrative about the experiences of Black students in [ ] mathematics courses….” [32, p. 259]. Jack [18] describes a similar idea, noting “Paying attention to these diverse experiences and the structural forces that influence them, such as poverty and segregation, can go a long way toward helping to design initiatives to promote all students’ sense of belonging.” (p. 78). Thus, it is uncertain to what extent having a large minority population in EMat could be either beneficial or detrimental to feelings of belonging and engineering identity.

Research Questions

This research explores five questions related to the case study of engineering math at LPI:

1) Did the engineering math course provide a setting where students in the minority among the first-year (FY) cohort in engineering overall had a higher representation?

2) Are there differences among incoming FY students’ math confidence, belonging, and identity between demographic groups in EMath (e.g. URM, gender)?

3) Are there correlations among confidence and belonging feelings among FY EMath students? Do correlations differ across demographic groups?

4) Do math confidence, belonging, and/or identity change between the beginning and end of the semester among students enrolled in the EMath course? Does this differ among demographic groups?

5) How do the changes in belonging and identity among EMath students compare to students at LPI not enrolled in the engineering math course?

This research is situated within a larger study of EMath that is tracking student retention and grades; those elements are beyond the scope of this paper.

Methods

Case Study Context

This research is situated within a case study at a single institution. A case study approach was deemed appropriate given the importance of institution found in previous research. LPI is
classified as a doctoral university with very high research activity, with arts & sciences plus professions undergraduate degree majors and high graduate coexistence [34]. The undergraduate profile is full-time, more selective, and lower transfer-in. The demographics of the enrolled students at the campus overall (2018) were: 44.3% female and 55.7% male; 65.9% White, 11.4% Hispanic/Latinx, 9.0% International, 7.8% Asian, 2.5% African-American, 1.6% American Indian / Alaska Native, 0.6% Native Hawaiian / Pacific Islander, and 1.2% unknown; 16.9% first generation; about 16% of the undergraduate students were awarded Pell grants.

The study includes three cohorts of students enrolled in a pilot engineering math course in fall 2017, 2018, and 2019. These students encompass all of the different engineering majors at the institution and were simultaneously enrolled in another math course (typically pre-calculus or the Calculus I with Algebra Part A course). Thus, the students were taking 8 credits total of math in their first semester. In each year of the pilot, student enrollment was handled differently, as summarized in Table 1 (2017 and 2018 are described in more detail in [30, 34-36]). Note that some students withdrew from the course. This could be due to a multitude of factors, including it being unclear if/how the course ‘counted’ to graduation and preferring to avoid having two rigorous math courses in the first semester of college, which was likely particularly daunting for this cohort of students who were weaker in math.

Table 1. Engineering Math Pilot Enrollment

<table>
<thead>
<tr>
<th>Year</th>
<th>Enrollment Characteristics</th>
<th>Enrolled n</th>
<th>Completed n</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>Targeted to placement in pre-calculus and priority to under-represented students</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>2018</td>
<td>All students who did not place into standard Calculus I, accommodating scheduling challenges and left to individual advisor discretion to allow withdrawing</td>
<td>120</td>
<td>99</td>
</tr>
<tr>
<td>2019</td>
<td>All students who did not place into standard Calculus I, requiring an official petition with student explanation and approval from course instructors prior to withdrawing</td>
<td>120</td>
<td>101</td>
</tr>
</tbody>
</table>

Engineering at LPI is designed for students to start their first semester in a 1-semester Calculus I course in order to complete a B.S. degree within 4 years. Math for all engineering majors requires three semesters of calculus plus differential equations with linear algebra. These math courses serve as pre-requisites for many other courses in the curriculum. Students are not automatically eligible to enroll in Calculus I. Historical data indicated a high rate of students failing Calculus I, earning a grade too low to proceed to Calculus II and/or withdrawing from the course due to risk of failure (so-called DFW). Therefore, the institution instituted a process to place students into a math course at the appropriate level. Just prior to the pilot study period, LPI switched from the ALEKS math placement test to a holistic placement process that included an in-house math placement exam, ACT/SAT scores in math, and the students’ overall high school GPA. The math placement test included questions on algebra, analytic geometry, trigonometry, exponentials, and logarithms. Frequently, engineering students failed to place into Calculus I despite passing a calculus course in high school. Students and parents are often frustrated with the math placement process, which often has both time-to-degree and cost implications.

The implementation of the Engineering Math course varied somewhat across the three years of the pilot in 2017-2019. In year 1, students in the single section shared lecture, lab, and recitation.
These elements and office hours were all held in a single, dedicated active learning laboratory space. In addition, a number of these students had participated in a summer bridge program together prior to the beginning of the semester. In years 2 and 3, the course included two lecture sections (52-56 students each), 5 recitations (14-30 students each), and 4 labs (22-31 students each). The same female instructor taught the course in 2017, 2018, and 2019. In 2019 a male instructor joined the team. In 2019 there was additional emphasis placed on integrating real world engineering examples into the course. More details are provided in [30, 35-37].

A strong focus of the course in all years was to avoid deficit thinking and messaging [36-39]. This began with the first emails to students over the summer when they were enrolled, describing the course as an “authentic immersion” into engineering where they would be using real engineering tools in real engineering contexts to solve real engineering problems. It also helped to sell the class as a unicorn – there are no other courses like it in the entire college that combine mathematics with engineering problem-solving in a hands-on lab based format where students also learn programming/MATLAB. This messaging intends to convince students that it is not a remedial class, rather a challenging class that illustrates why math is needed in engineering and will help give them an advantage in future courses. As the instructors were teaching the course they never referred to it as a remedial course, or that the students were “behind” in any way on the math pathway. Instead, the course focused on growth, building skills and experience. On day 1, instructors used the metaphor of a slope-intercept straight line, as introduced by Dr. Karl Reid of the National Society for Black Engineers (NSBE). Some students are obsessed with where they are entering college (the y-intercept), representing their prior math preparation or experience. But the instructors reiterate to students in EMath that it’s not where you start that counts, but how you grow from any starting point (the slope), showing examples to demonstrate that growth is ultimately what matters (dove tailing with the math topic of linear equations on the first day of class).

The study was conducted in accordance with an approved human subjects research protocol approved by the Institutional Review Board at LPI.

Survey
A survey was designed to measure students’ feelings of belonging, engineering identity, and self perceptions of math skills competence, as summarized in Table 2. These survey items had a 7-point response scale, with the exception of the math confidence (or self-efficacy) items that had a 5-point scale. The survey also included additional items, but these are beyond the scope of the research questions explored in this paper. The pre and post surveys in 2017 and 2018 included a fairly large number of items (73), with additional questions added to the post survey in fall 2018. Concerns with the length of the survey and quality of student responses led to an effort to optimize the survey. Using the data from the pre and post survey responses from 2017 and 2018 (n=230), the four survey items that yielded the highest Cronbach’s alpha for internal consistency for each scale (as calculated in SPSS) were used on the 2019 survey.
Table 2. Survey Instrument

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Definition</th>
<th>Reference(s)</th>
<th># items 2017+ 2018: alpha</th>
<th># items 2019 survey, alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Belonging</td>
<td>Feeling comfortable, supported, and accepted in the course / classroom</td>
<td>40</td>
<td>4; .993</td>
<td>4; .993</td>
</tr>
<tr>
<td>College Belonging</td>
<td>Belonging at the campus, engineering college and university; feeling togetherness, community, friendliness</td>
<td>41, 42</td>
<td>6; .760</td>
<td>4; .830</td>
</tr>
<tr>
<td>Centrality</td>
<td>Identity sub-scale: extent student defines self as an engineer</td>
<td>14</td>
<td>8; .634</td>
<td>4; .725</td>
</tr>
<tr>
<td>Private regard</td>
<td>Identity sub-scale: extent of positive or negative feelings about engineers and engineering</td>
<td>14</td>
<td>6; .803</td>
<td>4; .845</td>
</tr>
<tr>
<td>Group identification</td>
<td>Identity sub-scale: personal value on being an engineer</td>
<td>14</td>
<td>9; .679</td>
<td>4; .848</td>
</tr>
<tr>
<td>Math confidence</td>
<td>Confidence to successfully solve particular math problem if exposed to the course material</td>
<td>31</td>
<td>18^</td>
<td>12</td>
</tr>
</tbody>
</table>

^18 items on both pre and post, but only 12 items were the same; only the same items compared for pre/post across all years of the study

The survey was administered via Qualtrics, with students given time during class to complete it. The research study overall and survey were described during class by a member of the research team who was not one of the course instructors. The first survey question asked students whether or not they consented to have their responses included in the research. Students were encouraged to take the survey for the purposes of course evaluation, whether or not they agreed to participate in the research. The number of survey responses are summarized in Table 3, and represent an overall research participation rate of 74% on the pre survey and 54% on the post survey. The pre survey was administered in the first week of the semester and the post survey in the final week. Table 3 also shows that a number of students dropped the course. We believe this was due to a variety of reasons; some students felt like they were being “forced” into a remedial class that they didn’t sign up for and others felt it was too much math in their first semester (given their co-enrollment in a second math course).

Table 3. Number of students in course and represented by survey responses

<table>
<thead>
<tr>
<th>Student Characteristics</th>
<th>Year:</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrolled at end of week 1</td>
<td></td>
<td>28</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Completed &gt;50% of pre survey and consented to research</td>
<td></td>
<td>18</td>
<td>89</td>
<td>83</td>
</tr>
<tr>
<td>Completed &gt;50% pre survey and did not consent to research</td>
<td></td>
<td>5</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td>Enrolled at end of semester</td>
<td></td>
<td>22</td>
<td>99</td>
<td>101</td>
</tr>
<tr>
<td>Completed &gt;50% post survey and consented to research^</td>
<td></td>
<td>16</td>
<td>62</td>
<td>55</td>
</tr>
<tr>
<td>Completed &gt;50% post survey and did not consent to research</td>
<td></td>
<td>1</td>
<td>28</td>
<td>21</td>
</tr>
</tbody>
</table>

^ Due to a problem with survey administration, demographics unknown for 15 responses (which also could not be paired to pre survey responses)

All of the survey responses were examined to understand the course and validate the survey itself, while the quantitative findings reported in this paper only represent students who consented to participate in the research. A limitation of the study is the observation that students who consented to participate in the research differed from those who did not (previously discussed in [36]). For example, on the 2019 pre survey there was significantly higher course
belonging, college belonging, centrality, private regard, and group identification among students who consented to participate in the research (n=83) compared to those who did not (n=33); math confidence was similar. In addition, students could skip items on the survey. Fewer students completed the math confidence items than other questions on the survey.

In an attempt to compare to a control group not enrolled in EMath, limited data were available from pre/post surveys administered in a first year engineering projects course. The four college belonging items were identical in both the EMath and Projects surveys. Only one of the four private regard items on the EMath survey was included on the Projects survey, and three of the four items for group identification from the EMath survey were included on the Projects survey. The end-of-semester projects course survey also included 4 items to measure course belonging. Comparator data from the projects course was obtained for fall 2018.

Survey Data Analysis
To measure students’ sense of belonging and engineering identity, the responses across the four items determined to have the highest reliability were averaged. Non-parametric statistical tests were conducted in SPSS. The majority of the statistical tests were conducted on the combined cohort of 2017-2019 students.

Institutional data were used to characterize student demographics, including gender, underrepresented race/ethnicity (URM included Hispanic/Latino, African American/Black, Native American, Pacific Islander), low income (LI, defined as students within 150% of Pell grant eligibility), and first generation in family to attend college (FG). There was a large co-occurrence of some demographic factors. For example, in the pre-course survey data among individuals who consented to participate in the research, among the 80 low income students 74% were also first-generation students and 71% were also URM.

Limitations
A first limitation is that students who consented to participate in the research may or may not be representative of students in the course overall. Another limitation is the over-simplification of URM students, combining students from different race/ethnicities into a single group. Another limitation are a range of potentially confounding influences in the dataset. For example, many of the EMath students were also enrolled in a team-based hands-on engineering projects course which may contribute to building students’ sense of belonging in engineering and at the institution. A number of the URM, low income, and/or first-generation students were also within a cohort experience (i.e. Goldshirt) that included a summer bridge program before the semester, as well as cohort activities during the semester. In 2017, 2018, and 2019 the percentages of the students enrolled in EMath who were also part of the Goldshirt program were 61%, 34%, and 33%, respectively. Students may also have also experienced supportive cohorts via their living environment or other activities.
Results and Discussion

RQ1. Demographics

The students enrolled in EMath represented all majors in the College of Engineering, with the majority undeclared “open” engineering students, followed by chemical/biological, aerospace, environmental, civil/architectural, mechanical, computer, and electrical. As shown in Table 4, the demographics of the students enrolled in EMath differed from the overall population of incoming first-year (FY) engineering students in a number of characteristics. Students who were in the minority among FY students overall were generally less underrepresented within the engineering math course (e.g. URM, FG, LI). This may be particularly important for the URM, FG, and LI students not in the Goldshirt program (2017-2019 Goldshirt program students 77% URM, 70% FG, 70% LI). Multiple identities should also be considered; for example, a female Hispanic who is low income and first generation would likely feel very different at the institution and within engineering as compared to a white female who is not URM, FG, or low income. These multiple identities were not specifically examined in this research, due to low numbers making it difficult to detect statistically significant differences. Such an exploration may be better suited to qualitative methods.

Table 4. Student demographics in EMath and the overall FY cohort in engineering

<table>
<thead>
<tr>
<th>Year</th>
<th>Female (F), % EMath² Overall¹</th>
<th>URM, % EMath² Overall¹</th>
<th>First-generation, % EMath² Overall¹</th>
<th>Low income, % EMath² Overall¹</th>
<th>International, % EMath² Overall¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>36</td>
<td>82*</td>
<td>59*</td>
<td>73*</td>
<td>5</td>
</tr>
<tr>
<td>2018</td>
<td>56*</td>
<td>38*</td>
<td>34*</td>
<td>33*</td>
<td>11*</td>
</tr>
<tr>
<td>2019</td>
<td>52</td>
<td>49*</td>
<td>43*</td>
<td>40*</td>
<td>15*</td>
</tr>
</tbody>
</table>

* statistically significant difference; chi square test p < .05
1 The overall characteristics are based on census data from the College, typically on or around Sept. 14.
2 Demographics for 2017 and 2018 represent the end of the semester; 2019 are at census date.

RQ2. Incoming Differences

The pre-survey results among students who consented to participate in the research are summarized in Table 5. Note that the demographics of the students who consented to participate in the research (54% female, 48% URM, 42% LI, 42% FG) were similar to the demographics in the course overall (52% female, 48% URM, 40% LI, 41% FG). Although the mean is shown, the course belonging and private regard scores were highly non-normal (skewness -.6 and -.2, respectively; kurtosis 4.4 and 1.6, respectively); group identification was also moderately skewed (skewness -0.77). Due to the non-normal nature of many of these aspects, non-parametric Mann-Whitney U Tests were conducted to compare binary demographic groups (e.g. female vs. male; URM vs. non-URM); statistically significant differences are indicated in the table. Females differed from males in both categories of belonging (lower) and the three identity elements (lower). URM students differed from non-URM peers in only course belonging (higher), centrality (higher), and group identification (higher). Low income students and first generation students had the same comparative differences to majority peers as were found for URM (higher course belonging, centrality, group identification), with the addition of higher private regard. Confidence in math skills did not differ among demographic groups. Two intersectional groups are also shown (URM females and URM plus low-income); statistical comparisons were not made for these small groups.
Table 5. Pre survey results: mean and standard deviation

<table>
<thead>
<tr>
<th>Students (n)</th>
<th>Course belonging</th>
<th>College belonging</th>
<th>Centrality to identity</th>
<th>Private regard</th>
<th>Group identification</th>
<th>Math confidence^</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (191)</td>
<td>5.7 ± 1.1</td>
<td>5.8 ± 1.1</td>
<td>5.1 ± 1.0</td>
<td>6.3 ± .7</td>
<td>5.3 ± 1.0</td>
<td>2.8 ± .9</td>
</tr>
<tr>
<td>Male (87)</td>
<td>5.9 ± 1.1</td>
<td>6.0 ± 1.1</td>
<td>5.4 ± 1.0</td>
<td>6.4 ± .6</td>
<td>5.6 ± .9</td>
<td>2.8 ± .9</td>
</tr>
<tr>
<td>Female (104)</td>
<td>5.6 ± 1.0^</td>
<td>5.7 ± .7^</td>
<td>5.0 ± .9^</td>
<td>6.2 ± .7^</td>
<td>5.1 ± 1.1^</td>
<td>2.8 ± .9</td>
</tr>
<tr>
<td>Female + URM (37)</td>
<td>5.7 ± .9</td>
<td>5.5 ± .8</td>
<td>5.1 ± 1.0</td>
<td>6.1 ± .7</td>
<td>5.2 ± 1.1</td>
<td>2.8 ± .9</td>
</tr>
<tr>
<td>URM (91)</td>
<td>5.9 ± .9^</td>
<td>5.9 ± .8</td>
<td>5.3 ± 1.0^</td>
<td>6.3 ± .7</td>
<td>5.5 ± 1.1^</td>
<td>2.7 ± .9</td>
</tr>
<tr>
<td>Not URM (100)</td>
<td>5.6 ± 1.1</td>
<td>5.8 ± .8</td>
<td>5.0 ± .9</td>
<td>6.2 ± .7</td>
<td>5.2 ± 1.9</td>
<td>2.9 ± .9</td>
</tr>
<tr>
<td>URM + Low Income (57)</td>
<td>6.0 ± .9</td>
<td>5.8 ± .8</td>
<td>5.5 ± 1.0</td>
<td>6.4 ± .7</td>
<td>5.6 ± 1.0</td>
<td>2.8 ± .9</td>
</tr>
<tr>
<td>Low Income (80)</td>
<td>5.9 ± .9^</td>
<td>5.9 ± .8</td>
<td>5.4 ± .9^</td>
<td>6.4 ± .7^</td>
<td>5.6 ± 1.0^</td>
<td>2.8 ± .8</td>
</tr>
<tr>
<td>Not Low Income (109)</td>
<td>5.6 ± 1.2</td>
<td>5.8 ± .8</td>
<td>5.0 ± .9</td>
<td>6.2 ± .6</td>
<td>5.2 ± 1.0</td>
<td>2.9 ± .9</td>
</tr>
<tr>
<td>First Generation (80)</td>
<td>6.0±1.0^</td>
<td>5.9 ± .8</td>
<td>5.4 ± .9^</td>
<td>6.5 ± .6^</td>
<td>5.6 ± 1.9</td>
<td>2.7 ± .9^</td>
</tr>
<tr>
<td>Not First Generation (109)</td>
<td>5.6 ± 1.1</td>
<td>5.8 ± .8</td>
<td>4.9 ± .9</td>
<td>6.2 ± .7</td>
<td>5.2 ± 1.0</td>
<td>2.9 ± .9</td>
</tr>
</tbody>
</table>

^lower n for math confidence (all 172, male 78, female 94, URM 83, not URM 89, low income 74, FG 72)

Among the elements evaluated on the survey, the private regard scores were the highest, indicating that the majority of the students had strongly positive feelings about engineering and engineers. Private regard is one of the facets of engineering identity. This is logical given that these students are majoring in engineering. Only 4 students (2%) had private regard scores of 4 or lower (neutral). These results are similar to those among first-year students reported by Knight et al. [43] where private regard scores were higher than centrality and group identification. The results are also similar to first-year students at the University of Michigan, where perceptions of engineering (which included private regard survey items as well as public regard) were higher than belonging and community [44]. First generation and low-income students in EMath had particularly high private regard scores.

Students’ initial course belonging and college belonging scores were quite high on average (not statistically different from each other in paired tests); however, 3% and 7% of the students had average scores of 4 or lower indicating neutral to negative feelings. The timing of the survey at the very start of the semester is relevant to consider. For example, one student wrote, “I have no strong feelings towards engineering and [LPI] because I haven't been here long enough to have any.” Demographic differences were found in course belonging scores, which were highest among first generation and low-income students. College belonging scores did not differ among demographic groups, with the exception of being slightly lower among female students.

Group identification was generally positive, although 11% of the students had scores of 4 or lower. The lowest identity facet was centrality, and 17% of the students had average scores of 4 or lower. In a previous study where group identification and centrality items were combined into a single “engineering student identity” scale [44], incoming first-year students’ scores were similar to belonging, in contrast to the current study; the identity scores were lower than private regard, in agreement with the current study.

RQ3. Correlations

There were some statistically significant correlations found among the survey scales based on the
pre survey and post survey responses, summarized in Table 6.

Table 6. Statistically significant Spearman’s rho correlations among demographic groups

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Pre correlation to Math confidence</th>
<th>Pre correlation to College Belonging</th>
<th>Pre correlation to Course Belonging</th>
<th>Post correlation to Course Belonging</th>
</tr>
</thead>
<tbody>
<tr>
<td>College belonging</td>
<td>.278* FG</td>
<td>.280* FG</td>
<td>.480* All</td>
<td>.316* All</td>
</tr>
<tr>
<td></td>
<td>.548** URM</td>
<td>.548** URM</td>
<td>.492** Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.423** Female</td>
<td>.423** Female</td>
<td>.441* FG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.515** Male</td>
<td>.515** Male</td>
<td>.334* Low Income</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.690** FG</td>
<td>.690** FG</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.529** Low Income</td>
<td>.529** Low Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrality</td>
<td>.399** FG</td>
<td>.473** All</td>
<td>.368** All</td>
<td>.314* All</td>
</tr>
<tr>
<td></td>
<td>.503** URM</td>
<td>.503** URM</td>
<td>.439** URM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.372** F</td>
<td>.372** F</td>
<td>.307** Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.539** M</td>
<td>.539** M</td>
<td>.367** Male</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.620** FG</td>
<td>.620** FG</td>
<td>.427** FG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.463** Low Income</td>
<td>.463** Low Income</td>
<td>.372** Low Income</td>
<td></td>
</tr>
<tr>
<td>Private regard</td>
<td>.194* All</td>
<td>.484** All</td>
<td>.428* All</td>
<td>.387** All</td>
</tr>
<tr>
<td></td>
<td>.542** URM</td>
<td>.542** URM</td>
<td>.480** URM</td>
<td>.303** URM</td>
</tr>
<tr>
<td></td>
<td>.435** F</td>
<td>.435** F</td>
<td>.486** Female</td>
<td>.424** Female</td>
</tr>
<tr>
<td></td>
<td>.476** M</td>
<td>.476** M</td>
<td>.324** Male</td>
<td>.288* Male</td>
</tr>
<tr>
<td></td>
<td>.605** FG</td>
<td>.605** FG</td>
<td>.523** FG</td>
<td>.446* FG</td>
</tr>
<tr>
<td></td>
<td>.551** Low Income</td>
<td>.551** Low Income</td>
<td>.475** Low Income</td>
<td>.454* Low Income</td>
</tr>
<tr>
<td>Group identification</td>
<td>.197* All</td>
<td>.558** All</td>
<td>.470* All</td>
<td>.251* All</td>
</tr>
<tr>
<td></td>
<td>.671** URM</td>
<td>.671** URM</td>
<td>.559** URM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.398** F</td>
<td>.398** F</td>
<td>.469** Female</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.698** M</td>
<td>.698** M</td>
<td>.432** Male</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.670** FG</td>
<td>.670** FG</td>
<td>.530** FG</td>
<td>.360* FG</td>
</tr>
<tr>
<td></td>
<td>.589** Low Income</td>
<td>.589** Low Income</td>
<td>.512** Low Income</td>
<td>.316* Low Income</td>
</tr>
</tbody>
</table>

Significance (two-tailed)** < .001, * < .05.

On the pre survey, weak but statistically significant Spearman’s rho correlations (~.19) were found between EMath confidence and two identity elements (private regard and group identification) among all students. Moderate correlations were found between course belonging and college belonging and the three identity sub-elements. These correlations were somewhat weaker than correlations between college belonging and identity aspects. In Plett’s work [45] self identity items were weakly positively correlated with belonging in the major but not belonging at the University, the classroom, or university community.

Some differences in these correlations based on pre survey responses were found among students in different demographic groups. For example, female students’ math confidence correlated with private regard (.257), but this correlation was not statistically significant among male students (.118). In general, the strongest correlations on the pre survey between course belonging and identity aspects were found among URM and FG students.

On the post survey, math confidence was weakly correlated with private regard among all students and URM students (rho .248 at sig. .007 and rho .368 at sig. .010, respectively). Math confidence was also weakly correlated with course belonging among all students and female students (rho 0.185 at sig. .047 and rho 0.298 at sig. .021, respectively). Math confidence at the end of the semester did not correlate with belonging or engineering identity elements for male, low income, or first generation students (but note only 40-41 students in these groups). At the end of the semester, the correlations among course belonging with college belonging and identity scales were weaker than on the pre survey for all groups of students, with the exception of
female students. Note that there was less data contributing to correlations on the post survey (e.g. all students n=189 pre survey vs. n=133 post survey for course belonging vs. identity elements)

RQ4. Changes Across Semester

Across the semester, there were increases in the scores for course belonging and math confidence, based on the cohort of students that consented to participate in the research on both the pre and post surveys and where responses could be paired; neither identity or college belonging changed (Table 7). In previous studies, private regard, group identification, and centrality decreased slightly across the semester among first-year engineering students overall (~7 to 9%, 3 to 5%, and 2 to 3%, respectively) [43]. Thus, keeping these beliefs constant would represent an improvement.

Table 7. Comparison of paired data from EMath students, 2017-2019

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Pre Paired Avg</th>
<th>Post Paired Avg</th>
<th>% students increased</th>
<th>% students decreased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Belonging (n=102)</td>
<td>5.8</td>
<td>6.2**</td>
<td>60</td>
<td>19</td>
</tr>
<tr>
<td>College Belonging (n=100)</td>
<td>5.8</td>
<td>5.8</td>
<td>35</td>
<td>42</td>
</tr>
<tr>
<td>Centrality (n=99)</td>
<td>5.1</td>
<td>5.1</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Private regard (n=99)</td>
<td>6.3</td>
<td>6.2</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>Group identification (n=99)</td>
<td>5.4</td>
<td>5.4</td>
<td>44</td>
<td>43</td>
</tr>
<tr>
<td>Math confidence (n=77)</td>
<td>2.8</td>
<td>3.6**</td>
<td>79</td>
<td>17</td>
</tr>
</tbody>
</table>

paired, 2-tailed t-test: ** p < .001

The differences in these changes among demographic groups were not statistically significant, perhaps in some cases due to limitations of statistical inference with a low number of data points. However, some potential differences are evident. For example, female students’ change in group identification averaged -0.11 compared to +0.12 among male students. For private regard, URM students increased an average of 0.01 compared to -0.10 change among non-URM students; URM students also had larger average increases in math confidence (0.89 vs. 0.66).

It is also worth noting cohort differences between 2017 and 2018/2019. The most striking difference was in the course belonging score on the survey at the end of the semester: 2017 average 6.9 (among n=16; small n but nearly 100% rated at highest level of 7) versus 2018 average 5.9 (n=64) and 2019 average 6.1 (n=57). The smaller class with shared lecture, recitations, and labs and a high concentration of diverse students appeared to foster community significantly more than the larger 2018 and 2019 courses. But this group also had a much higher percentage in the Goldshirt cohort which had participated in a summer bridge program together prior to the semester. In addition, the larger non-respondent rate in 2017 may be a confounding factor; students who felt a stronger connection to the course perhaps opted to take the survey and consented to having their responses included in the research study.

RQ5. Comparison to Students Not Enrolled in EMath

A first-year engineering projects course is taken by a number of students in the first semester. In 2018 there were 279 students who took both the pre and post survey in the course, including 41 students also enrolled in EMath. There were not statistically significant differences in changes across the semester for students who were enrolled in EMath or not (Table 8). However, it is interesting that students in both EMath and projects on average increased slightly in group
identification compared to basically no change among students only taking the projects course. More significant differences begin to emerge when exploring specific demographic groups. For example, URM students taking both EMaMath and the projects course increased their group identification an average of 0.39 Likert points compared to a decrease of 0.22 Likert points on average among students enrolled in the projects course but not EMaMath.

Table 8. Changes across semester among students taking the engineering projects course

<table>
<thead>
<tr>
<th>Student Group</th>
<th>Element</th>
<th>College Belonging</th>
<th>Private Regard</th>
<th>Group Identification</th>
<th>Course Belonging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects 2018 and not EMaMath (n=238)</td>
<td>Avg change</td>
<td>-0.04</td>
<td>-0.14</td>
<td>-0.02</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>% increase</td>
<td>38</td>
<td>20</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% decrease</td>
<td>45</td>
<td>26</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Projects 2018 with EMaMath (n=41)</td>
<td>Avg change</td>
<td>-0.12</td>
<td>-0.12</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% increase</td>
<td>34</td>
<td>15</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% decrease</td>
<td>49</td>
<td>22</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>

Not significant difference in change for EMaMath vs. non-EMaMath

Looking only at the post data from the Projects course (Table 9), students enrolled in both EMaMath and the projects course had lower scores for team belonging and higher scores for private regard (one item) and group identification (identity), compared to students in the projects course who were not also taking EMaMath.

Table 9. Results from end-of-semester survey in engineering projects course, fall 2018

<table>
<thead>
<tr>
<th>Students</th>
<th>College Belonging</th>
<th>Private Regard</th>
<th>Group Identification</th>
<th>Team Belonging</th>
<th>Course Belonging</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMaMath (n=44)</td>
<td>5.7 ± .8</td>
<td>6.6 ± .6*</td>
<td>5.9 ± .9*</td>
<td>5.5 ± 1.6</td>
<td>5.9</td>
</tr>
<tr>
<td>Not EMaMath (n=259)</td>
<td>5.6 ± .9</td>
<td>6.2 ± 1.0</td>
<td>5.3 ± 1.1</td>
<td>6.0 ± 1.1*</td>
<td></td>
</tr>
<tr>
<td>Female EMaMath (n=26)</td>
<td>5.6 ± .8</td>
<td>6.4 ± .7</td>
<td>5.6 ± .9*</td>
<td>5.3 ± 1.6*</td>
<td>5.9</td>
</tr>
<tr>
<td>Female Not EMaMath (n=112)</td>
<td>5.6 ± .9</td>
<td>6.2 ± .9</td>
<td>5.2 ± 1.2</td>
<td>5.9 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>URM EMaMath (n=26)</td>
<td>5.8 ± .8*</td>
<td>6.6 ± .5*</td>
<td>6.0 ± .9*</td>
<td>5.5 ± 1.9</td>
<td>5.9</td>
</tr>
<tr>
<td>URM not EMaMath (n=38)</td>
<td>5.4 ± .8</td>
<td>6.0 ± .9</td>
<td>5.2 ± .9</td>
<td>6.0 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>FG EMaMath (n=23)</td>
<td>5.6 ± .8</td>
<td>6.6 ± .5</td>
<td>5.9 ± .9*</td>
<td>5.4 ± 1.7</td>
<td>6.0</td>
</tr>
<tr>
<td>FG not EMaMath (n=35)</td>
<td>5.9 ± .9</td>
<td>6.3 ± .8</td>
<td>5.4 ± 1.3</td>
<td>6.1 ± .9</td>
<td></td>
</tr>
<tr>
<td>LowIncome EMaMath (n=26)</td>
<td>5.6 ± .8</td>
<td>6.6 ± .5*</td>
<td>5.8 ± .9</td>
<td>5.6 ± 1.5</td>
<td>5.9</td>
</tr>
<tr>
<td>LowIncome not EMaMath (n=40)</td>
<td>5.8 ± .8</td>
<td>6.3 ± .8</td>
<td>5.4 ± 1.2</td>
<td>6.0 ± 1.1</td>
<td></td>
</tr>
<tr>
<td>Goldshirt program EMaMath (n=33)</td>
<td>5.7 ± .8</td>
<td>6.6 ± .5</td>
<td>6.0 ± .9</td>
<td>5.6 ± 1.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Goldshirt program not EMaMath (n=8)</td>
<td>5.9 ± .5</td>
<td>6.4 ± .5</td>
<td>5.6 ± 1.0</td>
<td>6.0 ± .8</td>
<td></td>
</tr>
</tbody>
</table>

^ Post data 2018 EMaMath consent only, n=64 total; smaller numbers of demographic sub-groups; ° p < .05, * p < .10

Interestingly, among EMaMath students the feelings of belonging with their project team was much lower than their course belonging in EMaMath. Note that these four items were identical between the two surveys with the only difference being the term “my project team” in the projects survey versus “this classroom” (2017) or “this Engineering Math class” (2018, 2019) in the EMaMath survey. In addition, there was little variation among the average course belonging scores among different demographic groups in the EMaMath course, compared to more variable team belonging among demographic groups in the projects course. This might be due, in part, to the richer diversity in EMaMath.
Extended Discussion

Ultimately, the quantitative data did not provide solid insights in regards to feelings of belonging and engineering identity among the cohort of engineering math students. This was partially due to the lack of appropriate controls – students with similar demographics but not enrolled in EMath. Students’ self selection into the research study also may have biased the results; some students may have opted out of research participation because it made them feel more singled out (despite messages from the research team that we were studying the course, not the students as individuals). In the future incentives might be used as a method to increase the research participation among students in the course.

In courses without much personal interaction, students’ feelings of “fit” (or lack of fit) are perhaps largely due to visible diversity, such as gender and race [46-48]. But when students work together closely in teams or other settings, other types of diversity (e.g. income) may become evident. For example, all of the hands-on laboratory exercises in EMath are performed in pairs of students: self-selected for the first 5 weeks, then instructor and Teaching Assistant assigned for the next 5 weeks and again for the final 5 weeks of the semester. Similarities or differences with regards to technology ownership (laptops, tablets, phones) are immediately apparent among lab partners and may signal socioeconomic status or other types of non-visible diversity.

Moving forward, changes to the course are planned. A new course title (“Engineering Investigation and Analysis”) will further the efforts to avoid framing the course as remedial math. Based on student feedback, the content in the course is being refocused to better integrate the math lessons with MATLAB and with the tools used in the laboratories. The weekly structure of the course will consist of one lecture and two laboratory sections. The lecture will be one hour, and the laboratory sections will each be 2 hours long. The more frequent laboratory sections will focus on the material from lecture and take place in the active laboratory room. By moving a greater percentage of the class from a lecture hall to the dedicated laboratory space, more in-depth student to teaching staff interaction can occur. The course will be reduced to 3-credits from 4-credits, resulting in better alignment with other technical electives (since the institution is not interested in changing its entire math curriculum similar to Wright State). We plan to reduce the fall enrollment cap of the course from 120 to 64 students and make the course an opportunity rather than mandatory. A section will also be offered in spring semester, capitalizing on the positive reputation of the course, which may attract students. Future changes could also include offering the course in the summer, allowing students to perhaps start Calculus I in fall semester with the majority of the engineering student cohort.

Longitudinal interviews are planned with former EMath students; but that work is beyond the scope of the current study. The qualitative interviews will probe elements of engineering identity (e.g. focus on helping others versus using math and science to solve problems), as well as retrospective analysis of impacts on their math confidence and engineering interest.

The institution is tracking student retention, although it is too early to examine 6-year graduation rates. Thus far, the percentage of EMath students enrolled in engineering and at the institution in the second fall is comparable to engineering students overall (Table 10), which is a success given the lower incoming math proficiency and unique student demographics. In addition, based on
224 EMath students who could be matched to a comparable group of students who did not complete EMath, there was a 3.1% lift in fall to spring persistence at the institution (+/-2.7%, p-value 0.02 based on an impact analysis using prediction-based propensity score matching; data not shown). The persistence increase for female students was slightly higher at 3.76% lift (+/-3.6%).

<table>
<thead>
<tr>
<th>Cohort</th>
<th>At LP Institution</th>
<th>In Engineering at LP Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EMath</td>
<td>All Eng students</td>
</tr>
<tr>
<td>2017</td>
<td>86</td>
<td>92</td>
</tr>
<tr>
<td>2018</td>
<td>94</td>
<td>91</td>
</tr>
</tbody>
</table>

### Conclusions and Implications

Identity theory indicates that students who struggle in math in college may receive a double hit to their engineering identity if they struggle in both EMath and their concurrent pre-calculus or yearlong calculus course (8 credits among a typical first semester load of 14 to 17 credits). These same students may have performed well in math during high school, and as a result may feel cognitive dissonance around their college-level math experience. For students who often choose to major in engineering because they were good at math and science in high school [49,50], this represents a challenge that may diminish the extent to which they personally identify as an engineering student, ultimately reducing their retention in engineering majors in college.

In this case study of an EMath course at a large public institution, the percentage of URM, first-generation, and low-income students enrolled in the course was significantly higher than their representation among incoming first-year engineering students. At the beginning of the semester in EMath, first-generation and low income students had higher course belonging and engineering identity than non-FG and non-LI students, respectively. At the beginning of the semester, course belonging correlated with college belonging and engineering identity, with some variation in correlation factors among demographic groups. At the end of the semester, course belonging and math confidence had increased, while engineering identity did not change. Among a cohort of students enrolled in a first-year projects course, at the end of the semester students also enrolled in EMath had higher engineering identity and college belonging compared to students not taking EMath.

Overall, there appeared to be benefits of the cohort environment within the EMath course with respect to feelings of belonging and engineering identity for incoming first-year students underrepresented in engineering at the institution. This may be particularly important among this group that may feel somewhat as outsiders in engineering, reinforced by being labeled as non-calculus ready. However, EMath is only one option to bring together a critical mass of diverse students that fosters a sense of belonging and community. For example, focused enrollment into sections of the first-year projects course or offering the EMath course in the summer prior to first semester provide alternatives.

The complexity of multiple identities and various communities within the college environment complicated the ability of quantitative methods to identify statistically significant effects among
these relatively small numbers of students. This points to focusing on qualitative research methods in future work.

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References


