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# Longitudinal Study of a First Year Curriculum Change on Student Identity and Belonging - Year 2

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# Longitudinal Study of a First Year Curriculum Change on Student Identity and Belonging

**Abstract**

The purpose of this evidence-based practice paper is to explore and document trends in students' engineering/computing science identity and sense of belonging in their discipline based on their experiences in a recently reimagined first year curriculum over the first full year of implementation.

Developing an identity and sense of belonging in engineering and computing science early in the collegiate years has had positive impacts on student retention and success. This is especially important for students coming from minoritized communities including women, people of color, and first generation students. Previous research suggests that exposing students early on to project-based learning can help build student identity as it exposes and inspires them to what can be accomplished in their major. Additionally, research shows that students who develop camaraderie within course-based teams can help build students' sense of belonging. The overall goal of this project is to reimagine the first year curriculum in the college of engineering and computing at an undergraduate-focused national public university in the Midwest in order to better engage first-year students in engineering and computing science. The courses were modified from courses that centered on introducing students to the university and their respective departments to college-level courses that focused on project-based learning leveraging multidisciplinary teams. The goal of this paper is to determine the impact of the course experiences on students' engineering/computing science identity and sense of belonging across multiple cohorts of data and to explore improvements in the impacts as the teaching team improves the course structure and delivery.

The two-semester course sequence was first developed as a pilot for the 2022 - 2023 academic year with approximately 20 - 25% of the student body randomly assigned to the new sequence. A previous paper explored the impact of the new sequence compared to the old sequence of courses and found a small increase in student sense of belonging and interest. Since the pilot year, all new students enrolled in the college are required to take the new course sequence. Two survey instruments, one for identity and one for belongingness, were used to document the impact of the course. Surveys were distributed to students at the start of the fall semester as well the end of the spring semester. Results of the survey responses for the previous academic year (AY 2023 - 2024) will be explored and discussed in the paper.

## Motivation and Background

There have been many national calls to improve recruitment and retention of more students in STEM fields to help support future workforce demands and to help support the United States in

remaining a strong economic and global competitor [1-3]. However, through analysis of national data sets, approximately only half of the students who enter a STEM major will graduate with a STEM degree [4].

Recent research examining the reasons why students leave STEM disciplines show that they typically leave for non-technical reasons including poor teaching, curriculum overload, limited advising and support, or a rejection of the competitive culture in many STEM disciplines [7-10]. In more recent years, studies have continued to document the same factors influencing attrition in STEM degrees as well as student's lack of self-efficacy, failure of the material to capture student interest, overly competitive grade structures, or issues with faculty and staff approaches to teaching and advising [10]. Although these issues can have an impact on any student, much of the literature indicates that women, minoritized individuals, and students from disadvantaged backgrounds are more likely to be impacted by the poor culture and environment described above and more likely to leave STEM disciplines without a degree.

Two factors that have been shown to be positive predictors of student success and retention in engineering are identity and belongingness [11-15]. Godwin defines engineering identity as "how [students] describe how they see themselves as the type of people that can do engineering as well as feel like engineering is 'for them'" [16] and developed a measure of engineering identity with three main factors: Recognition (feeling like others see them as an engineer), Interest (desire to think about engineering and its contexts), and Performance/Competence (belief in their ability to perform engineering tasks). Engineering identity has been shown to have an impact on persistence in engineering as well as be a significant predictor of retention in engineering programs [11, 17, 18].

Belongingness has been defined as "the degree to which an individual feels respected, valued, accepted, and needed by a defined group" [19]. Studies show that belongingness can be a predictor of student success as well as being positively associated with increased mental health, motivation, and self-efficacy. Additionally, belongingness can be fostered by instructors through intentional experiences of collaboration and engagement in the classroom. For example, one study suggests that camaraderie within a team in a course can promote a sense of belonging within engineering [15].

This paper sits within the context of a much larger project that is exploring the impact of a significant first-year engineering curriculum change on student success and retention within the college of engineering. The goal of this paper is to document the changes in identity and belonging over the course of a student's first year of college within the engineering program.

## Overall Project

The first-year engineering program at this institution has been reimagined to create a cohesive first-year experience for all students in the college of engineering and computing. The goals of this redesign have been multifaceted: (1) build a unifying experience for all engineering and computing students, (2) expose students to applications of engineering across the disciplines offered by the college, (3) develop teamwork and personal accountability skills, and (4) provide an opportunity for students to meet and socialize with others within the college.

The overall goal of this project is to document the effects this curriculum shift has on student success within the college. This includes their attitude about themselves (measured through identity) and their attitude about the college (measured through belonging).

### *Traditional Course Sequence*

The previous course sequence consisted of a 1-credit hour course in the fall focused on introducing students to university-wide support systems. Minimal engineering content was discussed except the course did introduce engineering ethics and require students to attend engineering-related content on occasion. In the spring, students took a 3-credit introduction to their engineering major course that was controlled by each department in the college. This course would introduce software, tools, or fundamental principles valuable to the majors in the department. All departmental introduction courses "counted" for each other so students who changed their majors were not delayed in their progress towards the degree, however, students who did switch majors often felt left behind because they did not develop the same fundamental knowledge.

### *New Course Sequence*

The new course sequence consists of two 2-credit hour courses (one in fall and one in spring) that focus on multidisciplinary, team-based, project-based learning. The fall class still integrates introducing students to university-wide support systems as in the previous course but also includes a collection of short (2 - 3 week long) discipline-specific projects. In the spring class, students develop quantitative analysis and programming skills as well as explore the multidisciplinary nature of engineering and computer science through a single semester-long project of building and refining a small wind turbine.

### *Comparing Course Sequences*

In the academic year of 2022 - 2023, a pilot of the new course sequence was implemented while the old course sequence was still being offered. Approximately 20 - 25% of the student body was randomly assigned to the new course sequence based on the student's orientation session. From that year, there was a statistically significant difference in belongingness amongst the pilot group as compared to the traditional group [20]. Additionally, although there was no statistically

significant increase in belonging for the pilot group, there was a statistically significant decrease in belonging for the traditional group [20]. For measures of engineering identity (Recognition, Performance/Competence, and Interest), there were no statistically significant changes on each dimension for the pilot group, but with small positive trends [20]. However, there was a statistically significant decrease in interest for the traditional group [20]. Please see the previous publication for a more in-depth discussion between the previous and new curriculum [20].

## Methods

Surveys were distributed to students at the start of the fall semester and end of the spring semester. Completion of the survey was required for a grade in the class with each survey assignment accounting for 0.8% of the total grade; however, students were required to consent to participating in the research study for every response to be included in this analysis. For example, if a student completed both fall and spring surveys and consented to participate in the study in the fall but did not consent to participate in the study in the spring, both fall and spring responses were removed from the analysis. The survey included identity [16] and belonging [21] items and also asked students to identify their race/ethnicity and gender (pertinent items are provided in the Appendix). Prior to analysis, responses were de-identified and incomplete responses were removed from the data set. Additionally, each respondent was provided a pseudo-ID to allow for pairwise comparisons across time points in future analysis. This study was reviewed and approved by the institutional IRB prior to data collection or analysis.

Type 3 two-way ANOVAs were used to identify any statistically significant differences between time points while controlling for either race or gender. Type 3 ANOVAs were used to control for group size. Pairwise t-tests were then used to determine statistically significant changes between groups. All analyses were performed in R version 4.4.1 [22].

## Results

Data was first analyzed as an aggregate to consider how the group as a whole and is summarized in Table 1. Two-way unbalanced ANOVAs were used to identify statistically significant differences between time points (stage) and no statistically significant differences were found although there was a slight difference ($F = 2.8196$, $p = 0.0605$) in belonging.

**Table 1**: Summary of Recognition, Interest, Performance/Competence, and Belongingness.

| Measure | August 2023 | | | December 2023 | | | May 2024 | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| Recognition | 221 | 3.87 | 0.800 | 153 | 3.89 | 0.834 | 180 | 3.94 | 0.869 |
| Interest | 221 | 4.43 | 0.672 | 153 | 4.32 | 0.803 | 180 | 4.30 | 0.869 |
| Performance/ Competence | 221 | 3.96 | 0.652 | 153 | 3.97 | 0.719 | 180 | 3.90 | 0.770 |
| Belonging | 221 | 4.24 | 0.677 | 153 | 4.20 | 0.749 | 180 | 4.07 | 0.828 |

*Race and Gender Aggregation*

Due to limited numbers, all participants who identified as trans man, trans woman, gender queer/gender non-conforming, identity not listed above, and prefer not to say were encapsulated into an “Other” category. Similarly, participants who identified as African American/Black, American Indian/Alaska Native, East Asian, Native Hawaiian/Pacific Islander, South Asian, South American, Central American, Other Asian, Other African, Other Latino, or Other were encapsulated into a “Person of Color” category. Students who identified with two or more races/ethnicities were encapsulated into a “Two or More Races” category. Although the authors recognize that the sweeping categories of “Other” gender, “Person of Color”, and “Two or More Races” dilute the unique and specific experiences for students with the identities listed above, there is not enough data to provide meaningful statistical analysis for these identities and acknowledge the limitations of the analysis below.

*Gender*

Measures of Recognition, Interest, Performance/Competence, and Belongingness are summarized in Table 2, Table 3, Table 4, and Table 5, respectively for both time point and gender. Two-way unbalanced ANOVAs were used to identify statistically significant differences between time points, gender, and their interaction for each individual factor. Tukey HSD pairwise tests were then used to identify statistically significant differences amongst groups. There were no statistical differences in recognition for semester, gender, or their interaction. For all other measures (Interest, Performance/Competence, and Belonging) the only statistically significant difference was between men and women at the December 2023 time point. Additionally, there was a near statistically significant difference between semesters for belonging ($F = 2.946$, $p = 0.0534$)

**Table 2:** Summary of Recognition broken down by gender categories. $^{+}$ indicates statistically significant difference with men within the same time point

| Gender | Recognition (Aug '23) | | | Recognition (Dec '23) | | | Recognition (May '24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| Man | 152 | 3.90 | 0.761 | 107 | 3.96 | 0.777 | 124 | 3.91 | 0.817 |
| Woman | 59 | 3.84 | 0.883 | 43 | $3.75^{+}$ | 0.971 | 52 | 4.01 | 0.989 |
| Other | 10 | 3.63 | 0.909 | 3 | 3.44 | 0.385 | 4 | 3.83 | 1.000 |

**Table 3:** Summary of Interest broken down by gender categories. $^{+}$ indicates statistically significant difference with men within the same time point

| Gender | Interest (Aug '23) | | | Interest (Dec '23) | | | Interest (May '24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| Man | 152 | 4.50 | 0.548 | 107 | 4.47 | 0.668 | 124 | 4.29 | 0.858 |
| Woman | 59 | 4.30 | 0.905 | 43 | $3.96^{+}$ | 0.987 | 52 | 4.32 | 0.907 |
| Other | 10 | 4.07 | 0.625 | 3 | 3.56 | 0.694 | 4 | 4.17 | 0.882 |

**Table 4:** Summary of Performance/Competence broken down by gender categories. $^{+}$ indicates statistically significant difference with men within the same time point

| Gender | Performance (Aug '23) | | | Performance (Dec '23) | | | Performance (May '24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| Man | 152 | 4.03 | 0.606 | 107 | 4.11 | 0.576 | 124 | 3.93 | 0.758 |
| Woman | 59 | 3.78 | 0.734 | 43 | $3.65^{+}$ | 0.886 | 52 | 3.81 | 0.794 |
| Other | 10 | 4.00 | 0.673 | 3 | 3.60 | 1.31 | 4 | 4.25 | 0.870 |

**Table 5:** Summary of Belongingness broken down by gender categories. No statistical difference

| Gender | Belonging (Aug ‘23) | | | Belonging (Dec ‘23) | | | Belonging (May ‘24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| Man | 152 | 4.34 | 0.592 | 107 | 4.38 | 0.640 | 124 | 4.09 | 0.776 |
| Woman | 59 | 4.03 | 0.812 | 43 | 3.81 | 0.852 | 52 | 4.00 | 0.952 |
| Other | 10 | 4.00 | 0.737 | 3 | 3.44 | 0.096 | 4 | 4.04 | 0.843 |

*Race*

Measures of Recognition, Interest, Performance/Competence, and Belongingness are summarized in Table 6 through Table 9 for both time point and race. Two-way unbalanced ANOVAs were used to identify statistically significant differences between stage, race, and their interaction for each individual factor. There were no statistical differences for any measure for semester, race, or their interaction, although belonging was almost statistically significant for semester ($F = 2.784$, $p = 0.0627$).

**Table 6:** Summary of Recognition broken down by racial categories.

| Race | Recognition (Aug ‘23) | | | Recognition (Dec ‘23) | | | Recognition (May ‘24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| White | 167 | 3.88 | 0.787 | 113 | 3.87 | 0.888 | 127 | 3.94 | 0.834 |
| Person of Color | 31 | 3.78 | 0.917 | 24 | 3.86 | 0.597 | 30 | 3.98 | 0.862 |
| Two or More Races | 18 | 3.89 | 0.824 | 13 | 3.97 | 0.799 | 18 | 3.87 | 1.17 |
| Prefer Not to Say | 5 | 3.93 | 0.435 | 3 | 4.44 | 0.509 | 5 | 3.73 | 0.760 |

**Table 7:** Summary of Interest broken down by racial categories.

| Race | Interest (Aug ‘23) | | | Interest (Dec ‘23) | | | Interest (May ‘24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| White | 167 | 4.46 | 0.643 | 113 | 4.28 | 0.829 | 127 | 4.28 | 0.902 |
| Person of Color | 31 | 4.34 | 0.728 | 24 | 4.41 | 0.710 | 30 | 4.29 | 0.806 |
| Two or More Races | 18 | 4.43 | 0.854 | 13 | 4.41 | 0.852 | 18 | 4.39 | 0.865 |
| Prefer Not to Say | 5 | 3.39 | 0.494 | 3 | 4.56 | 0.192 | 5 | 4.53 | 0.380 |

**Table 8:** Summary of Performance/Competence broken down by racial categories.

| Race | Performance (Aug ‘23) | | | Performance (Dec ‘23) | | | Performance (May ‘24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| White | 167 | 3.97 | 0.643 | 113 | 3.93 | 0.747 | 127 | 3.91 | 0.772 |
| Person of Color | 31 | 3.99 | 0.746 | 24 | 4.07 | 0.658 | 30 | 3.96 | 0.744 |
| Two or More Races | 18 | 3.94 | 0.569 | 13 | 4.08 | 0.597 | 18 | 3.76 | 0.861 |
| Prefer Not to Say | 5 | 3.68 | 0.729 | 3 | 4.40 | 0.529 | 5 | 3.96 | 0.713 |

**Table 9:** Summary of Belongingness broken down by racial categories.

| Race | Performance (Aug ‘23) | | | Performance (Dec ‘23) | | | Performance (May ‘24) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | St. Dev | N | Mean | St. Dev | N | Mean | St. Dev |
| White | 167 | 4.24 | 0.671 | 113 | 4.18 | 0.747 | 127 | 4.06 | 0.825 |
| Person of Color | 31 | 4.27 | 0.742 | 24 | 4.27 | 0.850 | 30 | 4.13 | 0.790 |
| Two or More Races | 18 | 4.25 | 0.652 | 13 | 4.26 | 0.669 | 18 | 4.07 | 0.969 |
| Prefer Not to Say | 5 | 3.97 | 0.671 | 3 | 4.50 | 0.333 | 5 | 3.90 | 0.796 |

**Discussion and Conclusion**

Developing an identity as an engineer or computer scientist as well as developing a sense of belonging are critical to academic and professional retention. The purpose of this research paper is to document changes in identity and belongingness in an engineering/computing science student in their first year of engineering. Our results show a difference between Interest, Performance/Competence, and Belonging measures at the December time point between men and women; however, those differences disappear by the end of the year. Based on previous analysis, we did expect to see increases in these measures either in aggregate or separated by race or gender, especially belonging. Although this is disappointing, we cannot conclude that the student experiences specifically in the reimagined course are not having a positive impact on students' sense of belonging or engineering/computing identity. There are a myriad of confounding variables that could be influencing this lack of change such as their experiences in their other courses, personal experiences that are unrelated to their classes, or having a better understanding of what it means to be an engineer/computer scientist and attenuating their views of the discipline. It is uncertain as to whether students in their first year of engineering would experience these perturbations as the semester continues in its natural course. The first survey (August) is distributed at the start of their first semester in college where students would typically have a very positive and exciting view of engineering and their college experience while the other two surveys (December and May) are distributed at the end of the semester where students are under a significant amount of stress and anxiety as they look towards finals or reflect back on the difficulties of transitioning to college.

Future work will be exploring this data more deeply and comparing across academic years (AY 2022 - 2023, AY 2023 - 2024, AY 2024 - 2025) as well as some qualitative analysis on some open-ended questions in the end of semester survey.

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**Appendix**

**Table A.1**: Survey items used to measure engineering/computing identity (adapted from [16])

Q16. The following questions use the term "engineer" to refer to all majors in Miami's College of Engineering and Computing, including computer science. Please keep your major in mind when answering the questions. (Response categories: Strongly disagree (1); Somewhat disagree (2); Neither agree nor disagree (3); Somewhat agree (4); Strongly agree (5))

| **Construct** | **Question** | **Statement** |
|---|---|---|
| Recognition | Q16_1 | My parents see me as an engineer. |
| | Q16_2 | My instructors see me as an engineer. |
| | Q16_3 | My peers see me as an engineer. |
| | Q16_4 | I have had experiences in which I was recognized as an engineer. |
| Interest | Q16_5 | I am interested in learning more about engineering. |
| | Q16_6 | I enjoy learning engineering. |
| | Q16_7 | I find fulfillment in doing engineering. |
| Performance / Competence | Q16_8 | I am confident that I can understand engineering in class. |
| | Q16_9 | I am confident that I can understand engineering outside of class. |
| | Q16_10 | I can do well on exams in engineering. |
| | Q16_11 | I understand concepts I have studied in engineering. |
| | Q16_12 | Others ask me for help in this subject. |
| | Q16_13 | I can overcome setbacks in engineering. |

**Table A.2**: Survey items used to evaluate belongingness (adapted from [21])

Q17. The following questions use the term "engineer" to refer to all majors in Miami's College of Engineering and Computing, including computer science. Please keep your major in mind when answering the questions. (Response categories: Strongly disagree (1); Somewhat disagree (2); Neither agree nor disagree (3); Somewhat agree (4); Strongly agree (5))

| **Question** | **Statement** |
|---|---|
| Q17_1 | I feel comfortable in engineering. |
| Q17_2 | I feel I belong in engineering. |
| Q17_3 | I enjoy being in engineering. |
| Q17_4 | I feel comfortable in my engineering class. |
| Q17_5 | I feel supported in my engineering class. |
| Q17_6 | I feel that I am part of my engineering class. |

**Table A.3**: Survey item used to identify gender

Q13. What is your current gender identity?

| **Category** |
|---|
| Man |
| Woman |
| Trans woman |
| Trans man |
| Gender queer/gender non-conforming |
| Identity not listed above |
| Prefer not to say |

**Table A.4**: Survey item used to identify race

Q14. Are you (select all that apply):

| **Category** |
| --- |
| White/Caucasian |
| African American/Black |
| American Indian/Alaska Native |
| East Asian (e.g., Chinese, Japanese, Korean, Taiwanese) |
| Native Hawaiian/Pacific Islander |
| South Asian (e.g. Indian, Pakistani, Nepalese, Sri Lankan) |
| South American |
| Central American |
| Other Asian |
| Other African |
| Other Latino |
| Other |
| Prefer not to say |