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Tracking First-Year Engineering Students' Identity Metrics*

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The first year of any engineering curriculum is critical. It has the potential to provide a strong foundation in the engineering discipline and positively impact a student's engineering identity. Specifically, increases in engineering identity have been shown to increase student persistence within the engineering field, along with other benefits. However, despite the importance of engineering identity, little is known about how First-Year Engineering (FYE) programs impact identity development. In order to provide insight on identity development, we examined the changes in a set of identity-related constructs (major choice, career choice, engineering identity, belonging in engineering, and engineering expectancy/ability) of FYE students at two different institutions with differing FYE structures. We gathered and analyzed results from three surveys administered across the first year of engineering. Three hundred students completed the initial survey, ninety of those three hundred completed the second survey, and fifty-one of the ninety completed the third and final survey. Our results indicate an increase in all the constructs from the beginning to the end of the year for students at both institutions. However, we observed a decrease in most constructs from the second to the third surveys. We also observed differences in career choice and engineering expectancy/ability across the two institutions. Additional research is needed to better understand the reason behind these changes; however, we believe this work has laid the foundation for better understanding changes in identity-related constructs for students in FYE.

Keywords: student development; survey; first-year; identity

1. Introduction

Many institutions have embraced First-Year Engineering (FYE) experiences within their curricula; however, there is wide variation in FYE experiences between institutions. Within the United States, the National Academy of Science recommended implementing FYE courses to "introduce the 'essence' of engineering early in their undergraduate careers" [1, p. 2]. By 2013, nearly 60% of engineering programs had adopted a FYE course [2]. Though the reasoning for FYE experiences is closely aligned with the need for an early introduction to the discipline [3], FYE experiences are vastly different across institutions with regards to their implementation, including content taught [4] and matriculation structure [2]. For example, some engineering colleges have developed FYE experiences that span multiple engineering disciplines and require courses that span across both semesters of the first year; other colleges have implemented standalone FYE introductory courses that focus on a single engineering discipline.

In order to meet the needs of an ever-changing world, engineering curricula are continually examined, updated, and enhanced. There have been formal calls for these changes to ensure that engineering students who graduate and enter the workforce have the skills to be successful in their future workplace (e.g., [5–8]). FYE experiences are not exempt from this cycle of improvement and revision. Though widespread, FYE experiences are continuing to evolve. Each year engineering programs create new or revise existing FYE experiences (e.g., [9–14]). Much of the FYE improvement has been driven by theories related to student self-efficacy (e.g., [15, 16]), self-regulation (e.g., [17]) or by formative assessment of an institution's existing FYE experience (e.g., [18, 19]). Thus far, little research has examined the experiences produced by the various FYE designs. Such research would provide insight into if and how varying FYE structure, content, and timing (i.e., formats) impact student development [20]. If certain FYE formats are found to be more beneficial for specific student development goals, this information would be valuable in the improvement and development of current and future FYE experiences.

This paper initiates a discussion of how different

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FYE experiences impact engineering identity development. We posit that variations in FYE format may impact students' engineering identity development resulting in an impact on persistence in engineering. Most FYE experiences are aimed at students in their first one or two semesters enrolled as engineering students. Thus, FYE experiences give students critical initial experiences in engineering which help students begin to form their individual engineering identity [21]. A strong engineering identity is important since engineering identity development is linked with persistence in engineering [22, 23]. Through a series of surveys administered to students in the 2017–2018 school year at two different institutions with different approaches to FYE, we seek to answer the research question: *How do engineering identity measures change throughout the first year for students enrolled in FYE experiences with different formats?*

2. Background

Identity research, which has often been based on the initial work of Erikson [24], seeks to understand how people view themselves and has been defined in many ways. Vignoles, Schwartz and Luyckx defined identity as the answer to the question "Who are you?" [25], whereas Gee defined identity as "the 'kind of person' one is recognized as being" [26, p. 99]. Additionally, identity can be examined as defining who someone sees themself becoming. Who people see themselves becoming can be investigated through many different theories such as Possible Selves Theory [27] and Future Time Perspective [28]. In addition to how individuals view themselves, identity research has also examined identity within groups [29], where groups included nationalities (e.g., [30]), family groups (e.g., [31, 32]), and careers (e.g., [33–36]). How people identify with careers is of particular interest to engineering education researchers, as researchers often seek to understand students' paths to and through college engineering programs and into the engineering profession.

Much of the engineering identity research regarding careers has focused on undergraduate engineering students [37]. Thus, FYE students have been the focus of many studies on engineering identity. For many students, FYE experiences are the first opportunity to explore engineering and begin to develop their engineering identity. In one study, Pierrakos, Beam, Constantz, Johri, and Anderson [21] investigated how freshmen students who switched out of engineering and freshmen who stayed in engineering differed. Though these students had similar levels of interest and knowledge prior to entering engineering, those who left engineering did not develop a strong connection to the engineering field, whereas those who stayed in engineering began to engage with the engineering community through engineering activities and showed signs of developing an engineering identity. In another study, Jones, Osborne, Paretti, and Matusovich [38] examined motivation and identity in first year students in relationship to their perception of their first-year engineering course. They found significant relationships between students' perception of the FYE course, motivation, identity, and course outcomes. During the development of her identity instrument [39], Godwin also focused on first-year engineering students. This instrument development identified constructs of recognition, interest, and performance/competence as important factors in engineering identity. These relationships show the importance of FYE courses that provide strong foundations and support to students who are early in their engineering career and determining where they fit within the engineering field.

In addition to the research focused specifically on FYE students, engineering identity research has focused on factors which affect engineering identity development. Factors found to positively affect engineering identity development broadly include previous exposure to engineering [40, 41] and experiences such as co-op or internship programs [41, 42]. Additionally, several factors were found to negatively affect engineering identity development broadly. These include marginalizing experiences as a woman [35] and marginalizing experiences as a racial minority [43], both of which may occur within FYE courses. Women have made up only 20% of engineering graduates since the early 2000s [44], and white students made up almost 2/3 of engineering graduates [45]. Therefore, due to these ratios of demographics, FYE may be a place where engineering identity is negatively affected due to marginalization.

Engineering identity has been shown to be a contributory element for student retention. In a study of aerospace engineering student success, Grimes, McFalls-Brown, Mohammadi-Aragh, and Sullivan [46] found that engineering identity is influenced by many identified factors (e.g., pre-collegiate experiences, mentors), and engineering identity is correlated with student retention. Similarly, Beam, Pierrakos, Constantz, Johri, and Anderson [40] found professional identity to be correlated with retention within an engineering major. In a longitudinal study, Matusovich, Streveler, and Miller [47] studied the personal and engineering identities of [first-year, second year, etc.] engineering students and found that students whose personal and engineering identity aligned were more likely to persist.

Despite the importance of engineering identity development in FYE courses, little is known about how different FYE formats (e.g., year-long general engineering programs, semester-long discipline-specific course) may influence students' engineering identity development. Previous research on FYE has focused on the outcomes of single engineering programs (e.g., [48, 49]) or individual projects (e.g., [50, 51]). However, there has been limited work comparing how students experience FYE courses across institutions. Two studies are the exception to this. Research by Chen, Brawner, Ohland, and Orr [2] defined nine matriculation practices across FYE, ranging from direct matriculation programs to a common first year structure. Additionally, work by Reid, et al. [4] has developed a taxonomy for classifying the content of FYE courses. While these two efforts provide valuable insight into FYE courses, they provide limited insight into how students are directly affected. Neither study provides insight into engineering identity development. Understanding where students' identity begins and how engineering identity develops across their FYE experiences will allow for research-based changes to be made to FYE. Overall, our work will allow FYE administrators and faculty to better support students' engineering identity development during the critical first year.

3. Methods

Applying Osborne and Jones' [52] model of domain identification to the engineering field, Kelly, Maczka, and Grohs [53] linked five constructs together. Increases in these constructs both contribute to engineering identification and result from engineering identity. These constructs were major choice, career choice, engineering belonging, engineering expectancy or ability, and engineering identity. These five constructs were used to provide a more complete picture of the changes across the first year. Comparing how these five factors change over the first year for students in two different FYE experiences will generate understanding of the impact of different FYE formats on identity development.

This quantitative study involved a survey administered three times to students during the 2017–2018 school year at two institutions. The initial survey was sent to all students who attended engineering orientation at one of two participating institutions during the summer of 2017. Our survey was developed from work by Jones et al. [49]. Jones et al. [49] found that both expectancy- and value-related constructs decreased over the first-year. They argue that expectancy-related beliefs may decrease as students encounter hard engineering assignments, and value-related beliefs may decrease if students were idealistic at the start of their first-year or if the FYE experience was not enjoyable. After a discussion with FYE instructors at our participating institutions, we believed that the Jones et al. [49] identified factors may be different for our institutions due to the course content. Our studied FYE experiences include experiences to promote expectancy – and value-related beliefs. Therefore, we hypothesized that the identity-related factors of major choice, career choice, engineering belonging, engineering expectancy or ability, and engineering identity specifically would increase over the course of students' first year. Once gathered, the data was analyzed to develop trends regarding how students' experiences differed across the FYE formats based on the measured constructs.

3.1 Participants

Two universities participated in this survey. Institution 1 is a large land-grant institution located in a rural area in the Southern United States. Institution 2 is a large land-grant institution located in an urban area of the Midwestern United States. Institution 1 uses direct matriculation with introduction courses required by all majors, and Institution 2 uses a pre-major with a FYE structure as defined by Chen et al. [2]. At Institution 1, each major offers their own FYE course. At Institution 2, all students take the same course. In early fall semester 2017, the initial survey was sent to approximately 800 FYE students at Institution 1 and approximately 1500 FYE students at Institution 2 who had attended engineering orientation in summer 2017 at either institution. By recruiting these students, the majority of the students who were enrolled in FYE were identified regardless of their specific course section. The second survey was administered early in spring semester 2018, and all students who provided a complete response to Survey 1 were sent a link. The final survey was administered in late spring semester 2018, and all students who had provided a complete response to Survey 1 and Survey 2 were sent a link. Table 1, details the response rate for the surveys and institutions.

3.2 Survey

Each survey was administered electronically and consisted of 32 questions in three sections: six-point Likert-type scale, open-ended response, and demographics. The Likert-type scale questions remained the same for each of the survey iterations. The scale questions ask respondents to rate their level of agreement with the statements regarding constructs such as major choice, consisting of five statements such as "I am confident in my choice of major"; career choice, consisting of two statements such as

Table 1. Number of Participants by Institution

Institution		**Survey 1**	**Survey 2**	**Survey 3**
Institution 1	Number of Responses	113	20	11
	Response Rate by Population	14.1%	2.5%	1.4%
	Response Rate by Survey	14.1%	17.7%	55.0%
Institution 2	Number of Responses	187	70	40
	Response Rate by Population	12.4%	4.6%	2.7%
	Response Rate by Survey	12.4%	37.4%	57.1%
Total	Number of Responses	300	90	51
	Response Rate by Population	13%	3.9%	2.2%
	Response Rate by Survey	13%	30%	56.7%

"My eventual career will directly relate to engineering"; engineering identity, consisting of four statements such as "Being good at engineering is an important part of who I am"; belonging in engineering, consisting of eight statements such as "The instructors in my first-year engineering program respect me"; and engineering expectancy or ability consisting of five statements such as "I am good at math, science and engineering". These questions were modified from Jones et. al [49]. The constructs and their variables names are shown in Table 2.

The open-ended questions changed for each iteration of the survey. In the first survey, students were asked about activities they participated in during their high school careers and activities they hoped to participate in while in college. In the second survey, students were asked about the activities that they were actively involved in, and during the third survey, respondents were asked about the activities they had taken part in throughout the school year. Additionally, students were asked "Who are you? Please describe yourself in 3–5 sentences". The final set of questions included demographic questions. The demographic questions included questions regarding gender, ethnicity, and major of the respondent, as well as if they are first generation students. More details regarding the specific questions can be found in our previous article [54]. Our present article focuses on the Likert-type scale and demographic questions only.

3.3 Analysis

All data analyses were performed using SPSS Statistics. First, to prepare the data from all three surveys for analysis, the results from each survey were combined into one dataset, keeping only the responses for which, a participant completed all three surveys, according to their specific code that allows the participant to remain anonymous. This step is important for analyzing how the respondents' answers changed over time. Next, for each of the five constructs (major choice, career choice, engineering identity, belonging in engineering, and engineering expectancy or ability), the scores were averaged for each respondent for each survey, incorporating any reverse coding of items as needed. Reverse coded statements included those such as "I wish I were in a major other than engineering". Strongly agreeing with one of these questions would indicate a low level of the construct the question was trying to measure. Therefore, in order to ensure that a high average score indicated higher levels of the measured concepts, the responses for the identified questions were "flipped", i.e. "Strongly Agree" became "Strongly Disagree", "Agree" became "Disagree, and so on.

Table 2. Construct Variable Names

Construct Name	**Variable Name**
Major Choice	M
Career Choice	C
Engineering Identity	I
Engineering Expectancy or Ability	A
Belonging in Engineering	B

Once the data was prepared, descriptive statistics were generated for each survey and institution, including the distributions of gender and major. For major, because each school used different names for some majors, the majors had to be streamlined, based on the schools' overall breakdown of majors and departments. This merge allowed for all majors to be represented by both schools in the responses. For example, "biological engineering" at Institution 1 was merged with the "food, agricultural and biological engineering" at Institution 2 because the department at Institution 1 is named the agricultural and biological engineering department. Similarly, "computer engineering" at Institution 1 was merged with "electrical and computer engineering" at Institution 2, and "computer science" at Institution 1 was merged with "computer science and engineering" at Institution 2. The frequencies of the number of participants by gender and major are provided in Table 3.

Following the descriptive analysis, tests for normality were performed for both 'Construct and School' and 'Construct and Survey' Baseline com-

Table 3. Frequencies of Gender and Major by Institution

	Institution 1	Institution 2	Total
Gender			
# Male Participants	4	21	25
# Female Participants	7	16	23
# Prefer Not to Answer	0	1	1
# No Response	0	2	2
Major			
Aeronautical and Astronautical Engineering	0	1	1
Biomedical Engineering	0	5	5
Chemical Engineering	1	3	4
Civil Engineering	4	2	6
Computer Science and Engineering	1	10	11
Electrical and Computer Engineering	2	2	4
Environmental Engineering	0	3	3
Food, Agricultural and Biological Engineering	3	1	4
Industrial and Systems Engineering	0	2	2
Mechanical Engineering	0	6	6
No Response	0	1	1
Undeclared	0	4	4

Table 4. Cronbach's Alpha Reliability Statistics

Construct	# of Items	Survey 1	Survey 2	Survey 3
Major Choice (M)	5	0.736	0.892	0.926
Career Choice (C)	2	0.516	0.861	0.909
Engineering Identity (I)	4	0.708	0.819	0.905
Engineering Expectancy or Ability (A)	5	0.812	0.909	0.914
Belonging in Engineering (B)	8	0.623	0.813	0.799

binations. This included Kolmogorov-Smirnov and Shapiro-Wilk tests, stem and leaf plots, Q-Q plots, and Boxplots for each. All combinations were normally distributed, and therefore, we did not need to perform non-parametric tests.

Following the descriptive analysis, reliability analysis was also performed. To do so, Cronbach's Alphas for the reduced sample were calculated for each Construct and Survey Baseline combination. The results are displayed in Table 4.

To compare the differences in scores between the schools, t-tests using a 95% confidence level were performed by construct for each baseline survey. In order to assess trends from one survey to the next, t-tests were performed to compare differences for each school and construct from Survey 1 to Survey 2, Survey 2 to Survey 3, and overall from Survey 1 to Survey 3. Similarly, additional descriptive analyses and t-tests were performed to further analyze the data by gender and major across the surveys by school and construct. Table 5, provides the full list of tests performed.

In addition to these t-tests, a linear regression was also performed on the difference in average scores between the baseline surveys from Baseline 1 to

Table 5. List of T-Tests Performed

Category	T-Test Scenario
By Construct	1. Institution 1 vs. Institution 2
	2. Survey 1 vs. Survey 2
	3. Survey 2 vs. Survey 3
	4. Survey 1 vs. Survey 3
By Institution and Construct	1. Survey 1: Institution 1 vs. Institution 2
	2. Survey 2: Institution 1 vs. Institution 2
	3. Survey 3: Institution 1 vs. Institution 2
Institution 1 by Construct	1. Survey 1 vs. Survey 2
	2. Survey 2 vs. Survey 3
	3. Survey 1 vs. Survey 3
Institution 2 by Construct	1. Survey 1 vs. Survey 2
	2. Survey 2 vs. Survey 3
	3. Survey 1 vs. Survey 3
By Gender	1. By Construct
	2. By Construct and Survey
	3. Institution 1: By Construct and Survey
	4. Institution 2: By Construct and Survey
By Major	1. By Construct
	2. By Construct and Survey
	3. Institution 1: By Construct and Survey
	4. Institution 2: By Construct and Survey

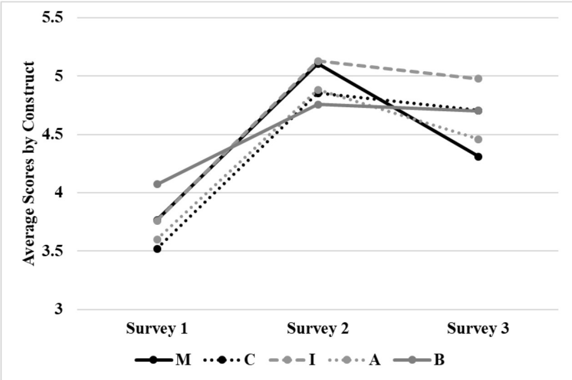

Fig. 1. Average Construct Scores.

Baseline 2 and from Baseline 1 to Baseline 3. This was performed for each of the five constructs using a 95% confidence interval. The model that was used for each of the scenarios was:

$$Difference = \beta_0 + \beta_1\ Institution + \beta_2 Gender + \beta_3 Race + \beta_4 Major + \epsilon$$

A multivariate test was also used to determine if interaction terms would be needed. The interaction between institution and major were significant for the Major Choice and Career Choice constructs. However, when this interaction term was included in the linear regression model, it was not significant and was therefore not included in the model. The model for each scenario did not result in any significant terms and the R^2 values ranged from 0.028 to 0.132 for the difference between Baseline 1 and Baseline 2, and from 0.021 to 0.137 for the difference between Baseline 1 and Baseline 3. Therefore, the institution, race, gender, and major are not predictors of change in the average construct scores from Baseline 1 to Baseline 2, or from Baseline 1 to Baseline 3.

4. Results

Overall, there was a general increase over time in all constructs, with a slight decrease between Surveys 2 and 3. This trend is depicted in Fig. 1.

While there was a general pattern of scores increasing from Survey 1 to Survey 2, decreasing from Survey 2 to Survey 3, and increasing overall from Survey 1 to Survey 3, not all participants followed this pattern. A summary of the patterns observed and the frequency for each pattern are displayed in Table 6, with the first row as the general trend in bold.

The average scores for each construct by institution are provided in Table 7, where significant differences in average scores between institutions are in bold.

When comparing the scores between institutions, there is no statistically significant difference in

Table 6. Change Patterns between Surveys by Construct

Change Pattern by Construct	M	C	I	A	B
Increase 1 to 2 – Decrease 2 to 3 – Increase 1 to 3	**24**	**9**	**16**	**17**	**20**
Increase 1 to 2 – Increase 2 to 3 – Increase 1 to 3	5	8	12	6	9
Increase 1 to 2 – Decrease 2 to 3 – Decrease 1 to 3	8	1	2	5	1
Increase 1 to 2 – Decrease 2 to 3 – No Change 1 to 3	5	0	2	1	1
Increase 1 to 2 – No Change 2 to 3 – Increase 1 to 3	3	18	9	9	7
Decrease 1 to 2 – Increase 2 to 3 – Increase 1 to 3	0	0	2	0	3
Decrease 1 to 2 – Increase 2 to 3 – Decrease 1 to 3	0	0	2	1	2
Decrease 1 to 2 – Increase 2 to 3 – No Change 1 to 3	0	1	0	1	1
Decrease 1 to 2 – Decrease 2 to 3 – Decrease 1 to 3	2	3	3	5	1
Decrease 1 to 2 – No Change 2 to 3 – Decrease 1 to 3	0	1	0	2	1
No Change 1 to 2 – Increase 2 to 3 – Increase 1 to 3	0	2	0	0	1
No Change 1 to 2 – Decrease 2 to 3 – Decrease 1 to 3	4	4	0	3	1
No Change 1 to 2 – No Change 2 to 3 – No Change 1 to 3	0	4	3	1	3
Total	**51**	**51**	**51**	**51**	**51**

Table 7. Average Construct Scores by Institution

	Survey 1		Survey 2		Survey 3	
Construct	**Institution 1**	**Institution 2**	**Institution 1**	**Institution 2**	**Institution 1**	**Institution 2**
Major Choice (M)	3.96	3.71	5.42	5.02	4.53	4.25
Career Choice (C)	3.27	3.59	5.45	4.69	5.09	4.60
Engineering Identity (I)	3.55	3.82	5.34	5.07	5.14	4.93
Engineering Expectancy or Ability (A)	3.75	3.56	4.96	4.86	5.00	4.31
Belonging in Engineering (B)	3.69	4.18	4.60	4.80	4.64	4.72

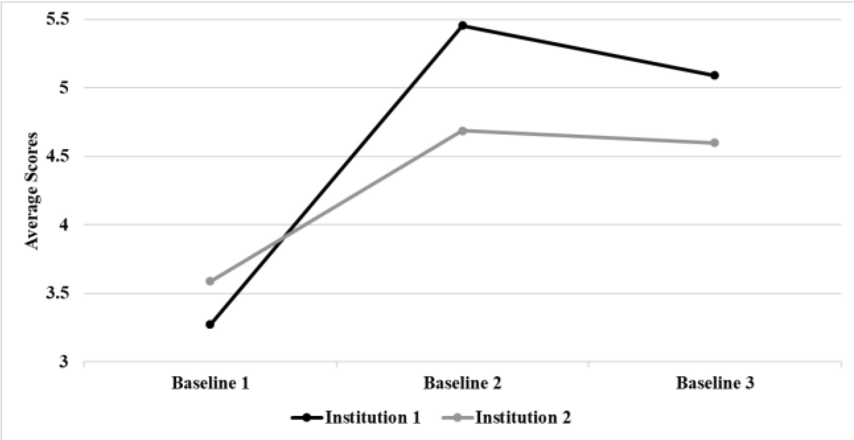

Fig. 2. Career Choice Average Scores.

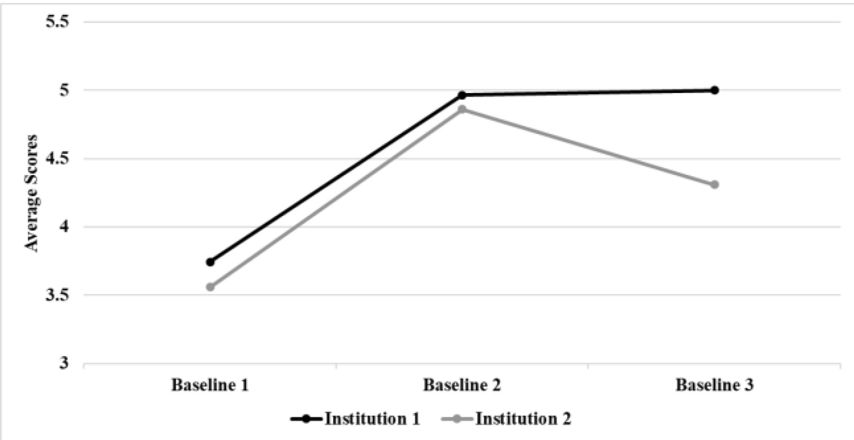

Fig. 3. Engineering Expectancy or Ability Average Scores.

scores between Institution 1 and Institution 2 for all constructs at Survey 1, as determined by the t-tests. For Survey 2, the career choice construct has significantly higher average scores for Institution 1 than Institution 2. Similarly, for Survey 3, the career choice and the engineering expectancy or ability constructs have significantly higher average scores for Institution 1 than Institution 2. These trends and differences are shown in the Figs. 2 and 3. The differences in scores for the other constructs are not significant between institutions.

When assessing the trends from one survey to the next, there were significant increases in averages for all constructs for both Institutions from Survey 1 to Survey 2. Furthermore, from Survey 2 to Survey 3, there were significant decreases in average scores for the Major Choice construct for both institutions as well as a significant decrease in the average score for the engineering expectancy and ability construct at Institution 2. All other differences going from Survey 2 to Survey 3 were not significant. Most average scores decreased, except for the 'engineering expectancy and ability' and 'belonging in engineering' constructs for Institution 1 where the increase in average scores were not significant. Overall, all average scores increased from Survey 1 to Survey 3 for all constructs at both institutions. These increases are significant in all cases except for the Major Choice construct at Institution 1. In this case, there was an increase in average scores, but it was not a significant difference. These results are summarized in Table 8, where the significant increases and decreases are in bold.

4.1 Results by Gender

Similar analyses as above were performed to assess any significant differences by gender between the surveys, constructs, and institutions.

Table 9 shows the resulting average scores by construct, institution, survey, and gender.

It is first noted that all cases where females had higher average scores than males occurred at Institution 1. However, there were a limited number of statistically significant differences between males and females. All of these cases occurred at Institution 2, where males had significantly higher average

Table 8. Significance between Average Scores for Surveys by Construct and Institution

Survey	Construct M		Construct C		Construct I		Construct A		Construct B	
	Institution 1	Institution 2	Institution 1	Institution 2	Institution 1	Institution 2	Institution 1	Institution 2	Institution 1	Institution 2
Survey 1 to 2	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**
Survey 2 to 3	**Sig. Dec.**	**Sig. Dec.**	Dec.	Dec.	Dec.	Dec.	Inc.	**Sig. Dec.**	Inc.	Dec.
Survey 1 to 3	Inc.	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**	**Sig. Inc.**

Note: Bolded values indicate significant changes between surveys.

Table 9. Average Scores by Gender

		Survey 1		Survey 2		Survey 3	
Construct	**Institution**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Major Choice	**Institution 1**	3.60	4.17	5.65	5.29	4.45	4.57
	Institution 2	4.01	3.36	*5.30*	*4.54*	4.44	3.83
Career Choice	**Institution 1**	3.50	3.14	5.75	5.29	5.00	**5.14**
	Institution 2	3.79	3.13	4.90	4.25	4.71	**4.31**
Engineering Identity	**Institution 1**	**2.75**	4.00	5.31	5.36	5.06	5.18
	Institution 2	***4.14***	*3.05*	5.07	4.92	4.90	4.83
Engineering Expectancy or Ability	**Institution 1**	2.85	4.26	4.75	5.09	4.95	**5.03**
	Institution 2	3.82	3.19	*5.14*	*4.43*	4.46	**4.09**
Belonging in Engineering	**Institution 1**	**3.31**	3.91	4.47	4.68	4.53	4.70
	Institution 2	**4.32**	3.88	4.95	4.55	4.83	4.50

Note: Italicized values indicate a significant difference between male and female students at a given institution. Bolded values indicate a significant difference in a gender between institutions.

scores than females for the major choice construct at Survey 2, the engineering identity construct at Survey 1, and the engineering expectancy or ability construct at Survey 2. These results are indicated by the italicized numbers in the table. Furthermore, Institution 2 had significantly higher average scores for males for the engineering identity and belonging in engineering constructs at Survey 1 while Institution 1 had significantly higher average scores for females for the career choice and Engineering

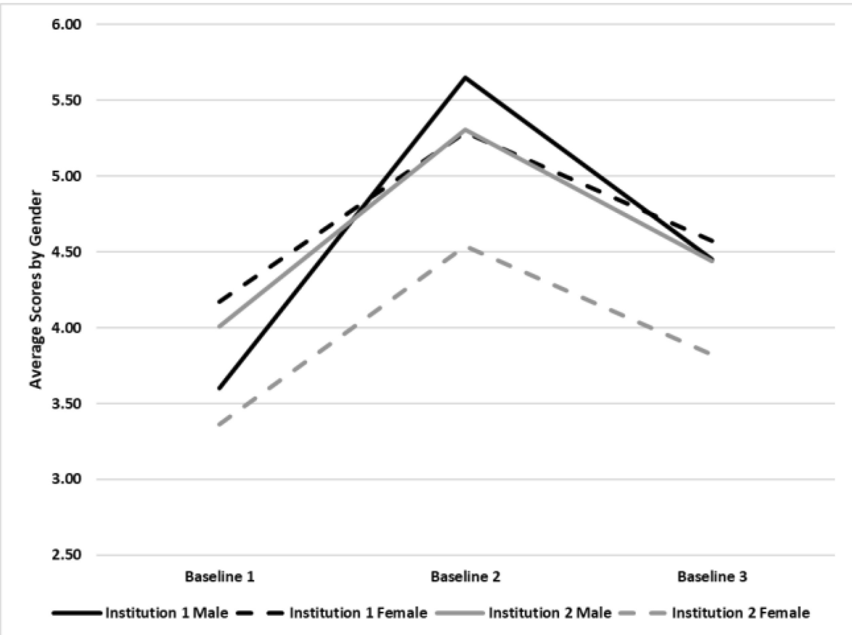

Fig. 4. Major Choice Average Scores.

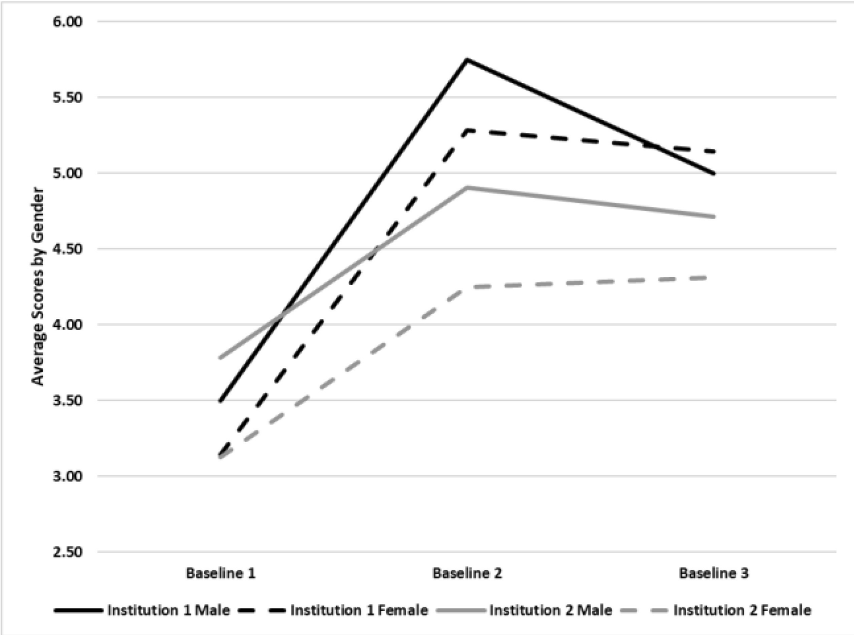

Fig. 5. Career Choice Average Scores.

Expectancy or Ability constructs at Survey 3. These results are indicated by the bold numbers in the table. To display these differences, the charts for each of the constructs are provided in Figs. 4–8.

4.2 *Results by Major*

The average scores by construct, survey, and institution are provided in Appendix A. As seen from Table *3*, there are five majors for which there were responses from students from both institutions: Chemical Engineering, Civil Engineering, Computer Science and Engineering, Electrical and Computer Engineering, and Food, Agricultural and Biological Engineering. Because many of the majors had only one respondent, t-statistics were not able to be computed. Therefore, when comparing Institution 1 and Institution 2 for each survey, construct, and major, none of the differences in values were statistically significant. When analyzing whether the trend from one survey to the next was significant within each of the institutions, it was found that Institution 2 had the most significant

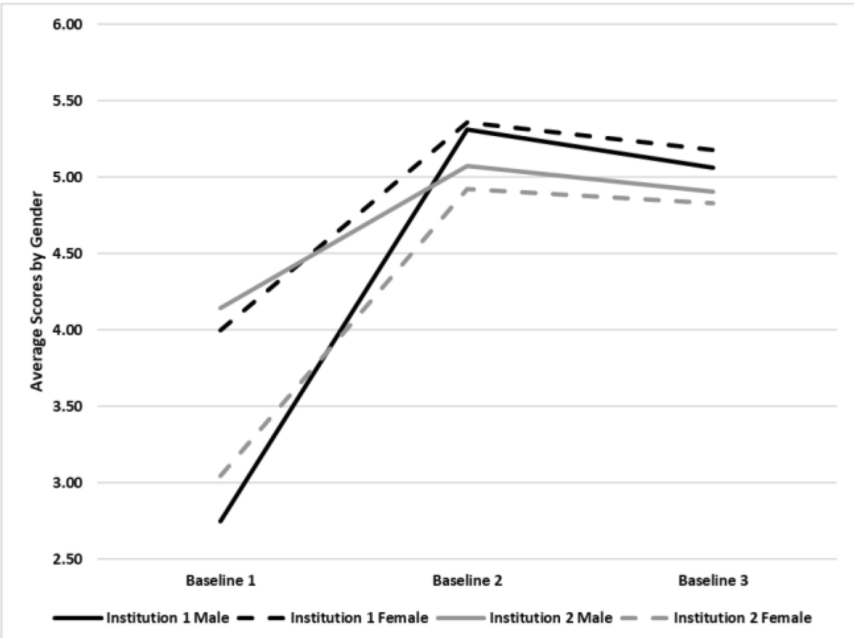

Fig. 6. Engineering Identity Average Scores.

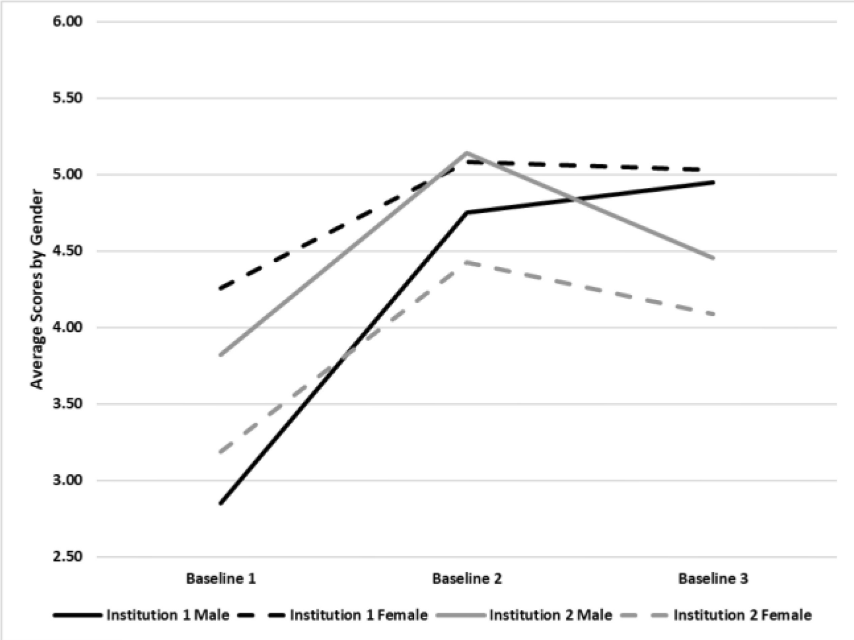

Fig. 7. Engineering Expectancy or Ability Average Scores.

increases from Survey 1 to Survey 2. The bold numbers in Appendix A indicate whether that number is a significant increase or decrease in the average score for that construct and major from the prior survey.

5. Discussion and Implications

Since the FYE experience introduces students to the ''essence'' of engineering, we hypothesized that we would observe an increase in engineering identity-related constructs over the first year. Overall, we did observe an increase for each construct over time. This observed trend contrasts with the results in the Jones et al. [49] study where constructs decreased over the first year. Jones and his coauthors attributed the decline for expectancy-related constructs to a reaction to challenging engineering tasks that reduce students' expectations for success. However, in our study, both institution's courses include

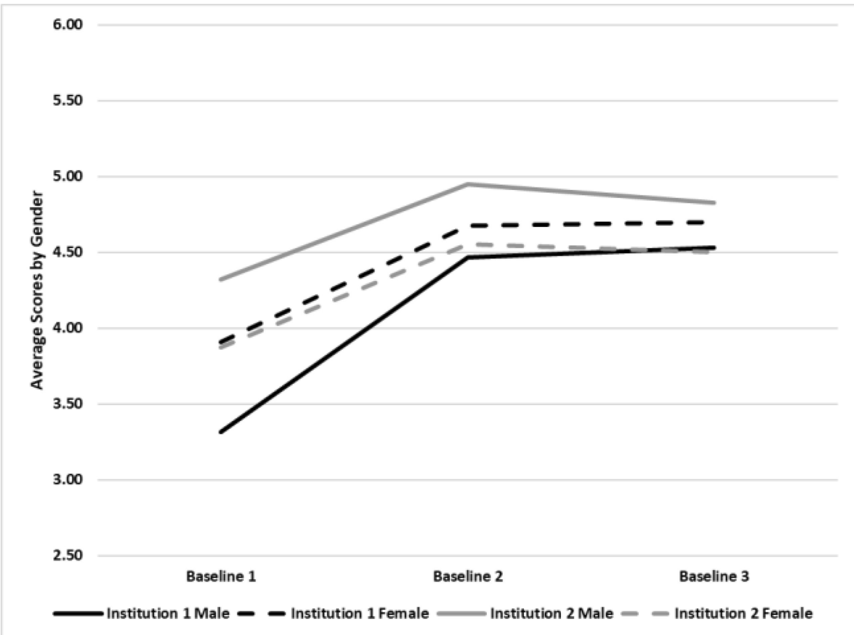

Fig. 8. Belonging in Engineering Average Scores.

challenging engineering tasks, and we observed the opposite trend for expectancy-related beliefs for both FYE formats we studied. This suggests that different FYE experiences do impact engineering identity metrics differently. Future FYE research should examine the FYE experience within the context of format (i.e., content taught, matriculation path employed) as this may play a role in the results.

Despite the overall increase in constructs we observed a slight decrease for each construct from the beginning to the end of the second semester (i.e., from Survey 2 to Survey 3) for a majority of the constructs at both institutions. This indicates that influential activities or experiences occur during the second semester. For example, it is possible the FYE programs at our study sites included more challenging engineering tasks in the second term or that the other classes outside of FYE may be getting more difficult. Future research should closely examine second semester activities to explore the types of activities that may negatively impact identity-related constructs. For example, it may examine constructs in Godwin's work such as performance/competence to see if these factors are being impacted [39]. Additionally, the work of Kajfez et al. [55] indicates that how first-year engineering students view various engineering majors varies across institutional contexts. Understanding how these perceptions of various engineering majors may influence identity-related constructs may also be an important area of investigation. As students' progress through FYE courses, they should learn more about various engineering disciplines, which may impact the identity-related constructs investigated in this study.

Since the FYE experiences at our study sites had different formats, we anticipated there would be differences in engineering identity-related constructs across the sites. We observed that while there was no initial difference, in the second and third survey career choice and engineering expectancy/ability were higher for students who participated in the direct matriculation model versus the common FYE model. One explanation might be that students who are admitted directly into a major and spend their FYE experience conducting activities relevant to their identified major may develop stronger beliefs regarding their career choice and expectancy-related beliefs. It is also reasonable that students who spend the first-year learning about engineering more generally may not develop as strong of connections with their career choice or expectancy-related beliefs. While additional research is needed to understand why these constructs are different for different FYE formats, the key implication for FYE research is that after no initial difference, differences emerge. Distinct FYE formats impact students in different ways. As researchers, we must quantify these differences so FYE administrators and instructors can appropriately design FYE experiences to meet their institutions' student development goals.

Future research should consider gender in its analysis. We observed that male students at Institution 2 had higher engineering identity and engineering belonging than the males at Institution 1 enrolled in the direct matriculation program. This difference was only significant for Survey 1, which could mean that a student who enrolls directly into a specific engineering discipline may not have the same developed identity as a student who enrolls in a common FYE program. The student may identify with "engineering" stronger than with a particular engineering discipline. The student may initially feel less belonging because the major is more specific. What is more concerning is the gender differences that were significant towards the end of the FYE experience. For the third survey, females enrolled in Institution 1's direct matriculation program had higher career choice and engineering expectancy/ability than females enrolled in Institution 2's common FYE program. Hatmaker's [35] previous work indicates that being female negatively affects engineering identity broadly, so it is important to understand the differences that may exist for females based on FYE experience design.

5.1 Limitations

The findings of this study should be understood within its limitations. First, the results represent only the one cohort of first-year students at two institutions. The year that is represented by this data may not be typical of first year experiences and may not be generalizable to other institutions. Additionally, the attrition across the three surveys may also limit how widely the data can be generalized. Though attrition is typical in survey responses, the response rate of our final survey was approximately 2% of our initial population (see Table 1), which was lower than expected. Finally, demographics of our respondents limits our ability to examine underrepresented minorities, with the exception of women. Differences in identity development in these populations may be significantly different than those in majority groups, so it is especially important to investigate minority groups in future studies. Despite these limitations, these findings provide valuable insight into how identity metrics change across students' first year of engineering.

6. Conclusions

We examined five identity-related constructs (major choice, career choice, engineering identity, belonging in engineering, and engineering expectancy/ability) for two FYE experiences at two different institutions. We observed a statistically significant increase for career choice and engineering expectancy/ability for students at both institutions. We also observed statistically significant differences by gender. Our results motivate additional research comparing student development in differently formatted FYE experiences in order to understand which formats support specific student development goals. Such insight will ensure purposeful and meaningful FYE changes that meet the needs of a changing world.

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Appendix A

Table A1: Average Scores by Major

		Survey 1		**Survey 2**		**Survey 3**	
Construct	**Major**	**Institu-tion 1**	**Institu-tion 2**	**Institu-tion 1**	**Institu-tion 2**	**Institu-tion 1**	**Institu-tion 2**
Major Choice	Aeronautical and Astronautical Engineering	n/a	6.00	n/a	6.00	n/a	5.20
	Biomedical Engineering	n/a	3.64	n/a	4.44	n/a	4.00
	Chemical Engineering	5.00	4.53	5.60	5.67	5.00	**4.80**
	Civil Engineering	4.05	2.80	5.30	5.30	4.50	5.00
	Computer Science and Engineering	2.40	4.18	6.00	**5.28**	4.60	**4.26**
	Electrical and Computer Engineering	3.00	4.80	5.40	5.80	4.60	4.80
	Environmental Engineering	n/a	2.40	n/a	3.73	n/a	3.40
	Food, Agricultural and Biological Engineering	4.67	3.20	5.33	4.80	4.33	5.00
	Industrial and Systems Engineering	n/a	3.40	n/a	5.00	n/a	4.60
	Mechanical Engineering	n/a	3.13	n/a	**5.03**	n/a	4.13

Construct	Major	Survey 1		Survey 2		Survey 3	
		Institution 1	Institution 2	Institution 1	Institution 2	Institution 1	Institution 2
Career Choice	Aeronautical and Astronautical Engineering	n/a	6.00	n/a	6.00	n/a	6.00
	Biomedical Engineering	n/a	2.30	n/a	3.70	n/a	3.70
	Chemical Engineering	2.00	3.33	5.50	6.00	5.00	5.67
	Civil Engineering	4.50	3.00	5.38	5.25	5.00	5.50
	Computer Science and Engineering	2.00	4.10	6.00	4.55	5.00	4.70
	Electrical and Computer Engineering	3.00	4.00	5.50	5.25	5.50	5.25
	Environmental Engineering	n/a	2.50	n/a	3.17	n/a	2.83
	Food, Agricultural and Biological Engineering	2.67	4.00	**5.33**	4.50	5.00	4.50
	Industrial and Systems Engineering	n/a	4.25	n/a	4.75	n/a	4.00
	Mechanical Engineering	n/a	4.00	n/a	5.00	n/a	4.92
Engineering Identity	Aeronautical and Astronautical Engineering	n/a	5.00	n/a	5.75	n/a	6.00
	Biomedical Engineering	n/a	4.10	n/a	4.90	n/a	4.80
	Chemical Engineering	4.50	3.17	5.25	**5.67**	4.75	5.08
	Civil Engineering	3.63	4.00	**5.19**	5.00	5.19	5.25
	Computer Science and Engineering	2.50	3.60	5.50	**5.00**	4.75	5.18
	Electrical and Computer Engineering	2.25	5.25	**5.13**	5.75	5.50	5.25
	Environmental Engineering	n/a	3.33	n/a	3.67	n/a	3.58
	Food, Agricultural and Biological Engineering	4.33	2.50	5.67	4.75	5.08	5.00