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Potential of a Values Affirmation Intervention for Marginalized Gender Students' Belonging and Recognition

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Abstract

This research paper investigates the effects of a values affirmation intervention on first-year students' of marginalized genders (which includes ciswomen, trans, and non-binary/third gender students) sense of belonging and identity in engineering. In this work, we examine marginalized genders because, while each of these groups has different experiences in engineering, they are also commonly impacted by the history of engineering as hyper masculine and heteronormative. Values affirmation interventions are short classroom activities designed to affirm important aspects of students' identities and thus help them cope with aversive experiences and resist negative messages (either internalized or environmental; McQueen & Klein, 2006). Values affirmations have been previously used in STEM settings to help address stereotype threat among women students (Cetinkaya, Hermann, & Kisbu-Sakarya, 2020), threats to science identity among Latinx students (Hernandez et al., 2017), and mathematics and socialization outcomes among STEM students (Peters et al., 2017; Turetsky et al., 2020). Most relevant to this study, values affirmations have been used to decrease performance gap between men and women studying engineering (Walton et al., 2015). However, values affirmation interventions are still new to engineering, and their specific effects on engineering identity and belonging are still unknown.

In this paper, we document preliminary results from an experiment testing the effects of a values affirmation during the first few weeks of a first-year, first-semester engineering course. A total of 199 participants were randomly assigned to three conditions (control, challenges, and values). Before and after completing the intervention activity, participants completed measures of their belonging, engineering identity, future time perspective, and test anxiety. They also completed a comprehensive demographics section that asked about their gender identity.

Two repeated-measures ANOVAs were used to test for pre/post differences in engineering identity recognition and engineering belonging across intervention groups (control, challenges, or values) and gender identity (cismen or any marginalized gender). There was a significant gender differences in recognition ($p = .015$), with women and non-binary students reporting lower recognition than cismen. Recognition scores increased over time for all participants ($p < .001$) but this improvement was not impacted by the intervention ($p = .866$). There was also a significant main effect of gender on belonging ($p < .001$), with cismen reporting higher belonging, and a significant interaction of gender and time ($p = .068$), in which students with marginalized genders reported improved belonging at post-test that was still significantly lower than their cismen peers. Participation in the intervention did not significantly impact belonging for students ($p = .278$). Although preliminary, these findings suggest that the intervention may

not benefit this population as strongly as anticipated, although future work with a larger sample and additional longitudinal data points may yet find an effect.

Introduction

Engineering identity and belonging are important parts of engineering education, although they are rarely considered part of the official curriculum. Engineering identity, or one's sense of self as an engineer, is often conceptualized as consisting of three parts: recognition, or experiences in which one is recognized by faculty, peers, and family as an engineer; performance/competence, or one's sense of self-efficacy and competence when performing engineering tasks; and interest, or one's sense of engagement and enjoyment when learning about or doing engineering [1]. Belonging in engineering is one's sense of community, acceptance, and shared identity with other engineers, such as fellow engineering students or in wider engineering spaces [2]. Students draw upon these two factors to make sense of their engineering experiences and their place in the field. For instance, identity-based motivation theory highlights the importance of identity, particularly in the face of negative experiences when students must make sense of the difficulty they have encountered and whether it's a sign that they belong in their chosen field [3]. They also play a role in students' short- and long-term decision-making–previous research with successful students who leave STEM highlights the fact that academic success alone is not enough to make one an engineer [4], [5].

Thus, there is a robust body of work linking identity and belonging to a variety of outcomes in engineering. For instance, previous work has linked belonging to persistence, career trajectories, emotional engagement, sense of community, and academic performance, among others [4] - [11]. Research in this area also highlights the importance of engineering identity and belonging to women, non-binary students, Black, Latino/a/x, Indigenous students, and students at the intersections of these identities. In this work we explicitly name groups where possible and refer to marginalized students as this collective group that is disadvantaged by the historical and cultural norms of engineering. STEM has long been perceived as a White, masculine environment in which women and students of color do not belong and are unlikely to be successful [12]. Although marginalized students continue to enroll in STEM, and initially express interest on par with their peers, they still drop out at much higher rates than their white, Asian, and male peers [13]. Encouraging students to develop their engineering identities is thus an important goal of engineering classrooms and departments, and values affirmation interventions one potential strategy for doing so.

Values affirmation interventions have the benefit of being brief activities with long lasting effects; although different varieties of this intervention exist, they are usually short surveys or writing prompts that ask students to reflect on their values [14]. These interventions draw from self-affirmation theory, which argues for the use of self-affirmation (i.e., positive messages from the individual about themselves) to support coping [15]. By affirming important aspects of students' identities, values affirmations help them reframe aversive experiences (such as a bad grade on an exam) and resist negative messages (such as narratives about who belongs in engineering or that students who struggle academically are not "cut out" to be engineers). Values affirmations have been previously used in STEM settings to support students' academic achievement and address issues of belonging and inequity. For instance, a previous study found that values affirmations eliminated a gender gap in GPA between men and women, and improved women's attitudes towards adversity and academics [16]. Other values affirmations helped combat stereotype threat among women students in STEM [17] and combat stereotypes and threats to science identity among Latinx students [18]. Non-marginalized students benefit from values affirmations as well, as previous research has used these interventions to improve students' social networks and numeracy skills [19], [20], indicating that values affirmations are potentially brief, low-impact, and universally beneficial activities that can be integrated in a variety of classrooms.

However, value affirmation interventions remain largely untested with engineering populations, and their effects on engineering identity and belonging in engineering are still unknown. In this paper, we document preliminary results from an experiment testing the effects of a values affirmation during the first few weeks of a first-year, first-semester engineering course. A total of 199 participants were randomly assigned to three conditions (control, challenge-intervention, and values-intervention). Before and after completing the intervention activity, participants completed measures of their belonging, engineering identity, future time perspective, and test anxiety. They also completed a comprehensive demographics section that asked about their gender identity. Based on previous research in this area, we proposed two hypotheses:

> H1: Participants who complete the intervention, in either the challenge-condition or the values-condition, will report higher belonging than participants in the control condition.
>
> H2: Participants who complete the intervention, in either the challenge-condition or the values-condition, will report higher engineering recognition than participants in the control condition.

In the sections below, we detail our experimental procedure, sample, and analyses in more depth, and then discuss our results and their implications.

Method

Procedure

Data was collected in three batches across two semesters (Summer 2021 and Fall 2022) at a public land-grant research university in the Midwestern U.S and a comprehensive, state-supported university in the U.S. West. Researchers directly contacted participants and asked them to complete the survey online three times; first, during the first week of classes (pre-test); second, two weeks later (post-test), and third, in the final two weeks of classes (follow-up). The intervention was administered between the pre- and post-tests. To avoid linking the intervention to the research effort, which has been found to impact the intervention's effectiveness [14], instructors presented the intervention as a regular classroom activity without linking it to the surveys. For the intervention, participants were directed to a Qualtrics form that randomly assigned them to one of the three conditions and asked them to complete the requisite activity (described in more detail below).

Survey Measures. This study focuses on data collected immediately before and after completing the activity (i.e., the first two timepoints) for consistency among the two universities. The survey consisted of seven measures assessing belonging in engineering, engineering interest, engineering recognition, test anxiety, and three aspects of future time perspective (instrumentality, perceptions of the future, and expectancy; the full list of items is provided in Appendix 1). These items were a subset of the larger survey used in the SUCCESS project which this intervention was a part of [21], and were selected based on previous research that indicated them as variables of interest [22], [23]. Our measure of belonging was adapted from the Measures of Belonging in Higher Education scale [24] and consisted of four items asking about participants' comfort and belonging in engineering and their engineering classes. This scale has been previously used with engineering and science students and had a Cronbach's alpha (α) of .89.

Engineering interest and recognition were measured using seven items from Godwin's engineering identity instrument [1] and ask about participants experiences with recognition and their interest and fulfillment in studying engineering (α = .78). Test anxiety was assessed using five items from the Motivated Strategies for Learning Questionnaire, an instrument that has been used to study test anxiety in a wide range of college students [25]. Lastly, 12 items from Kirn and Benson's (2015) previous work with engineering students were used to assess future time perspective motivation across three subscales. During the third and final data collection time point, participants were also asked about their propensity to make attributions to prejudice using 8 items from Miller & Saucier's (2018) scale. Although not analyzed in this study, this data was collected to examine whether completing a values affirmation activity impacts students' awareness of and willingness to acknowledge racism and prejudice. Given the sensitivity of this topic, this scale was presented at the very end of the survey and only in the final survey to avoid introducing potential confounds into the study design.

Demographic information was collected using ten items that asked about participants' race/ethnicity, military status, gender identity, sexual identity, disability status, and family background (including parent education level and nationality). These items were developed from previous research and aimed to create a comprehensive, inclusive, and parsimonious demographics form [29]. Of these items, responses from the gender identity question are used in this analysis. This item asked participants to select their gender identity from a list, with multiple selections permitted and eight response options provided (woman, man, agender, genderqueer, cisgender, transgender, non-binary, and another gender not listed).

Intervention Activities. Participants were randomly assigned to one of three conditions: values-intervention, challenge-intervention, and control. The values-intervention was intended to target the psychological mechanisms described earlier in this paper. The challenge-intervention was designed to be an equivalent task focused on general engineering-related challenges but not personal values. The control group was asked to write about a generic but unrelated topic. We chose these three approaches to not only understand the effect of a values-intervention compared to "business as usual" but also to examine if the values component as personally relevant versus a general interest area like engineering was the driving mechanism for any detected effects.

A previous systematic review of values affirmation interventions [14] provided an overview of different strategies used in earlier experiments. We used the most promising of these approaches to design our procedures. Two approaches were used for this study; first, participants were asked to rate a list of engineering values (values-intervention condition) or challenges (challenge-intervention condition) as either very important, somewhat important, or not important (refer to Appendices 2 and 3 for the full activity text). Once this was complete, participants were shown their selections and asked to respond to two writing prompts about their choices ("Can you give an example of when this [challenge]/[value] was especially interesting or meaningful to you, and why?" and "How will [this value]/[focusing on this challenge] contribute to your success in the classroom and in the future as an engineer?"). Participants in the control group were asked to write about something they were looking forward to in the upcoming term. All participants were asked to write 30-50 words for each prompt and a word count was shown, but participants were able to proceed with responses below the requested word count.

The lists of values and challenges were developed from existing materials. For the list of values, previous value lists in earlier value affirmations were reviewed [29], alongside classic studies of values (e.g., Allport and Vernon's Study of Values; [30]), modern studies of universal and scientific values [31], [32], and examinations of communal and agentic values and goals [33], [34]. The final list of values (Appendix 2) derived mainly from Schwartz's (1992) list of values that were studied in 20 countries, with definition text written by researchers and drawing from Kevser & Ünal's (2020) scale of scientific values and Diekman et al.'s (2010) list of agentic and communal goals. For the list of challenges, the 14 Grand Challenges for Engineering from the

National Academy of Engineering (2008) were used as the basis for 14 short items (Appendix 3). For both lists, a final “other” option was provided with a space for students to write-in any values or challenges important to them but not covered by the existing options.

A previous systematic review of values affirmation interventions suggested that they functioned best when presented as part of a classroom’s normal activities, and that introducing the intervention as part of a research study or emphasizing its potential benefits impeded the intervention’s effectiveness [14]. As a result, instructors presented the activity as a regular extra credit opportunity or a required assignment, and participants were informed of the deception at the end of the academic term and consent to use their data was sought. Across both semesters, a total of 1270 students were invited to participate, with response rates for each wave of the study ranging from 30% to 90%. A total of 199 participants completed data collection at all time points and consented to participate (16% completion rate) and are analyzed in this paper. This is a severe rate of attrition, and the potential implications of this attrition for this study’s finding are discussed in the Discussion and Limitation sections below.

Participants

Our sample is largely white (65%) and male (68%), making our sample less diverse than the institutions (56% white and 55% male) but comparable to the population of recent engineering graduates (59% white and 77% male; [36], [37]). Full information about our sample racial/ethnic backgrounds and gender identities are provided in Table 1. Participants in this study were first-year students at two institutions, one in the U.S. Midwest and the other in the U.S. Southwest. They were enrolled in one of two courses, depending on their institution. At the first institution, the course is one for all engineering students that introduces them to concepts from engineering, such as design processes and making evidence-based engineering decisions. At the other institution, the course is an introduction to mechanical engineering required for all ME students. Due to Covid-19 procedures at the first institution, a combination of in-person and online classes were used across the two semesters of data collection, while at the second, classes were conducted in person. All data were collected online using Qualtrics survey software.

Table 1: Demographics of study sample

		Count	Percentage
Race/Ethnicity*			
	Asian	53	26.63%
	Black/African American	5	2.51%
	White	130	65.33%
	Hispanic/Latino	27	13.57%

Middle Eastern/North African	5	2.51%
American Indian/Alaska Native	3	1.51%
Native Hawaiian/Pacific Islander	1	0.50%
Another Race/Ethnicity Not listed	1	0.50%
Biracial/Multiracial	3	1.51%
Gender Identity*		
Cis Male	136	68.34%
Cis Female	60	30.15%
Non-Binary or Genderqueer	4	2.01%
* Item was multiple-response and asked participants to select as many options as applied to them.		

Analysis

All analyses were completed in R. Outliers were screened using Mahalanobis' distance (n = 8). Composite scores were created for the target constructs (belonging and recognition) by averaging participants' responses to the individual items. The distributions for each construct were examined by condition to confirm normality using QQ-plots and Bartlett and Levene's tests [38]). The afex package was used to run two factorial repeated measures analyses of covariance (RM-ANOVAs) to test for group differences by gender identity, condition, and for interactions between the two [36]. In the event of significant results, the means were compared using Tukey's HSD post-hoc test via the emmeans package [40]. Given the small sample and preliminary nature of this analysis, an alpha value of .10 was used for the ANOVAs.

Results

The 2x2x3 RM-ANOVA of engineering identity recognition found a significant effect of gender identity ($F(1,165) = 6.01$, $p = .015$, $\acute{\eta}_p^2 = .04$), with cismen reporting higher recognition than women and non-binary students. It also found a significant effect of time ($F(1,165) = 17.75$, $p < .001$, $\acute{\eta}_p^2 = .10$), with recognition increasing significantly from one time point to the next. However, there was no interaction with condition (p = .866), suggesting that neither of the intervention conditions impacted students' recognition (Figure 1).

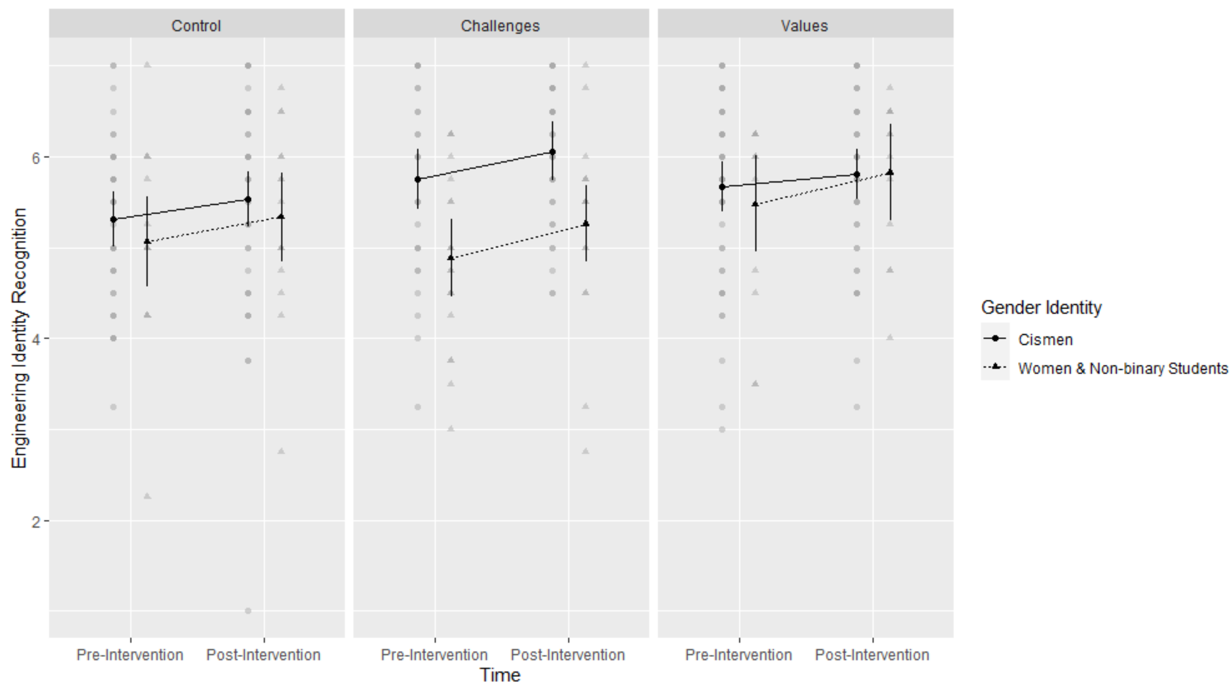

Figure 1: Scores of engineering identity recognition for cismen and women/non-binary students before and after completing the intervention activity, separated by experimental condition.

The 2x2x3 RM-ANOVA of engineering belonging also found a significant main effect of gender identity (F(1,167) = 26.88, p < .001, $ή_p^2$ = .14), with men once again reporting significantly higher scores than women and non-binary students. There was also a main effect of time (F(1,167) = 15.75, p < .001, $ή_p^2$ = .09), with participants reporting significantly higher belonging at post-test. Lastly, there was also a significant time x gender identity interaction (F(1,167) = 3.38, p = .068, $ή_p^2$ = .02), with women and non-binary students reporting a half-point increase in belonging while men's belonging remained constant. There was no interaction with condition (p = .278), suggesting again that the intervention did not impact belonging (Figure 2).

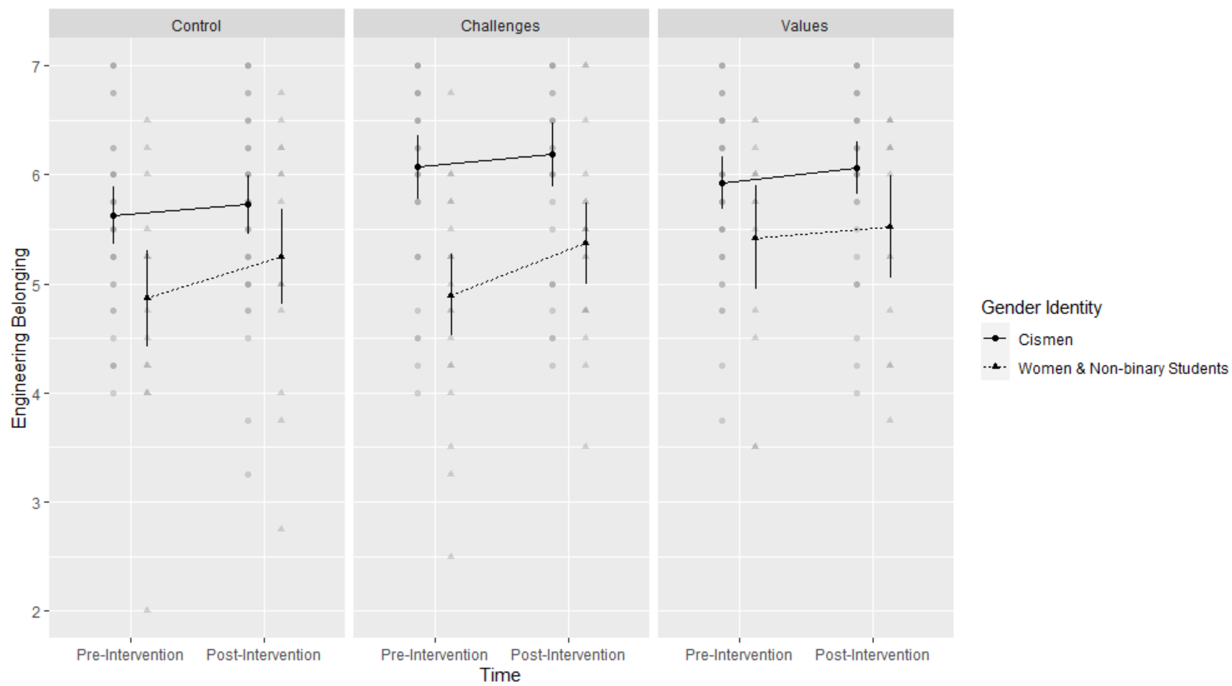

Figure 2: Scores of engineering belonging for cismen and women/non-binary students before and after completing the intervention activity, separated by experimental condition.

Discussion

To summarize, there were gender differences in engineering identity recognition and belonging, with cismen reporting higher scores than women and non-binary students. From pre- to post-test, recognition increased for all students, while belonging increased for women and non-binary students. There were no effects of the intervention for either recognition or belonging.

In short, although students show gender differences in identity and belonging, the intervention has so far failed to address them. This lack of results can be attributed to several potential causes. The most obvious and least encouraging is that values affirmation interventions simply do not support recognition and belonging in engineering students. Values affirmation intervention are often tested with secondary students or in undifferentiated STEM populations (see [17] and [18] for examples), and so engineering undergraduate students and settings may have unique qualities that make the intervention less effective. However, there have been successful applications of the intervention with engineers in the past [16], and so there may be other explanations for the current analysis' lack of findings. The first is that the impact of the intervention may take longer to emerge. Values affirmations are theorized to work by subtly altering students' self-messaging and thus their behavior, a process expected to iterate and thus build an effect over time [15]. In the previously cited study of engineering undergraduate the effects emerged over an academic year [16], while our study looks at changes in identity over a three-week period. The current study is collecting data from the end of the academic term and so future analyses can shed light on this hypothesis.

The other possibility is that the intervention does not impact engineering identity and belonging as measured in our study. Previous work with engineering students used an unspecified series of items to measure belonging, and did not examine engineering identity directly [16]. Differences in the operationalization and measurement of belonging may account for the lack of findings, and despite the conceptual overlap between belonging and identity, the two constructs may be sufficiently different that identity is unimpacted by the intervention. Participants in this study did provide consent for researchers to pull their institutional records and link them to their survey responses, and so future examinations of the full dataset may find differences in GPA across the three conditions.

Limitations

The results of this study are preliminary, as data collection is still ongoing, and this should be kept in mind when interpreting and reflecting upon our results. A larger participant pool may address some of the issues regarding random assignment (e.g., pre-test differences in identity and recognition) and may find that trends in the data become statistically significant findings. We have also only examined two of the variables and one of the demographic characteristics measured. Future analyses may find an effect of the intervention on these variables or a moderation effect using one of the unexamined demographic categories. Most importantly, the largest limitation of this study is the small sample size, largely driven by attrition from the study's multiple waves of data collection. Although a large number of students were approached for participation (n = 1270), only 16% (n = 199) of them completed the experimental manipulation and agreed with the delayed consent at the end of the academic term. Power analyses for a 2x3 RM-ANOVA recommend at least 200 participants, with that number increasing if additional between subjects variables (e.g., gender identity) are included in the analysis, and so our current sample is short of this recommendation. A meta-analysis examining survey response rate found that, on average, web surveys have a response rate around 34% [41]. Our survey had participation at or above this level for all rounds of data collection; however, the longitudinal nature of the data collection means that only a subset of total respondents participated in all phases of the study.

Low participation rates raise two questions about the validity of a survey. The first is of numbers; larger samples have more normal distributions and are more representative of the underlying population. Since most inferential analyses make assumptions of normality, and since the goal of quantitative research is to generalize outward from the sample to the population, small sample sizes are a potentially serious issue. The second question is of potential bias, e.g., only students who identify strongly as engineers complete a survey about engineering identity, thus leading researchers to make erroneous conclusions about engineering identity in the total population. Although low participation rates are not inherently biasing, unit nonresponse (e.g., when participants do not respond to any part of a survey) makes it difficult if not outright impossible to confirm that systemic bias has not occurred [42].

Although our results are preliminary, the issues of attrition and response rate are important to consider when making sense of the results. This study also presents the opportunity to reflect on future waves and how to maximize participation. A review of previous research regarding response rates made ten recommendations for maximizing response rates [43]. Of these recommendations, five are relevant for the current study (the other recommendations, such as the use of multiple contacts or statements of confidentiality are already incorporated into recruitment messaging): (1) Paper versus web, or the benefits of using paper surveys instead of web surveys; (2) Length, which refers both to individual survey length and, in our case, the length of all phases of data collection; (3) Survey salience, or the extent to which the survey is seen as relevant and important to participants; (4) Requests for help, in which phrases like “it would really help us out” are used in recruitment materials; and (5) Deadlines, which includes deadlines for participation (which are already used in our study) and statements of selectivity (e.g., “You are part of a group selected for participation….”). Of these recommendations, most can be integrated into our data collection procedures without changing the study paradigm – for instance, we can emphasize the importance of the survey and the selectivity of recruitment, provide clearer messaging about survey length and the amount of time needed across all phases, and emphasize a direct request for help. The use of paper surveys is potentially problematic, as setting can have a potential priming effect on certain constructs, such as engineering identity and belonging. This approach also relies on the use of in-person classes, which may not be possible given the ongoing pandemic. However, changes will be made to future waves of data collection that can hopefully maximize our participation.

Implications and Future Research

Although the current preliminary results provide little in the way of concrete recommendations for instructors, there are a few take home points. The first is that, despite widespread efforts in engineering and STEM more broadly, gender differences in belonging and recognition still exist for first-year students in engineering. Although our work does not find an effect of the intervention, the previous research cited in this paper suggests that affirming students’ sense of self and their belonging in the classroom are necessary to help close these gaps. Future analyses that examine the effect of the intervention on end-of-term GPA and the contents of students’ qualitative responses may reveal additional adaptations for the intervention and resources for instructors to help boost identity and belonging in their classrooms.

Conclusion

In summary, our results indicated that differences in students' feelings of recognition and belonging by gender with cismen reporting higher levels of recognition than women and non-binary students. Recognition and belonging both increased over the term, but the interventions did not have a significant impact on these measures. As previous research has indicated a possible delayed or iterative effect, future analyses will examine late-semester data for differences to continue exploring the possibility of an effect. Additionally, our future work will attempt to better translate interventions to an engineering context and will examine these variables with a larger participant pool. We also plan to expand our analyses to include other constructs of interests measured on the pre- and post-surveys. With larger sample sizes, we will also be able to center our analyses on other student identities, such as race/ethnicity and first-generation status, that are linked to marginalization in academia and thus may impact identity and belonging.

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Appendix 1: List of Survey Items

- Belongingness
    - I feel comfortable in engineering.
    - I feel I belong in engineering.
    - I enjoy being in engineering.
    - I feel comfortable in my engineering classes.
- Engineering Identity Recognition
    - My parents see me as an engineer
    - My instructors see me as an engineer
    - My peers see me as an engineer
    - I have had experiences in which I was recognized as an engineer
- Engineering Identity Interest
    - I am interested in learning more about engineering
    - I enjoy learning engineering
    - I find fulfillment in doing engineering
- Future Time Perspective - Instrumentality
    - I will use the information I learn in my engineering classes in other classes I will take in the future.
    - I will use the information I learn in engineering classes in the future.
    - What I learn in my engineering classes will be important for my future occupational success.
- Future Time Perspective - Perceptions of Future
    - I am confident about my choice of major.
    - Engineering is the most rewarding future career I can imagine for myself.
    - My interest in an engineering major outweighs any disadvantages I can think of.
    - I want to be an engineer.
- Future Time Perspective - Expectancy
    - I expect to do well in my engineering classes.
    - I am certain I can master the skills being taught in my engineering classes.
    - I believe I will receive an excellent grade in my engineering classes.
    - I am confident I can do an excellent job on the assignments in my engineering classes.
    - Considering the difficulty of my engineering classes, the teacher, and my skills, I think I will do well in my engineering classes.
- Test Anxiety
    - When I take a test I think about how poorly I am doing compared to other students.
    - When I take a test I think about items on other parts of the test I can't answer.
    - When I take tests I think of the consequences of failing.

- I feel my heart beating fast when I take an exam.
- I have an uneasy, upset feeling when I take an exam.

Appendix 2: Values-Intervention Activity

Below is a list of values and traits that are often important to engineers. Thinking about yourself, both inside and outside of your engineering classes, please indicate which values are very and somewhat important to you.

Please indicate at least 3 Very Important and 3 Somewhat Important values. The items are marked as 'Not Important' by default; to indicate your chosen values, select from the other two columns as needed.

	Not Important	Somewhat Important	Very Important
Self-direction: I value independence and self-direction when solving engineering problems.	x		
Stimulation: I value novel engineering challenges, new experiences, and creative problem-solving.	x		
Hedonism: I value the personal gratification of solving technical problems or helping to address real-world issues.	x		
Achievement: I value persistence in the face of difficulty and demonstrating competence and success in engineering.	x		
Power: I value leadership and the ability to make decisions and control resources in group efforts.	x		
Face: I value the prestige that an engineering degree offers.	x		
Security: I value security and stability (for example, financial security or access to clean water) for myself and others.	x		
Conformity: I value adhering to an objective engineering process and the ability to maintain a stable working environment.	x		
Tradition: I value the knowledge and understanding that traditional culture or religion provide when seeking engineering solutions.	x		
Benevolence: I value the welfare of people, such as the safety of my co-workers/classmates, and the wellbeing of my community.	x		

Universalism: I value understanding and appreciating all people and all of nature, seeking kindness and justice in my engineering work.	x		
Collectivism: I value collaboration and teamwork when working to achieve engineering goals.	x		
Other (Write-In Response)	x		

The values you picked as "Very Important" are listed above. With at least one of these values in mind, please respond to the prompt below and write 30-50 words in response.

Can you give an example of when this value was especially important or meaningful to you, and why?

The values you picked as "Very Important" are listed above. Using the same value you chose for the last prompt, please respond to the prompt below and write 30-50 words in response.

How will this value contribute to your success in the classroom and in the future as an engineer?

Appendix 3: Challenge-Intervention Activity

Below is a list of engineering challenges from the National Academy of Engineering. Thinking about yourself, both inside and outside of your engineering classes, please indicate which challenges are very and somewhat important to you.

Please indicate at least 3 Very Important and 3 Somewhat Important challenges. The items are marked as 'Not Important' by default; to indicate your chosen challenges, select from the other two columns as needed.

	Not Important	Somewhat Important	Very Important
Advance personalized learning (e.g., tailoring instruction to students' individual needs)	x		
Make solar energy economical and more widely used	x		
Enhance virtual reality for use in training, therapy, and entertainment	x		
Reverse-engineer the brain to further artificial intelligence, health care, and communication	x		
Engineer better medicines and tailor them to individuals	x		
Advance health informatics to enhance medical care and response to public health emergencies (like epidemics and pandemics)	x		
Restore and improve urban infrastructure to support communities and nations	x		
Secure cyberspace to protect privacy and enhance security	x		
Provide access to clean water for everyone	x		
Provide clean energy from fusion	x		
Prevent nuclear terror	x		
Manage the nitrogen cycle by developing better fertilizers and recycling waste	x		

Develop carbon sequestration methods to prevent global warming	x		
Engineer the tools of scientific discovery	x		
Other (Write-In Response)	x		

The challenges you picked as "Very Important" are listed above. With at least one of these challenges in mind, please respond to the prompt below and write 30-50 words in response.

> Can you give an example of when this challenge was especially interesting or meaningful to you, and why?

The challenges you picked as "Very Important" are listed above. Using the same challenge you chose for the last prompt, please respond to the prompt below and write 30-50 words in response.

> How will focusing on this challenge contribute to your success in the classroom and in the future as an engineer?