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The Impact of Inclusive Excellence Programs on the Development of Engineering Identity among First-Year Underrepresented Students

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Miss Jordan Michelle Hornback

The Impact of Inclusive Excellence Programs on the Development of Engineering Identity among First-Year Underrepresented Students

Abstract

The desire to broaden diversity in engineering has permeated STEM discourse and engineering education for decades. National leaders and funding agencies have given attention, priority and inducements to increase diversity in engineering. Yet, even with pervasive college-based initiatives aimed at broadening participation, national results remain stagnant. In the College of Engineering and Applied Science at the University of Colorado Boulder, an NSF-sponsored research project is creating a system-based model with *elements* and *practices* that could be applied to begin to alleviate the shortfall of diverse students in U.S. engineering schools.

"Inclusive excellence" refers to creating pathways to and through engineering that promote success for a highly diverse student body through learning communities, engaging academics and innovative policies. The *Inclusive Excellence Research Project* aims to investigate and define a system of varied pathways *to and through engineering* composed of three integrated sub-models: *Access*, *Performance* and *Retention*.

The data and results presented in this paper represent a glimpse into the larger *Inclusive Excellence Research Project*, specifically exploring the impact of our first-year curriculum strategy for underrepresented students. The research team posits that early development of professional engineering identity is a critical piece to scaffolding academic excellence and persistence within engineering. Identity development is investigated over time in four key curricular interventions—two short summer bridge programs targeting underrepresented populations, a large first-year engineering design course, and a large introduction to engineering course designed to help students understand various engineering career tracks. A comparison across these interventions begins to reveal elements leading to identity development related to community, team-building, fostering engineering skills and knowledge, and understanding engineering career paths.

For each intervention, identity was measured via the Group Identification Survey, a product of the Academic Pathways Study. The survey was administered before and after the two bridge programs and pre- and post-course for the two first-semester courses—totaling 510 participants across programs. To determine possible correlates of identity, students were also administered additional survey items, influenced in part by the Academic Pathways of People Learning Engineering (APPLE) survey. Four underrepresented populations—underrepresented minorities, women, low-socioeconomic, and first-generation students—were investigated for identity development. Data were analyzed using repeated measures analysis of variance procedures to determine pre to post differences and between demographic groups and programs. Results indicate significant differences in identity development across all four course/programs and specific relationships between demographics as well as additional associated variables.

Introduction

As our nation's population demographics shift, the rationale for increasing diversity in the engineering workforce has been articulated by leaders from all aspects of the engineering enterprise, and discussion on broadening participation has increasingly permeated STEM discourse and engineering education agendas for decades.[1-3] Yet, even with pervasive college-based initiatives aimed at broadening participation, results remain stagnant; the national average for underrepresented minority BS engineering graduates is flat, hovering at ~10% for the last 15 years[4,5] while the national average for women engineering BS graduates peaked at ~21% in 2002.[5,6] Clearly, a need exists to identify models that bolster diversity; very likely, these models will be multifaceted and complex.

Inclusive Excellence Research Project

The *Inclusive Excellence Research Project* is an NSF-funded investigation at the University of Colorado Boulder that takes a *systems approach* to promoting academic excellence and retention through inclusion. "Inclusive excellence" refers to creating pathways to and through engineering that promote success for a highly diverse student body through learning communities, engaging academics and innovative policies. Thus, the holistic *Inclusive Excellence System Model* (Figure 1) we hope to create will weave research-based *elements* with successful *practices* from three core sub-models: *Access*, *Performance* and *Retention*. The *Access* sub-model investigates how to broaden the pathways into engineering college for students from underrepresented backgrounds and for the *next-tier*[*] of potential students, subsequently expanding the diversity of the engineering student population. The *Performance* sub-model focuses on mechanisms and strategies to increase academic performance and probes how performance is related to persistence to graduation. The *Retention* sub-model concentrates on multiple methods and interventions to foster learning communities and development of a professional engineering identity. These sub-models are interrelated, with each element critical to the overall success of the *Inclusive Excellence System Model*.

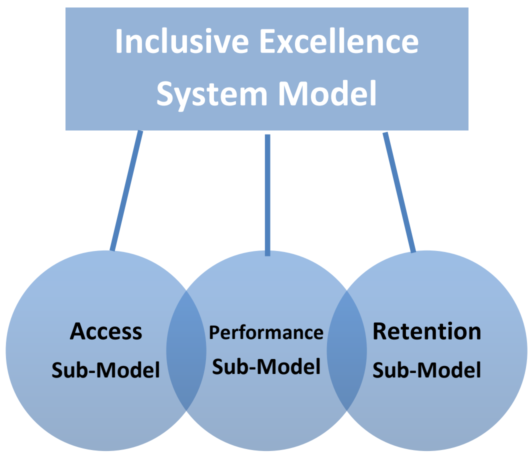

Figure 1. *Inclusive Excellence System Model* and associated sub-models.

The intended outcome of the *Inclusive Excellence Research Project* is dissemination of practices, models and outputs that other institutions may adapt and adopt to create their own inclusive excellence system to counter the shortfall of diverse students in U.S. engineering schools.

[*] Next-tier students are those just below "making the cut" for acceptance to a given engineering college based on its admission requirements. These students are deemed to have high potential and probability for success in engineering if a pathway for such can be identified.

For the *Retention* sub-model, we hypothesize that the early cultivation of professional engineering identity is a way to scaffold academic excellence and persistence to graduation. Previous studies have demonstrated relationships between engineering identity and retention,[7-10] and preliminary data leads us to believe that our summer bridge and first-year engineering courses influence student professional engineering identity. Thus, our first research question asks: what impact do summer bridge and first-year engineering courses have on engineering identity development?

For this paper, the authors used quantitative surveys, with an emphasis on underrepresented first-year students, to investigate professional engineering identity development over time. The interventions investigated include GoldShirt Program Bridge, as well as the Achieving Student Performance Interest and Retention in Engineering (ASPIRE) Bridge. The two targeted courses are First-Year Engineering Projects (FYEP) and Introduction to Engineering.

The *Inclusive Excellence System Model* is under early development; thus, this paper does not test specific model components *yet.* The research covered in this paper is exploratory to identify variables that impact development of engineering identity.

Research-to-Practice Testbed

The BOLD Center (Broadening Opportunity through Leadership and Diversity), with college-wide responsibility for broadening participation in engineering, serves as a research-to-practice testbed for implementing elements of the *Inclusive Excellence System Model*. Executing an inclusive excellence strategy, the BOLD Center leads the design and implementation of programmatic and curricular elements—responding to and incorporating real-time research and evaluation findings.

Background

Summer Bridge Programs

GoldShirt Bridge is part of an innovative program supporting motivated, next-tier students who may benefit from an additional partial year of math, science and humanities course preparation before diving into the full undergraduate engineering curriculum. Students in this program agree to a five-year curriculum, live together in a dorm-based residential learning community, and participate in the two-week summer bridge—all of which is designed to create an immersion environment that jump-starts the creation of a cohesive learning community.

ASPIRE Bridge—also two-weeks—presents more of a standalone experience in which students from a variety of engineering majors come together to create community, develop leadership skills and study habits, and gain academic scaffolding skills. Structured opportunities throughout the following year help students reconnect, share experiences and support each other.

During the two simultaneous summer bridge programs, students live in the same residential hall, eating and participating in social activities together. In both programs, exposure to math and physics is introduced through collaborative exercises and homework taught by a mix of engineering faculty and students. A team design project expo culminates both two-week experiences (an example project is a solar oven created and tested to achieve maximum temperature and cooking efficiency), providing an opportunity for students to showcase their craftsmanship.

In addition to academic experiences to help students transition to engineering college expectations, a number of community-building activities are conducted during both bridge programs. Each program kicks off with a team challenge course in a mountain setting, reported to be eye-opening and inspirational for many students. A challenge course features close-to-the-ground activities that require group problem solving and collaboration to achieve given goals.

To cultivate student comfort, students from both bridge programs meet college faculty and leaders at two casual dinners. Additional informal activities cultivate social and community ties, such as attending on-campus plays and visiting local industry sites and college research labs. Upper-division student mentors are pervasively involved with the bridge students, and are selected based on their backgrounds, applications and interviews; all attend a mandatory training workshop that instills programmatic approaches to working with students. For instance, student mentors are trained in using positive messages about engineering, such as “engineers use their creativity to change the world.”[22]

First-Year Courses

The two first-year courses include the First-Year Engineering Projects (FYEP) course and the Introduction to Engineering course.

First-Year Projects—The FYEP course focuses on hands-on, team-based, project-centered design, and is a three-credit, one-semester course serving ~450 first-year students yearly in sections of 32 students. The course is required for mechanical, aerospace, civil and environmental engineering majors, and is an elective for all others. The main course goal is to make connections between the theoretical aspects and the professional practice of engineering, helping budding engineers understand that engineering is a helping, people-oriented profession that underpins our economy and quality of life. This integration is accomplished by introducing students to the design-build-test product prototype cycle in a team-based setting, with students learning manufacturing, electronics and assembly skills as they develop group projects from scratch. Other course components include team dynamics, communications and social styles workshops. Many projects are created for clients—introducing the ambiguity and social aspect of considering evolving customer demands in product design specifications. FYEP results over a 10-year period show a 19% increase in engineering retention to graduation for “takers,” with higher retention attainment for women and minorities.[23-24]

Introduction to Engineering—This course, themed around the NAE Engineering Grand Challenges, introduces the engineering profession through a broad, multidisciplinary perspective of contemporary engineering practice, and prepares students to make informed engineering major choices. The course is in pilot phase and is required for undeclared, aerospace and mechanical engineering students, and may ramp up to serve most of the first-year cohort. Students meet in a large plenary format and in smaller discipline-specific sections.

In the plenary sessions, class activities and peer feedback exercises provide skills practice and exploration of topics such as ethical challenges, new engineering developments, and historical engineering achievements and disasters. Course highlights include visits from upper-division students and industry professionals who provide sage insights and interesting commentary on academic and career choices.

Professional Identity Study

This study is concerned with the impact of the four curricular offerings described above on the development of students' *professional engineering identity*. Professional or career identity can be considered a form of social identity that develops over time, and includes shared discourse, values and skills characteristic to members of that profession.[11-12] It is also a feeling of fitting within the group (in this context, engineering), and can influence post-graduation career choices.[8,13,14] Emerging engineering identity formation research has examined the influencing factors on students' engineering identities, how identity changes throughout a student's education, and how much a student's identification with engineering plays a part in individual decisions to persist in engineering.[7-10,15]

Influencing factors that have been connected to professional identity include understanding of team dynamics, technical/theoretical knowledge, and experience in the profession.[11,16,17] Preliminary studies on engineering students' attitudes towards these influencing factors suggest that they are significantly impactful during the first years of an undergraduate degree.[18,19,20,21] Students who know more about the profession are more likely to relate to it, so an engineering student's connection to her academic environment may impact her long-term professional career identity.[11,14,16] *This suggests that the opportunities for strengthening identity should be systematically increased during the early years of an engineering education.*[10] The present study builds upon these findings by investigating identity development just prior to, and during, the first semester of an engineering program.

Method

Participants

Students in the two summer bridge programs included 29 GoldShirt Bridge and 37 ASPIRE Bridge students. Participants in the two first-year engineering courses included 98 students in the FYEP design course, 211 students in the Introduction to Engineering course, and 135 students who took both—for a total of 444 students in the first-year courses.

Participant demographics were self-reported by gender, ethnicity, socioeconomic status and generational status. Table 1 displays the gender breakdown for the two bridge programs and the two first-year courses. ASPIRE Bridge had the highest number of female participants (59%), followed by GoldShirt Bridge (38%).

Table 1. Participants by gender, for each program/course.

Program/Course	Male	Female
GoldShirt Bridge	62%	38%
ASPIRE Bridge	41%	59%
Taking FYEP only	73%	27%
Taking Introduction to Engineering only	83%	17%
Taking both first-year courses	73%	27%

Tables 2 and 3 present the (self-reported) ethnic and socioeconomic distribution of participants. In GoldShirt Bridge, the largest ethnic group was Latino students, while ASPIRE Bridge and both first-year courses were primarily comprised of Caucasians students.

Table 2. Participants by ethnicity, for each program or course.

Program/Course	African American	Asian American	Latino	Native American	Caucasian	Multi-Racial	Other
GoldShirt Bridge	7%	17%	41%	0%	21%	7%	7%
ASPIRE Bridge	0%	3%	19%	3%	67%	0%	8%
Taking FYEP only	0%	6%	10%	0%	80%	3%	2%
Taking Intro to Engineering only	1%	11%	8%	1%	75%	2%	3%
Taking both first-year courses	2%	8%	8%	1%	77%	2%	2%

Table 3. Participants by socioeconomic status, for each program or course.

Program/Course	High	Upper-Middle	Middle	Low-Middle	Low
GoldShirt Bridge	0%	39%	41%	24%	17%
ASPIRE Bridge	14%	17%	25%	14%	8%
Taking FYEP only	9%	43%	37%	8%	3%
Taking Intro to Engr only	8%	42%	33%	11%	5%
Taking both first-year courses	10%	42%	31%	13%	4%

Table 4 indicates the numbers of students in the bridge programs and first-year courses who identified themselves as the first generation in their families to attend college.

Table 4. Participants by generational status, for each program or course.

Program/Course	First-Generation College	Not First-Generation
GoldShirt Bridge	52%	48%
ASPIRE Bridge	8%	92%
Taking FYEP only	13%	87%
Taking Introduction to Engineering only	12%	88%
Taking both first-year courses	14%	86%

GoldShirt Bridge overwhelmingly had the highest percentage of first-generation college students (52%).

Bridge and First-Year Assessment

For each bridge program and first-year course, pre- and post-surveys were administered, with professional engineering identity measured via the Group Identification Survey from the Academic Pathways Study.[25] The identity survey has been found to have adequate reliability and validity; it is composed of 29, six-point, Likert-type items that are summed into four subscales:

- *Centrality:* The extent to which a student defines himself or herself as an engineer,
- *Private regard*: The extent to which a student feels positively or negatively about engineering and engineers,
- *Public regard:* The extent to which a student perceives others feel positively or negatively about engineering and engineers,
- *Group identification:* The value an individual places on being an engineer and the emotional-affective dimensions of belonging to this group.

The first-year course surveys also incorporated additional items developed in-house and from the APPLE survey from the Academic Pathways Study[26], as well as the Community Service Attitudes Scale.[27] These items were also Likert-type questions and measured variables that might be associated with professional identity, such as items related to pre-college engineering experiences, engineering skills, interest in engineering and knowledge of engineering as a career.

Data Analysis

Identity development was measured from the pre- to post-assessment, employing a repeated measures ANOVA for each subscale and for the overall identity survey. Each subscale and the overall identity survey were tested for concordance, a non-parametric measure of association similar to the coefficient of internal consistency as a measure of reliability. Finally, a non-parametric, chi-square-based procedure known as Exhaustive Chi-squared Automatic Interaction Detection (CHAID) analysis[28] was employed in an attempt to identify variables that might be associated with the identity measures.

Results

Concordance

Tests of Kendall's coefficient of concordance indicated that the items included in each subscale of the identity survey were concordant ($p < 0.05$; using the standard null hypothesis that H_0: W' = 0, which is equivalent to the assumption that no concordance exists[29]) within the pre- and post-tests for the two bridge programs and the two first-year courses. This provides additional evidence that the items within each subscale are measuring the same construct, justifying the use of a total index value for each set of subscale responses.

Centrality

Table 5 displays the centrality (the extent to which a student defines himself or herself as an engineer) subscale results for each program/course. Identity results are presented as percentages to foster comparison across subscales. Results revealed the greatest gains in centrality scores for ASPIRE Bridge students.

Table 5. Participant centrality scores, for each program/course.

Program/Course	Pre-Assessment	Post-Assessment	Change
GoldShirt Bridge	66%	69%	5%
ASPIRE Bridge	62%	71%	15%
Taking FYEP only	62%	61%	-2%
Taking Introduction to Engineering only	63%	61%	-3%
Taking both first-year courses	62%	60%	-3%

The repeated measures ANOVA revealed significant differences in the mean values among the participants from the pre- to post-assessment for both bridge programs ($p < 0.05$, $\omega^2 = 26.2\%$) and first-year courses ($p < 0.05$, $\omega^2 = 0.9\%$). However, changes were in different directions—with students in bridge programs significantly gaining in centrality while students in first-year courses significantly declined. Subsequent analyses did not find significant differences for changes in mean centrality levels between the two bridges or between the two first-year courses.

Exhaustive CHAID analyses of the bridge programs using all of the demographic variables available for the participants indicated a higher centrality score associated with low-socioeconomic students at the pre-test, but these differences disappeared in the post-test. Exhaustive CHAID analyses of the first-year courses, which included demographic as well as additional variables that were thought to have a potential effect on these scores, indicated that higher centrality *scores* at the pre- and post-assessment were most associated with students who chose to study engineering because it was fun and it felt good, while positive *changes* in centrality were most associated with students who intended to complete an engineering major.

Private Regard

Table 6 depicts the private regard (the extent to which a student feels positively or negatively about engineering and engineers) subscale results for each program/course. Results revealed higher pre-test scores compared to centrality, and the maintenance of these scores throughout the bridge programs.

Data analysis indicated no statistically significant differences between the pre- and post-assessment for the bridge programs. Rather, high scores in the 90^{th} percentile were maintained. And, no significant differences between the bridge programs were indicated. However, private regard scores dropped significantly ($p < 0.05$, $\omega^2 = 24.8\%$) for both first-year courses without finding differences between them.

Table 6. Participant private regard scores, for each program/course.

Program/Course	Pre-Assessment	Post-Assessment	Change
GoldShirt Bridge	90%	90%	0%
ASPIRE Bridge	93%	93%	0%
Taking FYEP only	86%	80%	-7%
Taking Introduction to Engineering only	89%	81%	-9%
Taking both first-year courses	87%	80%	-8%

Exhaustive CHAID analyses on the demographic variables for the bridge program participants indicated that Caucasian students had higher pre- and post-assessment private regard *scores*, versus all other non-Caucasian participants. Analyses of the first-year courses indicated that higher private regard scores at the pre-assessment stage were associated with scores of students who chose to study engineering because it was interesting, while *changes* in private regard scores were associated with self-ratings of higher math skills.

Public Regard

Table 7 describes the public regard (the extent to which a student perceives others feel positively or negatively about engineering and engineers) subscale results for each program/course. The greatest gains for this subscale were for GoldShirt Bridge students.

Table 7. Participant public regard scores, for each program/course.

Program/Course	Pre-Assessment	Post-Assessment	Change
GoldShirt Bridge	84%	87%	4%
ASPIRE Bridge	87%	89%	2%
Taking FYEP only	82%	81%	-1%
Taking Introduction to Engineering only	86%	83%	-3%
Taking both first-year courses	84%	83%	-1%

Repeated measures analyses found a statistically significant pre to post gain ($p < 0.05$, $\omega^2 = 7.3\%$) for the bridge programs and a significant pre to post drop for both first-year courses ($p < 0.05$, $\omega^2 = 4.1\%$). No differences were found between the bridge programs. A statistically significant interaction ($p < 0.05$) was found for the Introduction to Engineering course, which dropped at a steeper rate than either the FYEP course or taking both first-year courses together.

Exhaustive CHAID analyses of the bridge programs indicated Caucasian students as having higher public regard scores on the pre- and post-assessment than non-Caucasian students. Analyses of the first-year courses found higher self-ratings of data analysis skills to be associated with greater gains in public regard scores while higher scores at the post-assessment were associated with a greater community service orientation towards volunteerism.

Group Identification

Table 8 summarizes the group identification (the value an individual places on being an engineer and the emotional-affective dimensions of belonging to this group) subscale results for each program/course. Double digit gains were found for GoldShirt Bridge participants.

Table 8. Participant group identification scores, for each program/course.

Program/Course	Pre-Assessment	Post-Assessment	Change
GoldShirt Bridge	81%	89%	10%
ASPIRE Bridge	79%	84%	6%
Taking FYEP only	74%	71%	-4%
Taking Intro to Engineering only	75%	71%	-5%
Taking both first-year courses	73%	71%	-3%

Repeated measures ANOVA analyses revealed statistically significant differences for both bridge ($p < 0.05$, $\omega^2 = 31.1\%$) and first-year programs ($p < 0.05$, $\omega^2 = 6.0\%$), again with bridge scores gaining significantly while the first-year course group identification scores dropped. No statistically significant differences were found between the bridge programs or first-year courses.

Exhaustive CHAID analyses on the demographic variables associated with participants from the bridge programs found no explanatory factors at the pre-test, but minority students had a higher group identification score at the post-test than their Caucasian counterparts. For minorities, a program effect was found for group identification scores, with GoldShirt Bridge students having higher scores at the post-test than ASPIRE Bridge students. Analyses of the first-year courses indicated that higher pre-assessment group identification scores were associated with students who chose to study engineering because it felt good, while higher post-assessment scores were associated with higher community service orientations towards service projects. Changes in group identification scores in the first-year courses were most associated with ethnicity, with African American students' scores dropping more sharply than students of other ethnicities.

Total Identity

Table 9 displays the total identity scores across all four subscales for each program/course. Modest gains were found for GoldShirt Bridge participants.

Table 9: Participant total identity scores, for each program/course.

Program/Course	Pre-Assessment	Post-Assessment	Change
GoldShirt Bridge	77%	82%	6%
ASPIRE Bridge	80%	84%	5%
Taking FYEP only	74%	72%	-3%
Taking Introduction to Engineering only	77%	72%	-6%
Taking both first-year courses	75%	73%	-3%

Data analysis results indicated a gain in total identity scores for the bridge programs ($p < .05$, $\omega^2 = 31.9\%$) and a drop ($p < .05$, $\omega^2 = 10.3\%$) for the first-year courses. No differences were found between the bridge programs or between the various first-year course options.

Exhaustive CHAID analyses on the demographic variables for the bridge courses indicated Caucasian students had higher total identity at the pre- and post-assessment, and these students experienced greater *gains* in identity. Analyses of the first-year courses indicated that higher total identity scores were associated with students who chose to study engineering because it was fun, while higher post-assessment scores were associated with higher community service orientations towards service projects. Changes in overall identity were most associated with an intention to complete a major in engineering, with greater gains associated with greater identity.

Discussion

One overall pattern that emerged from the results was that professional identity tended to increase during the summer bridge programs and decrease during the subsequent fall's first-year engineering courses. Given the generally high identity scores at the pre-assessment for the first-year engineering courses, one possible interpretation is that students begin to question whether an engineering major is a good fit. An increase in identity during the summer bridge programs is an interesting contrast to these fall semester declines.

Bridge program results suggest that during a controlled, inclusive, and yet demanding program, a sense of professional engineering identity can be increased. While gains were modest overall, a 15% gain in centrality for ASPIRE bridge and 10% gains in group identification for GoldShirt bridge are worthy of future research—especially since group identification was a key objective for the underrepresented students engaged in the bridge programs.

Results from the Exhaustive CHAID analyses provide interesting insight into the impact of demographic factors and variables that are associated with *identity*. From the demographic analysis of the bridge scores, ethnicity emerged as a key factor associated with identity development—with Caucasian students generally having higher scores than minority students at the pre- and post-assessment stages.

Ethnicity results turned out differently in the case of *group identification*, with minority students having higher group identification scores at the bridge post-test than Caucasian students. And, ethnicity did not emerge in the first-year courses, with one notable exception—African American ethnicity was most closely associated with a *decline* in group identity during the first year.

Exhaustive CHAID analyses of the first-year courses indicated that non-demographic variables were more associated with identity development during the first semester. One repeated pattern was the association at the pre-assessment between higher identity scores and students who chose engineering because it was fun and felt good. In contrast, identity declined for those students who lost interest in obtaining engineering degrees. These results highlight the importance of capturing early interest in engineering and striving to maintain it during the critical first-year of engineering studies. Another factor associated with change in interests was the students' selfestimates of their own math and data analysis skills, highlighting the importance of confidence in one's quantitative skills in the development of an engineering identity.

Finally, a community-service orientation related to volunteering for service projects emerged as an associate of identity at the post-assessment, indicating some shift from a professional identity centered on intrinsic motivators (such as good feelings about engineering) to extrinsic motivators such as a community service orientation. This is likely a result of the emphasis placed on service as part of an engineering career in both first-year courses, particularly the First-Year Engineering Projects course, in which 60% of the students engaged in client-based service design projects.

Implications

The gains in identity during the summer bridge programs suggest that these types of programs might be important for building professional engineering identities, particularly in the area of group identification for minority students, which emerged as a strength in the bridge programs and a weakness during the subsequent fall semester for African American students. These findings echo other research that has found that professional identity develops at an early age.[11] Another implication is the possible need to do more in first-year engineering courses to stem the tide of potential dis-identification with engineering during the first year, especially for African American students. Although implicit in course objectives, professional identity development is not a specific goal of the FYEP course. While it is an explicit goal of the Introduction to Engineering course, the latter curriculum lacks the client-based, hands-on service learning projects that were found to be associated with identity development. Perhaps better curriculum integration is called for.

The data analysis for this study highlighted the importance of incorporating non-parametric methods—underutilized in survey analysis—which provide an alternative lens to parametric methods for investigating data from a mixed methods perspective. In this study, measures of concordance provided additional technical support for the consistency of the survey and its subscales, and the Exhaustive CHAID analysis provided a useful and engaging method for determining associates of identity.

Finally, factors beyond student demographics—gender, minority/majority, socioeconomic and first-generation status—were associated more with identity scores in the first-year courses. These results suggest that first-year engineering education endeavors could benefit from much more focus on identity development by capturing student interest in engineering, developing a sense that engineering is fun, and cultivating confidence in math skills. These associates of identity will be applied to the development of the *Inclusive Excellence System Model*.

Limitations and Suggestions for Future Research

The study is limited by sample size with respect to both numbers of students in the bridge programs and underrepresented students, including underrepresented ethnicities, women, low-socioeconomic and first-generations students. The small sample sizes do not allow for cross-category comparisons, such as underrepresented women. Thus, a note of caution is warranted when interpreting results for underrepresented students, particularly those for African American students whose status emerged as an associate of group identification. While the continuing research will add bridge programs participants annually (including underrepresented students), a better picture of identity development among underrepresented engineering students may require collaboration among universities.

Another limitation is that percentage change scores are modest, ranging from 15% to -9%. While a number of these changes are significant, caution should be used in interpreting significant results in combination with small sample sizes. A decline of 9% in private regard should be viewed with concern, and as a call for more research and modest changes, not for wholesale curriculum restructuring.

The contributions of the results are also limited by not having a control group to assess identity development among first-year students not enrolled in the two first-year courses. During the first semester, engineering students are blitzed with challenging math and science courses; future research might peer into whether identity undergoes *an even steeper* decline if first-year students are not engaged in interdisciplinary courses focused on hands-on design and engineering careers. Our longitudinal retention results over 11 years consistently show that students who take the FYEP course are 19% more likely to graduate from engineering than non-takers. So while engineering identity is not enhanced by the course, something good is happening and deeper investigations are recommended.

Future research will also target a more longitudinal pattern of identity development. This study provides a snapshot of development during the bridge programs and then during the subsequent first semester of engineering study. The next level of data analysis will follow identity development from the bridge through the entire first year and beyond.

The *Inclusive Excellence Research Project* will be expanded to include additional correlates of identity, other than self-reported data, such as retention and grades. Also, qualitative information will be combined with quantitative results to provide a deeper explanation of findings. Finally, the *Inclusive Excellence System Model* will be expanded to a greater level of specification from phase 1 (our current phase) of the overall research study, incorporating findings from this analysis and investigating the impact of specific model components on identity development.

Conclusions

Professional engineering identity was analyzed during two summer bridge programs and two first-year engineering courses and found to develop in a positive direction in the bridge programs and deteriorate in the first-year courses. This highlights the need to isolate identity-building components of bridge programs that could be intentionally infused into the design of first-year engineering courses, and supports the importance on focusing on early career identity development as emphasized in other studies.

A number of factors also emerged as *associates* of identity, including ethnicity, interest, skills and community service orientation. These results can be used to find additional methods for nurturing interest in engineering, leveling the access playing field, building quantitative skills and emphasizing the service-oriented side of engineering. With these improvements, we might attract and support an engineering student population that is more inclusive and passionate about providing engineering in service to society.

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