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Inclusive Engineering Identities; Two New Surveys to Assess First-Year Students' Inclusive Values and Behaviors

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The under-representation of women and people of color in engineering careers is not fully explained by their lower representation in engineering degree programs. There is also attrition from the profession after engineering degrees are earned. Currently, 20% of engineering degrees are awarded to women, and only 13% of the engineering workforce are women. Also, underrepresented minorities earn a small proportion of the science, technology, engineering, and mathematics (STEM) degrees, and represent an even smaller proportion of the workforce. For example, while approximately 11% of the total workforce is Black, only 6% of the STEM workforce is Black (U.S. Department of Education, 2016). Often cited issues for leaving engineering are uncomfortable and unsupportive work climates (Singh, Fouad, Fitzpatrick, & Chang, 2014). Women who have earned bachelors degrees in engineering left engineering at much higher rates than men, and these women cite issues of poor workplace climates, bosses, or culture (Singh et al. 2014). Women who stayed in engineering cite being supported by their organizations and perceiving their work as valued (Singh et al. 2014). More recent research demonstrated this uncomfortable culture exists well before entering the workforce. Undergraduate women cite informal interactions and sexism in teams as propagating a culture that is unwelcoming to women (Seron, Silbey, Cech, & Rubineau, 2016).

Most efforts to change these percentages of representation both in the workforce and in school focus exclusively on those in the minority. However, our NSF funded study seeks to change the culture of engineering to be more welcoming and supportive of women and underrepresented minorities by helping ***all*** engineers appreciate and seek out diversity In our project we have worked with several instructors to infuse first year engineering classes with activities to promote diversity and inclusion. By working towards cultural change we hope to impact both university degree programs and engineering practice. We developed intervention activities for first year engineering courses to promote what we termed an inclusive engineering identity. Inclusive engineering identity is displayed by engineers who value diversity in engineering and promote inclusive behaviors within the profession. When we tried to measure the impact of our intervention on all engineering students, we quickly discovered there were no psychometrically sound measures to assess how engineering students valued diversity specifically in the context of engineering and how likely they were to enact inclusive behaviors. Thus, this research study details the development of two new scales to measure how students develop an inclusive engineering identity.

Background

The current study. In fall 2015, we developed new curriculum to promote inclusive engineering identities within first year engineering courses at a large public university. To assess the impact of the new curriculum, we used two previously developed scales: *Appreciation of Cultural and Ethnic Diversity* scale (Price et al., 2011) and *Science Identity* survey (Chemers et al. 2010; Estrada et al., 2011) adapted for engineering. While these two scales addressed diversity broadly and a more general engineering identity, the two scales did not capture how students valued diversity within engineering specifically or how likely students were to enact inclusive behaviors. Thus, we created two new scales: Valuing Diversity within Engineering and Inclusive Behaviors in Engineering.

To determine what constructs needed to be addressed in the two scales, we examined literature addressing reasons for promoting diversity and inclusion in the workplace and school – specifically in engineering; and barriers to participation encountered by students from underrepresented populations in engineering For the Valuing Diversity Scale, three constructs surfaced. Specifically, engineers should value diversity to (a) address issues of social justice (e.g. Baillie, Pawley, & Riley 2012), (b) improve the bottom line (e.g. Lückerath-Rovers 2013), and (c) improve the work environment (e.g. Fouad, 2014). For the Inclusive Behaviors scale, three constructs also surfaced. Namely, engineers should engage in behaviors that (a) value all team members, (b) create an environment free of discrimination and bias, and (c) leverage diversity to improve teams (Finelli et al., 2011; Tonso, 2006).

Valuing Diversity scale. The items on the valuing diversity scale are intended to go beyond the general *Appreciation of Cultural and Ethnic Diversity* scale, to give specific attention to why diversity is valuable to engineers and engineering practice in particular. The three constructs considered in the initial conception of the scale asked respondents to consider societal concerns, economic issues, and workplace dynamics as reasons for engineers to value diversity.

Social justice can be defined as "…full and equal participation of all groups in a society that is mutually shaped to meet their needs" (Adams, Bell and Griffin 2007). This definition relates to engineering in more than one way. First, to achieve social justice, all members of society with the interest and aptitude must have the opportunity to fully participate in engineering practices. Thus the changing demographics of the United States might be one reason engineers should care about diversity (Change the Equation, 2015). Second, as described in the preamble to the National Society of Professional Engineers Code of Ethics, "Engineering has a direct and vital impact on the quality of life for all people" (NSPE, n.d.), and thus engineers must create products and design solutions to meet the needs of all people. There are numerous historical examples demonstrating the ways in which engineering/scientific/technical teams with limited perspectives have contributed to inequitable designs, (e.g. the interstate highway system (Karas 2015), medical research (Holdcroft 2007), automobile testing standards based on a male occupant (Shaver, 2012).

The second construct in the Valuing Diversity scale recognized the very pragmatic rationale behind many diversity efforts: to improve the bottom line. A recent McKinsey & company report studied the financial performance of companies in the UK and North America and found that companies with leadership demographics "in the top quartile of racial/ethnic diversity were 30 percent more likely to have financial returns above their national industry median" (Hunt, Layton and Prince, 2015, p. 1) while companies in the bottom quartile for both ethnic/racial and gender diversity lagged behind in their industry. While the demonstrated link between diversity and financial performance is not causal, several possible reasons behind the link have been hypothesized, such as the ability of diverse engineers to better understand customer needs and to design improved products.

The final construct looked at diversity as a way to improve the work environment. Because of the power of diversity to foster creativity and provide new perspectives on a problem, diverse teams have been shown to be more capable of solving truly difficult problems than teams of the similar "smart" people (Page 2007). Diversity in leadership has also been shown as a way of attracting and retaining the best talent (Hunt, Layton and Prince, 2015). For example, women have been shown to leave the engineering profession due to poor workplace climate (Fouad, Singh, & Fitzpatrick, 2011).

Inclusive Behaviors scale. While valuing diversity is an important characteristic, we argue that behaving inclusively is an equally critical trait educators can teach students as they develop inclusive professional identities. Subsequently, we created the Inclusive Behaviors scale to measure three constructs where engineers can manifest inclusivity in their actions.

Valuing all team members is the first construct we address in the Inclusive Behaviors scale. The notion of teamwork is supported by statements from the National Academy of Engineering (NAE; 2004) and the Accreditation Board for Engineering and Technology (ABET), the engineering accreditation body. More specifically, NAE has articulated the important role teamwork plays in the engineering profession, and ABET (2016) has required engineering programs to show how their students graduate with the ability to work on teams with a diversity of disciplines. Student teams that work effectively exhibit positive interdependence, which Johnson, Johnson, and Smith (2007) use to describe the relationship between individual success and team success, where a team cannot experience overall success unless each individual member on the team experiences success. We expand upon this concept by making explicit the relationship between facilitating individual success and valuing each team member, where a student can experience more success when s/he is valued. Arguably, creating opportunities for students to engage in robust teamwork can be facilitated when educators increase students' awareness about the benefits of valuing all team members, a construct that is often implied but not explicitly discussed in teamwork literature.

Creating an environment free of discrimination and bias is the second construct we address in the Inclusive Behaviors scale. According to Cooper (2009), teams function better when space and bandwidth exist for team members to reflect on how well they work together. A prerequisite for collaborating productively is to purposefully design and facilitate a robust learning environment where people recognize and work to decrease their own biases. While overt forms of discrimination and bias exist, there are implicit forms of discrimination and bias as well. To mediate implicit bias, for example, Project Implicit (2011) is a multi-institutional and multi-disciplinary initiative that uses research and practical tips to help people recognize where they are subconsciously treating people differently and enacting discrimination. When educators organize curricular and co-curricular experiences for students to reflect on their own potential biases and discriminatory actions, they can work toward creating an environment free of discrimination and bias.

Leveraging diversity to improve teams is the last construct we address in the Inclusive Behaviors scale. Although higher education institutions and political bodies laud the benefits of diversity (Paguyo & Moses, 2011), the presence of diversity in and of itself is insufficient toward creating robust outcomes in classrooms, teams, workplaces, and societies (Page, 2007). In addition to creating teams that represent diversity in terms of gender, race, and problem-solving perspectives (Hong & Page, 2004; Tonso, 2006), such heterogeneous teams must be sustained through purposeful activities where people understand how to bring diversity to bear in ways that progress engineers toward project goals (Finelli et al., 2011).

Method

Sample and Procedure. The larger study was focused on changing first year engineering curricular activities, thus our sample are all first year engineering students. All students were from a large, R1 mid-west public university and enrolled in at least one of three first introductory engineering classes (mechanical engineering, civil engineering, and a general engineering course that covered multiple engineering disciplines). All students were invited to participate. Out of approximately 400 invitations to participate, 276 students responded to the survey (69% response rate). Students responded to the survey via an online platform.

Item generation and initial validation. After writing multiple items per construct for each scale, the initial items (44 total items across the two scales) were reviewed by four content experts using the recommendations by Netemeyer, Bearden, & Sharma (2003). Multiple areas of expertise were represented by the content experts: educational psychology, assessment, philosophy/feminist theory, diversity, and science, technology, engineering, and mathematics (STEM) content. Three reviewers had terminal degrees, and one had a masters degree. After incorporating their feedback, we piloted the surveys with first year engineering students in fall 2016.

For the Valuing Diversity in Engineering scale, students were prompted by the following statement, "Engineers should value diversity in order to" followed by a series of value statements, such as "better serve a diverse population." Students were asked to respond on a Likert scale (1- strongly disagree to 7- strongly agree).

For the Inclusive Behaviors scale, students were prompted by the following statement, "While working on a team, I" followed by a series of behaviors, such as "encourage every team member to share their perspective." Students then responded to each statement on a Likert scale (1-very unlikely, 7- very likely).

Factor extraction and item retention. As an initial step in providing evidence of validity for each of the scales, we conducted exploratory factor analyses. The valuing diversity in engineering scale asked how strongly students agreed with statements related to what diversity can bring to engineering. The inclusive behaviors in engineering scale asked students to indicate how likely they were to enact specific behaviors. As a result the two scales had differing stems—the first asked students to what degree they agreed with statements and the second asked students to indicate actual behavior. Because the scales were designed to capture unique although potentially related constructs and used different stems, we chose to conduct separate exploratory factor analyses for each scale.

We applied exploratory factor analysis (EFA) with principal axis factoring (Thompson, 2004) to the data from the two surveys. We examined Kaiser-Guttman rule, scree plot, parallel analysis

(Hayton et al., 2004), and Velicer's minimum average partial (MAP; Velicer, Eaton, & Fava, 2000) test to determine the number of factors. To maintain a simple structure, for items to be retained on a factor, the item had to have a pattern coefficient of at least .40 on the primary factor and less than .25 on any secondary factor.

Results

Survey 1: Valuing Diversity within Engineering. Although we intended the survey to capture three constructs, all of the results (Kaiser-Guttman rule, scree plot, parallel analysis, and MAP) indicated a two factor solution. The resulting two factors were a collapsed version of the original three. The two factors were engineers should value diversity to: (a) fulfill a greater purpose (internal motivation) with 6 items, $r = .90$, and (b) serve customers better (external motivation) with three items, $r = .81$. The extracted factors explained 63% of the variance in the data. See Table 2 and 3 for the final retained items and factor loadings.

Fulfill a greater purpose. The retained items contained items from all three of the original hypothesized constructs. There were six items on the scale, such as: "Engineers should value diversity to work for a greater cause." The pattern coefficients exceeded .60 for each item. A high score on this factor indicated the engineering student perceived valuing diversity aligned with a strong inward desire for purpose and fairness in their work. As shown in Table 1, students mostly agreed with the statements with a moderate amount of variation. The mean scores indicate a strong internal motivation for students in fulfilling a purpose in the field of engineering.

Serve customers better. Three items were retained on this subscale, such as: "Engineers should value diversity to improve products." The focus here is external or a desire to meet needs of others. The pattern coefficients exceeded .65 for each item. A high score on this factor indicated the engineering student believed customers are better served when diversity is valued. The mean scores of students, illustrated in Table 1, indicate that students strongly endorsed the importance of diversity in service to customers. Also, the smaller deviation, in comparison to fulfilling a purpose, show that students generally agreed diversity promoted better customer service.

The two subscales, fulfill a greater purpose and serve customers better, were positively correlated, $r = .59$.

Survey 2: Inclusive Behaviors in Engineering. The MAP and parallel analysis both indicated a two factor solution, the scree plot indicated a three factor solution, and the Kaiser-Guttman rule indicated a four factor solution. Because the Kaiser-Guttman rule and the scree plot tend to over extract factors (Velicer et al. 2000), we chose to extract two factors. The two factors were engineers should (a) challenge discriminatory behavior with five items, $r = .89$ and (b) promote a healthy team culture with ten items, $r = .85$. The extracted factors explained 52% of the variance in the data. See Table 4 and 5 for the final retained items and factor loadings.

Challenge discriminatory behavior. The final items represented a more narrow conception of the original factor (i.e, create an environment free of discrimination and bias). For example, one item that did not have a high enough pattern coefficient to be retained on this factor was: while working on a team, I "actively work to overcome personal stereotypes." This item was also strongly related to the other extracted factor, promote a healthy team environment. While the final five items on this scale were all on the originally created subscale, not all of the originally created items were retained. The truncated scale was focused exclusively on challenging discriminatory behavior. There were five items retained on the subscale, such as: "While working on a team, I challenge any type of discriminatory behavior." The pattern coefficients exceeded .50 for each item. A high score on this factor indicated that the engineering student would challenge any type of discriminatory behavior while working on a team. As indicated in Table 1, compared to the other subscales, scores for this subscale were the lowest with the largest standard deviation. In general, students were only somewhat likely to behave in ways which challenge discriminatory behaviors.

Promote a healthy team environment. The original two subscales, i.e., value all team members and leverage diversity to improve teams, collapsed into one subscale that we renamed promote a healthy team environment. Some of the sample final retained items for this scale included: "While working on a team, I include everyone in team meetings", and "While working on a team, I make sure to give credit to team members who make contributions to the project." The pattern coefficients exceeded .50 for each item. A high score on this factor indicated the engineering student would take measures to ensure every team member was included and valued and sought to have a variety of skills represented on the team. In contrast with challenging discriminatory behavior, students strongly agreed with the statements in promoting healthy team environments, as shown in Table 1. This relatively high mean and small standard deviation show students more readily endorsed promoting a healthy team environment than challenging discriminatory behaviors.

The two subscales, challenge discriminatory behavior and promote a health team environment, were negatively correlated, $r = -.50$. On the surface, the negative correlation seems odd, but all of the items on the challenge discriminatory behavior subscale negatively loaded on the factor, which produced a negative correlation between the two subscales.

Discussion

When designing the survey, we originally conceptualized three constructs that describe what valuing diversity within engineering means and what inclusive behaviors look like. The three constructs related to valuing diversity were creating a more just and equitable society (social justice), improving the bottom line, and providing for a positive work environment. Research results suggest that students may not see as many distinctions in terms of valuing diversity and break things down along the more simple lines of internal motivators to appreciate diversity and external motivators to appreciate diversity. In some ways this result is not surprising, as during development of the initial items the research team encountered several items that might fit in more than one of the constructs depending on how the item was interpreted by the respondent.

The three constructs related to enacting inclusive behaviors were valuing team members, challenging discriminatory behaviors, and leveraging diversity to improve team synergy.

Research results suggest that students tended to see valuing team members and leveraging diversity to improve team synergy as a single construct and challenging discriminatory behaviors as a second construct. Students were more likely to endorse the combined construct of promoting a healthy team environment and showed less willingness to challenge discriminatory behaviors. This finding is interesting as teams of undergraduates often complain about working together and teamwork skills do not always come readily to the students (Henry, Tawfik, Jonassen, Winholtz, & Khanna, 2012), especially if professors do not purposefully teach students how to work productively in teams. Additionally, disrupting discriminatory behaviors tends to be more difficult than fostering positive group relations when educational environments become places where "almost everyone is afraid to speak" due to political differences (Samuels, 2017, para. 4). This raises the question for instructors wishing to promote inclusive behaviors in their students – should they focus on helping students challenge discriminatory behaviors because students appear less comfortable with this type of action? Or should instructors focus on building teamwork skills as student responses indicate that they are more open to this type of inclusive behavior? Or perhaps instructors should consider treating these efforts as overlapping, complementary behaviors as opposed to mutually exclusive possibilities? In the future, we may consider designing interventions that address how students can promote a healthy team environment AND challenge discriminatory behaviors.

The result that students tended to blur of some of the constructs is potentially an implication. While this iteration of the survey suggests that students did not perceive social justice and valuing team members as separate constructs, quite possibly this lack of consideration reflects the environment in which engineering students learn. More specifically, if students do not participate in ongoing pedagogical interventions about social justice and valuing their peers, then *not recognizing* these as distinct constructs may be a natural outcome. This points to the possibility that while the experimental interventions may have some effect, more work can be done to make inclusion more explicit.

Future Research. We intend to use the new scales in conjunction with the two original diversity and identity scales to determine how the curricular interventions impacted student appreciation for diversity and inclusive engineering identity development. Now that we have established the initial validity of the two surveys separately, we intend to follow up with separate confirmatory factor analyses for the two scales. Also, we plan to extend validation of these scales to other samples, such as upper-class students, recent graduates, and employed professional engineers.

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Table 1.
Reliabilities and Descriptive Statistics for Valuing Diversity within Engineering and Inclusive Behaviors in Engineering Scales

Survey	Subscale	*n*	*r*	*M*	*SD*
Valuing Diversity	Fulfill a Greater Purpose	267	.90	5.82	1.07
	Serve Customers Better	267	.81	6.05	0.83
Inclusive Behaviors	Challenge Discriminatory Behavior	266	.89	5.50	1.19
	Promote a Healthy Work Environment	267	.90	6.14	0.64

Table 2.
Final Items for Valuing Diversity in Engineering Scale

	Valuing Diversity within Engineering*
Fulfill a Greater Purpose	
F1	Do the right thing
F2	Work for a greater cause
F3	Fulfill a social responsibility for making the world better
F4	Promote positive attitudes
F5	Help improve the bottom line
F6	Be fair
Serve Customers Better	
S1	Help them understand client and customer needs
S2	Better serve a diverse population
S3	Improve products

* Prompt read, "Engineers should value diversity in order to…"

Table 3.

Pattern and Structure Matrices for Valuing Diversity within Engineering Scale

	Pattern Matrix		Structure Matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
F1	0.89		0.84	0.43
F2	0.86		0.87	0.52
F3	0.83		0.84	0.50
F4	0.73		0.76	0.48
F5	0.72		0.76	0.49
F6	0.64		0.65	0.39
S1	-0.10	0.83	0.39	0.77
S2		0.75	0.51	0.80
S3	0.16	0.65	0.54	0.75

Note: Pattern coefficients less than .10 are not included for simplicity.

Table 4.
Final Items for Inclusive Behaviors in Engineering scale

Inclusive Behaviors in Engineering*	
Challenge Discriminatory Behavior	
C1	Challenge racist behaviors
C2	Challenge any type of discriminatory behaviors
C3	Challenge sexist behaviors
C4	Challenge xenophobic behaviors
C5	Challenge homophobic behaviors
Promote a Healthy Team Environment	
P1	Make sure all team members have the opportunity to take part in decision making
P2	Include everyone in all team meetings
P3	Make sure every team member feels comfortable sharing opinions
P4	Make sure every team member has the opportunity to contribute to the project
P5	Make sure to give credit to team members who make contributions to the project
P6	Let team members choose roles according to their varied strengths and backgrounds
P7	Recognize the need for a wide variety of skills and background needed to address complex problems
P8	Thank team members who are good team players
P9	Want to have lots of skills represented on my team

* Prompt read, "While working on a team I…"

Table 5.

Pattern and Structure Matrices for Inclusive Behaviors in Engineering Scale

	Pattern Matrix		Structure Matrix	
	Factor 1	Factor 2	Factor 1	Factor 2
C1		-0.94	0.46	-0.93
C2		-0.91	0.50	-0.93
C3		-0.88	0.47	-0.89
C4		-0.76	0.46	-0.79
C5		-0.55	0.26	-0.54
P1	0.82		0.77	-0.31
P2	0.78	0.16	0.70	-0.23
P3	0.66	-0.15	0.73	-0.48
P4	0.64		0.63	-0.29
P5	0.62	-0.12	0.68	-0.43
P6	0.62		0.60	-0.28
P7	0.60	-0.14	0.67	-0.44
P8	0.59	-0.11	0.64	-0.40
P9	0.50	-0.15	0.57	-0.40

Note: Pattern coefficients less than .10 are not included for simplicity.