AN INTERSECTIONAL APPROACH TO UNDERSTANDING UNDERREPRESENTED STUDENTS' SUSTAINABILITY GOALS

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Abstract: The lack of diversity in engineering is a persistent issue which hinders the development of more sustainable engineering solutions. We hope to help address this problem by investigating the sustainability-related career outcome expectations among engineering students who identify with groups underrepresented in the field. This research examines the intersectionality of students' race, ethnicity, and gender, which can help us understand how unique individuals pursue sustainability goals through the cultures of engineering. We investigate this sustainability-related beliefs among underrepresented groups using data from a national (U.S.) survey in which we collected responses about these variables of interest from students in introductory college courses. The sample was stratified by institution type and the number of enrolled students. In total we received responses from 6,772 individuals enrolled at 50 institutions. We analyze the data using descriptive statistics and multinomial logistic and linear regression. Our results suggest that showing students the connection between certain sustainability issues and engineering careers could help as we strive to diversify participation in engineering. For example, white females, black females are less likely than other groups to want to address climate change in their careers while their while male counterparts are more likely than other groups to want to address the same issue. These results highlight ways in which some populations may be more excited about engineering careers or less based on topics emphasized. This results may help bring a broader range of engineers would likely bring new ideas and ways of thinking to engineering for sustainability.

1 INTRODUCTION

The underrepresentation of women and minorities in engineering limits the ability of an engineering workforce to meet the needs of the 21st century (National Academy of Engineering, 2004; Committee on Prospering in the Global Economy of the 21st Century, 2007). Emphasizing aspects of engineering that students from diverse background find appealing may be one way to improve the climate of engineering and infuse it with a diversity of ideas and lived experiences (Felder & Brent, 2005; Chubin & Babco, 2005). Evidence exists that sustainability, broadly defined, is one such subject. Women are recognized catalysts for sustainable development (Charkiewicz et al., 1994). In engineering, the perceived lack of a connection to societal problems is a top barrier to women entering the field (Widnall, 2000), and the subject of sustainability addresses this barrier, explicitly connecting engineers' contributions to problems such as resource depletion, catastrophic climate destabilization, and social inequity. Further, increased diversity has been identified in various engineering groups that emphasize sustainability including: sustainability leadership positions at the largest U.S. design and construction firms; faculty attending national workshops to share best practices in teaching sustainability (Harrison & Klotz, 2010); sustainability-themed engineering groups at Georgia Tech and Carnegie Mellon (Zimmerman & Vanegas, 2007); and the leadership board of the Engineers without Borders Program at the University of Colorado at Boulder, which organizes service-learning opportunities illustrating the social dimension of sustainability (Bielefeldt, 2006).

Sustainability career intentions and beliefs have been shown to be a potential pathway to increasing diversity in engineering (Klotz et al., 2014). Our previous work found that issues related to social sustainability such as providing opportunities for future generations can foster interest in engineering (Klotz et al., 2014). Additionally, environmental issues like addressing energy or water supply increases students odds of choosing engineering in college by 4.7 and 1.5 times respectively, even when controlling for race, gender, socioeconomic status, and prior academic preparation. There is a documented need to recruit and retain a more diverse engineering workforce to provide greater representation of perspectives and backgrounds (Felder & Brent, 2005; Chubin & Babco, 2005; Miller, 2003; Wulf, 1999; Keith et al., 2003). The next step in learning more about this pathway is to learn more about how different intentions and beliefs align with different types of diversity (gender, race, and ethnicity).

1.1 Intersectionality

This research used an intersectional approach to understand how the experiences and backgrounds of different students affect their sustainability-related carer goals and beliefs. Intersectionality examines the connections between social constructs of race, class, and gender (Crenshaw, 1991). Often in quantitative education research, averages of students or student groups are reported as a monolith. For example, studies report on women or on Black students compared to men or White students respectively. However, the results of such comparisons are not additive (e.g. combining the outcomes of women with Black students does not equal the outcomes of Black women) (Hancock, 2007). To address this issue, the intersections of race and gender were compared to examine how these identities interact with sustainability career outcomes and beliefs. This approach allows for better understandings of how differences and diversity within engineering can create more sustainable engineering innovations. Representation from multiple perspectives can increase innovation (Keith et al. 2003; Wulf 1999) and better represent a customer base (Miller, 2003; “2010 U.S. Census Data,” 2014).

1.2 Research Questions

To understand the differences at the intersection of race/ethnicity and gender, our research addressed the questions:

1. How do students from underrepresented groups compare to one another on sustainability career intentions?
2. How do these students different in their sustainability-related beliefs?

To understand the full spectrum of these responses in comparison, White and Asian males, who are traditionally overrepresented in engineering, were also included as comparisons.

2 METHODS

2.1 Sampling

The data for this analysis were drawn from the Sustainability and Gender in Engineering (SaGE) survey (https://engineering.purdue.edu/ENE/Research/SaGE_survey_Godwin_2014). Administered in Fall 2011, this survey examined how sustainability as a topic may engage more underrepresented groups, especially women, in engineering. This study collected data from a nationally representative sample of fifty institutions across the U.S. in introductory English courses to obtain a representative sample of both STEM and non-STEM students in the college population. In all, 6,772 students participated in the SaGE survey. The survey instrument focused on background factors, sustainability pedagogy in physical science classrooms, classroom achievement, and student attitudes toward STEM and sustainability. Sustainability is most commonly and broadly defined as meeting the “needs of the present without compromising the ability of future generations to meet their own needs” (Bruntland, 1987). The focus of this study was on understanding the sustainability-related beliefs of underrepresented students.

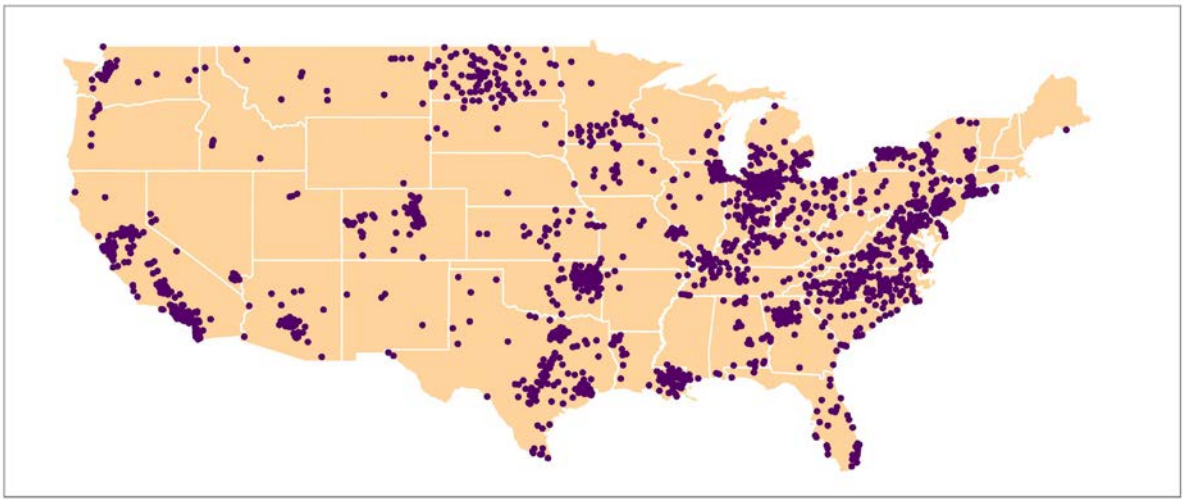

Figure 1: Reported students' hometowns within the contiguous United States by ZIP code. This figure illustrates the geographic representativeness of the population which is reflective of the population of the United States (Wickham 2009; Bivand and Lewin-Koh 2013; Mackun and Wilson 2011).

Using this cross sectional approach, similar to epidemiological study, allowed for substantial natural variation in students' backgrounds, abilities, and prior experiences to be captured. Students reported that they came from home in over 2,533 different ZIP codes across the United States (Figure 1).

2.2 SaGE Survey

The survey included 47 Likert-type, multiple-choice, and categorical variables. Two questions were utilized in this analysis to measure students' sustainability career goals (Q4) and student sustainability-related beliefs (Q22). These questions are listed in Table 1.

Table 1: Questions from SaGE.

Q4: Which of the following topics do you hope to directly address in your career?	Q22: To what extent do you disagree or agree with the following:
Q4a – Energy (supply or demand)	Q22a – I feel a responsibility to deal with environmental problems
Q4b – Disease	Q22b – Environmental problems make the future look hopeless
Q4c – Poverty and distribution of wealth and resources	Q22c – Nothing I can do will make things better in other places on the planet
Q4d – Climate change	Q22d – I have the knowledge to understand most sustainability issues
Q4e – Water supply	Q22e – Climate change is caused by humans
Q4f – Food availability	Q22f – I think of myself as a part of nature, not separate from it
Q4g – Opportunities for future generations	Q22g – We should be taking stronger actions to address climate change
Q4i – Opportunities for women and minorities	

Students were also asked to report on their gender and the racial group(s) with which they identified. These responses were used to categorize students into specific underrepresented groups as listed in Table 2.

Table 2: Number of students in each intersectional group.

Intersectional Groups	Number of respondents (N)
Black females	250
Hispanic females	411
Asian females	121
White females	1714
Black males	186
Hispanic males	349
Asian males	118
White males (comparison group)	1374

2.3 Analysis

Differences between answers to underrepresented groups' sustainability-related career goals and beliefs were examined by multinomial logistic regression for Q4 (which was binary) and multinomial linear regression for (Q22) which was an anchored outcome from zero to four. All analyses were conducted using the statistical program R (R Core Team, 2013). The cut off for significance was set at $\alpha < 0.01$ level to reduce the risk of Type I error.

3 RESULTS

The results of these analyses are summarized in Tables 3 and 4. Blanks in each table are where analyses showed no significant differences between the intersectional group and the sample population. For example, Asian females were no more or less likely to have energy related career goals than the overall sample population. Significant results are shown as *** ($p < 0.001$) and ** ($p < 0.01$) in the table. For instance, Black females (**) and Hispanic males (***) possess significantly different energy related career goals than the overall sample population. For these significant correlations, odds ratios (Table 3) and standardized estimates (Table 4) are also listed in the tables. These show the direction of the correlation and give some idea of the magnitude. Negative estimates indicate a negative correlation and vice versa. Odds rations below 1.0 indicate a negative correlation. The aforementioned correlation between Black females and energy related career outcome expectations, with an odds ratio of 0.21, indicates that Black females are less likely than the sample population to have energy related career goals. Odds ratios above 1.0 indicate a positive correlation. For example, Hispanic males (odds ratio 2.44) are more likely to have energy related career goals.

With this understanding, one would infer from the first column in Table 3 that White females are less likely to want to address energy and more likely to want to address disease and provide opportunities for women. The first column of Table 4 shows that white females are less likely to believe that climate change is caused by humans, that we should be taking stronger actions to address climate change and that humans are a part of nature. Discussion of these results, in particular instances where the intersectional approach leads to insights that may otherwise have been missed, are discussed in the following section.

Table 3: Differences in sustainability-related career goals by intersectional group. Significance is given as *** < 0.001 and ** < 0.01. The numbers listed are the odds ratios for these outcomes. All blank spaces represent non-significant results

Career Goals	Black females	Hispanic females	Asian females	White females	Black males	Hispanic males	Asian males	White males
Q4a – Energy	** 0.21	** 0.58		*** 0.43		*** 2.44	*** 2.75	*** 1.82
Q4b - Disease	*** 2.03	*** 1.89	*** 2.71	*** 1.85				*** 0.63
Q4c – Poverty	*** 1.67	*** 1.77	*** 2.11					
Q4d – Climate								
Q4e – Water						** 1.54	*** 2.18	
Q4f – Food	*** 1.78							
Q4g – Future	*** 1.66	*** 1.55			** 1.53			
Q4h – Women	*** 3.59	*** 2.77	** 1.91	*** 1.34				*** 0.52

Table 4: Differences in sustainability-related beliefs by intersectional group. Significance is given as *** < 0.001 and ** < 0.01. The numbers listed are the standardized estimates for these outcomes. All blank spaces represent non-significant results.

Career Goals	Black females	Hispanic females	Asian females	White females	Hispanic males	Black males	Asian males	White males
Q22a - Responsible		** 0.04						*** -0.06
Q22b - Hopeless future		** 0.05						*** -0.10
Q22c - Nothing I can do					*** 0.06	** 0.04	*** 0.05	** 0.04
Q22d - Knowledge				** -0.05				
Q22e - Climate change caused by humans				*** -0.07			*** 0.05	*** -0.08
Q22f - Part of nature				** -0.06				*** -0.08
Q22g - Stronger actions				** -0.06				*** -0.13

4 DISCUSSION

Due to page limitations, for this discussion we highlight *some* of the differences found in this work. Tables 3 reveals numerous instances where treating female students as one monolithic group would miss nuances in their sustainability related career outcome expectations. Each of the female groups is more

likely than the sample population to want to address disease and opportunities for women in their careers. But there were differences for many of the other outcome expectations. Whereas each of the other female groups was less likely to want to address energy issues, Asian females were no different from the sample population. White females were no more likely to want to address poverty issues, while each of the other female groups were. Black females were the only group more likely to want to address population than the other comparison groups and Black and Hispanic females were the only groups more likely to want to address opportunities for future generations.

Differences are also apparent when males are broken into races and ethnicities. With the exception of Black males, each group is more likely to have energy related career expectations. White males are significantly less likely to desire careers where they can address poverty and opportunities for women; the other male groups are no different than the sample population in these desires. Hispanic and Asian males are more likely to want careers where they address water issues, and Black males are the only group more likely to desire careers where they can provide opportunities for future generations.

Table 3 also shows that grouping respondents by gender only would tell a skewed story. White males and females have significant differences from the overall population for energy, disease, and opportunities for women. Yet while White females are less likely to desire energy careers and more likely to want careers where they can address disease and opportunities for women, White men are just the opposite. While disease, poverty, food, and opportunities for women; Black males are no different from the sample population in these areas. Black females are more likely to desire careers where they can address

All Black females are less likely to want to address energy and more likely to want to address disease and provide opportunities for women. Asian females were more likely to desire careers where they could address poverty, disease, and opportunities for women; three areas where Asian males were no different from the sample population. Likewise, Asian males were more likely to want to address energy and water, whereas Asian females showed no difference for these issues. Hispanic males showed a preference for energy and water related careers, but did not share the desire among Hispanic females to address poverty, disease, and opportunities for women and future generations.

Table 4 also shows differences in sustainability beliefs that would not be apparent without the intersectional approach. With the exception of shared beliefs between White males and females are both less likely to believe that climate change is caused by humans, humans are a part of nature, and we should be taking stronger actions to address climate change. All males are more likely than the sample population to believe that nothing they can do will make things better in other places on the planet. In all other cases, beliefs differ between genders, races, and ethnicities.

5 CONCLUSION

Intersectionality is important. Gender is a more influential identity than race and ethnicity for sustainability career outcomes. Female students tended to share similar sustainability-related career outcomes, regardless of race or ethnicity. For sustainability beliefs, race and ethnicity are similarly influential as gender. The results of group comparisons on sustainability beliefs show marked differences between students of different genders *and* races/ethnicities. Most important to remember is that ignoring the overlap of either of these traditionally used demographic markers would be a mistake. Of course, research at the individual student level gives insight into specific and singular outcomes, but typically these qualitative results are not widely generalizable for wide scale understanding and pedagogical reform. In quantitative studies with more generalizable results to the sampled population, studies are often too small to detect significant differences between groups and comparisons are made without and intersectional approach.

Our findings show clearly that distinguishing between different races and ethnicities within a specific gender (and vice versa) will show significant differences that may not otherwise appear. If we hope to recruit Black females to engineering, for example, we may emphasize different opportunities and sustainability-related career interests than if we consider all females as one group. If sustainability interests can be used as a tool to recruit and retain a diverse population in engineering, then student

groups should be treated differently rather than a “one size fits all” application of recruitment efforts and pedagogy taught in engineering classrooms. To this goal, inclusive pedagogy may be one way of teaching engineering with these findings in mind. This approach is a method of teaching that incorporates dynamic practices and learning styles, multicultural content, and varied means of assessment, with the goal of promoting student academic success, as well as social, cultural, and physical well-being. Research has shown that the most significant among the barriers reported were the lack of an inclusive mindset, lack of knowledge about pedagogy, high teaching loads, and lack of time for instructional development (Moriarty, 2007). To reduce these barriers schools need to provide faculty with evidence to become aware of difference in their student body, provide opportunities for learning about inclusive instructional approaches, and provide support for faculty implementing these innovations in their classroom.

In utilizing a cross-sectional study design, the data gathered have some strengths: large statistical power, national representativeness in the sample, and the ability to test hypotheses surrounding events that were introduced to students naturally rather than through an intervention. This study design also has certain weaknesses, notably including the inability to draw causal conclusions. Rather, results are correlational in nature. The results do indicate substantial correlations between intersectional groups and students' sustainability-related career interests and beliefs, but further work is necessary to indicate a causal direction to these relationships.

Also bear in mind that responses we have analyzed identify sustainability-related outcome expectations and not the level, degree, or nature of planned actions; both students who intend to mine tar sands and those who want to work in the solar power industry may have energy outcome expectations. Finally, many other important barriers to broader, more diverse participation in engineering are not dealt with in this article. Sustainability topics may help attract a more diverse group, but discrimination and prejudice may continue to inhibit progress towards attracting this group (Steele and Aronson 1995).

Our future research on this work includes understanding the reasons for differences seen between intersectional groups in sustainability-related career outcome expectations and beliefs. In understanding these differences, targeted interventions can be developed and tested to see if making engineering appealing to diverse groups by teaching material aligned with their interests can attract more diverse individuals into engineering and create more sustainable engineering solutions.

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