

Do Great Minds Think Alike?

Racial/Ethnic and Gender Differences in Mindset of Undergraduate Engineering Students

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Abstract— In this work-in-progress research category paper, we explore diversity and inclusion in undergraduate engineering programs by examining racial/ethnic and gender differences in undergraduate engineering students' growth and fixed mindsets. We use multiple regression analyses on survey data to examine the main and interaction effects of race/ethnicity and gender on growth and fixed mindset to answer our overarching research questions: "How do fixed and growth mindset differ by race/ethnicity and gender for undergraduate engineering students?" and "To what extent do undergraduate engineering students' race/ethnicity and gender interact for growth or fixed mindset?" Our results indicate that there are significant racial/ethnic group differences but no gender differences on growth and fixed mindset. Also, we found that gender did not moderate the relationship between race/ethnicity and mindset. Thus, while the men and women in our sample appear to share similar mindsets, most of the participants of different racial/ethnic backgrounds did not share similar mindsets.

Keywords—mindset, race/ethnicity, gender, regression

I. INTRODUCTION

Cultivating a broadly inclusive engineering workforce has remained a central mission of the National Science Foundation—and indeed the nation—for several decades. Achieving this goal, however, has been challenging. Traditionally, an engineering student's success in engineering education is measured through a grade point average [GPA], which is a number that represents the average of the student's grades in school, with higher GPAs representing better grades. Most women who leave engineering achieved higher GPAs than male students who leave the major [1]. This finding suggests that factors beyond GPA influence how an engineering student values the discipline. There is a need to broaden success metrics in engineering beyond the usual academic competencies to better support all students. Underrepresented minorities leave engineering at higher rates than whites, a phenomenon that might be explained by several factors, such as stereotype threat [2]. According to Dweck's report in [3], negative stereotypes are fixed mindset beliefs that erode students' sense of belonging in the major and beliefs in their own abilities. As a result, these negative stereotypes can reduce a students' desires to continue in their major [3]. As such, there is growing interest in the role of students' mindsets and other non-cognitive competencies as key factors that can

support student success [4]–[8]. However, few studies have explored how race/ethnicity and gender intersect to affect these non-cognitive outcomes, such as mindset.

Mindset refers to individuals' beliefs on their own talents and intelligence. Individuals with growth mindsets tend to think that their talents and intelligence can be cultivated and developed, while individuals with fixed mindsets tend to think that their talents and intelligence are set and unmalleable [6]. Students carry fluctuating levels of growth and fixed mindsets in each situation, and this fluctuation can affect their academic and personal success. For example, the growth mindset has been correlated with intrinsic motivation and persistence at the face of difficulty, skills crucial to succeed in engineering education [6]. Also, people with higher growth mindset tend to experience reduced depression and anxiety [9]. On the other hand, research suggests that people with higher fixed mindsets tend to have more external sources of motivation and attribute setbacks to external influences that are outside of their control [10]. Generally speaking, research has shown that students with stronger fixed mindsets tend to achieve worse academic outcomes than those with stronger growth mindsets [10]. As a result, students with more of a growth mindset tend to achieve more than those with more of a fixed mindset. Although students' mindsets can impact their academic and personal success, mindset is only one measure of students' profiles. Thus, findings from this study are meant to serve as a first step towards understanding the diversity of mindsets in undergraduate engineering programs.

Understanding the differences in mindset of different racial/ethnic and gender groups can serve as a first step to inform engineering education policies and structures for a more diverse and inclusive engineering education. While growth and fixed mindsets are well-researched topics in the literature, few studies have explored how race/ethnicity and gender intersect to effect mindset for undergraduate engineering students. A better understanding of undergraduate engineering students' racial/ethnic differences in mindset can provide valuable insights towards broadening success metrics in engineering education.

In this paper, we explore undergraduate engineering students' growth and fixed mindsets for racial/ethnic and gender differences. Based on our review of a subsection of extant literature on growth and fixed mindset, we hypothesize

that there will be significant racial/ethnic group differences on growth and fixed mindset [11], and that gender will moderate the relationship between race/ethnicity and mindset [12], [13]. More specifically, we hypothesize that women engineering students will have more fixed mindsets than men [14]. Understanding differences in mindset for different races/ethnicities and genders can serve as a first step towards better understanding, supporting, attracting and retaining more diverse engineering students.

II. METHODS

A. Procedure

From Summer 2017 to Spring 2018 semesters, we surveyed undergraduate engineering and computer science students from eleven universities around the United States using the four-item growth mindset subscale and four-item fixed mindset subscale [15]. We combined participants' survey responses from the 2017-2018 academic year to increase the sample size enough to examine statistical differences between most of the underrepresented minority racial/ethnic groups. The participants in our dataset come from different years in college, geographic locations, engineering and computer science majors, racial and ethnic backgrounds, sexual identities, and socioeconomic statuses. This mindset scale was part of a larger survey that examined the impact of various non-cognitive factors on engineering student success (NSF #1626287). In this paper, we include computer science students in our discussion of engineering students. Survey participation was optional, and participants consented through either a signed consent form or electronic consent form.

We measured growth and fixed mindset based on an anchored numeric scale ranging between 1- "Strongly Disagree" to 7- "Strongly Agree", with higher scores indicating a stronger affiliation with that mindset. The 8-item mindset scale we used [15] measured growth and fixed mindset as orthogonal constructs. As a consequence, a participant can score high on both growth and fixed mindset, low in both, or high in one and low in the other. Mindset is considered context-specific [16]. Thus, a students' mindset in one context might differ from that in another context. For example, the same student might have a high growth mindset in physics class and a high fixed mindset in math class.

B. Participants

Out of 1689 total responses, we included only participants who selected single race/ethnicity identities and either "male" or "female" for gender ($n = 1556$). To get a large enough sample for the statistical analyses in our study, we analyzed participants who selected either "male" or "female" for gender. We hope to include genderqueer students in future research once we collect enough data from participants in this category to enable meaningful statistical analyses. Similarly, we analyzed only participants who identified with a single race/ethnicity, since this analysis explores how participants belonging to each categorical race/ethnicity differ in mindset. At this early stage of research, we acknowledge that participants who identified as more than race/ethnicity ($n = 177$) or "I prefer to identify as --- " ($n = 20$) were not included

in the analyses due to the low number of participants in these categories. We further justified this decision because research suggests that people with multi-racial identities navigate unique racial and ethnic experiences that differ from the sum of multiple single-race identities [17].

With these selection criteria, our final sample size included 1464 participants. Table I contains the demographic information of our participants' race/ethnicity and gender.

TABLE I. STUDENT DEMOGRAPHICS

	Asian	Black	Latinx	Middle Eastern	White	Total
Male	166 (11%)	31 (2%)	44 (3%)	20 (1%)	773 (53%)	1034 (71%)
Female	71 (5%)	10 (1%)	26 (2%)	10 (1%)	313 (21%)	430 (29%)

C. Descriptives

Fig. 1 and Fig. 2 show two split violin plots that compare the probability density distributions for female and male participants of each race/ethnicity on growth and fixed mindset ($M = 2.67, SD = 1.28$) and fixed mindset ($M = 2.85, SD = 1.38$). Scores range between 1 to 7, and the diamonds indicate the means for each ethnic group. Analysis of skewness and kurtosis indicates that the distributions of growth and fixed mindset for our sample are not significantly different from normal distributions.

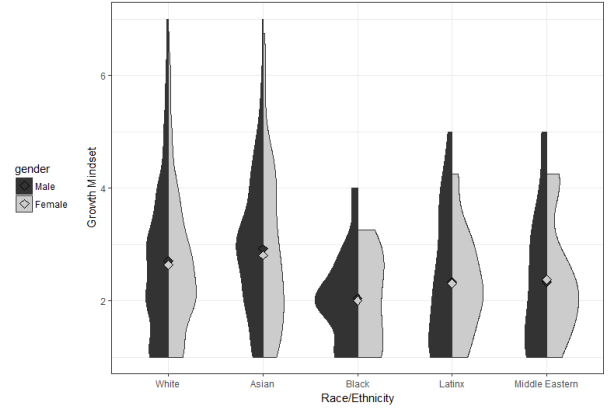


Fig. 1. Distributions of Participant Responses on Growth Mindset

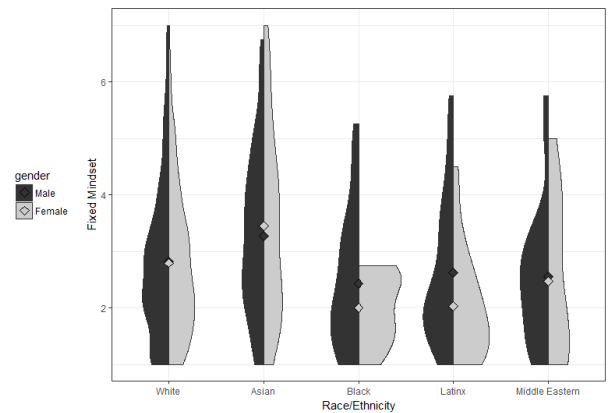


Fig. 2. Density Distributions of Participant Responses on Fixed Mindset

D. Multiple Regression Analysis and Variables

We conducted multiple regression analyses as one way to explore our research questions. First, we examined differences between White undergraduate engineering students—the group with the largest number of participants—and each underrepresented minority race/ethnicity on growth and fixed mindset. Then, we examined differences between males and females on growth and fixed mindset. Finally, we explored potential intersectionality of race/ethnicity and gender on engineering students’ growth and fixed mindsets. It is important to note that our multiple regression analyses are not used to *predict* growth or fixed mindset based on race/ethnicity and gender. Instead, we are using the coefficients of our regression analyses to explore the relative weights of each gender and race/ethnicity on growth and fixed mindset.

To conduct multiple regression analyses, we first need to determine the dependent and independent variables. The *independent variables* include race/ethnicity and gender. To examine student differences at the intersections of both race/ethnicity and gender, we constructed a series of dummy variables for each racial/ethnic and gender subgroup. First, the participants’ races/ethnicities and genders were dummy coded with white men as the reference group. Gender was also dummy coded with male as the reference group. The *dependent variables* are Growth Mindset and Fixed Mindset. Tables II and III show the main effects of race/ethnicity and gender on growth and fixed mindset, while Tables IV and V include the interaction term for race/ethnicity and gender.

III. RESULTS AND DISCUSSION

TABLE II. MULTIPLE REGRESSION ANALYSIS OF GROWTH MINDSET BY RACE/ETHNICITY AND GENDER

Variable	B	SE B	t value	Pr(> t)	Sig.
(Intercept)	2.71	0.04	61.26	<.0001	***
Asian	0.20	0.09	2.14	0.03	*
Black	-0.66	0.20	-3.23	<.001	**
Latinx	-0.36	0.16	-2.26	0.02	*
Middle Eastern	-0.34	0.24	-1.47	0.14	
Female	-0.07	0.07	-1.02	0.31	

Note: $R^2 = .0172$ ($n = 1464$).

In this paper, *** = $p < 0.0001$, ** = $p < 0.001$; * = $p < 0.01$

TABLE III. MULTIPLE REGRESSION ANALYSIS OF FIXED MINDSET BY RACE/ETHNICITY AND GENDER

Variable	B	SE B	t value	Pr(> t)	Sig.
(Intercept)	2.82	0.05	59.75	<.0001	***
Asian	0.52	0.10	5.30	<.0001	***
Black	-0.48	0.22	-2.24	0.03	*
Latinx	-0.40	0.17	-2.41	0.02	*
Middle Eastern	-0.28	0.25	-1.12	0.27	
Female	-0.03	0.08	-0.38	0.71	

$R^2 = .0304$ ($n = 1464$)

In our analyses, race/ethnicity and gender account for more variance on undergraduate students’ fixed mindsets than on growth mindsets. When controlling for gender, race/ethnicity accounts for 1.64% of the variance in growth mindset and 3.03% of the variance in fixed mindset. On the other hand, when controlling for race/ethnicity, gender accounts for 0.07% of the variance in growth mindset and 0.01% of the variance in fixed mindset. Students’ race/ethnicity seems to have a larger effect on fixed and growth mindset than gender, with minority students more likely to have fixed mindsets. This finding aligns with Dweck’s prior research [3] stating that negative stereotypes are fixed mindset beliefs. As such, minority students in engineering, who are more likely to experience these stereotype threats, may be more likely to hold fixed mindsets regarding their abilities.

We also found significant racial/ethnic group differences on growth and fixed mindset. Consistent with prior research [11], our results indicate that the mindsets of Asian, Black, and Latinx participants differed significantly from those of white participants. More specifically, only Asian participants have higher levels of both growth and fixed mindset compared to those of White participants, while Black, Latinx, and Middle Eastern participants have lower fixed and growth mindsets than that of White participants. Black participants had the lowest levels of growth and fixed mindset compared to White participants, followed by Latinx participants. Once again, these results do not predict students’ mindsets based on their race/ethnicity. Mindset is one of many variables we measured, and it is infeasible to conclude that certain racial/ethnic groups have “better” or “worse” mindsets without knowing the context or causal explanations behind these results.

Surprisingly, our analyses found insignificant gender differences in fixed and growth mindset, despite having relatively large numbers of men ($n = 1034$) and women ($n = 430$) participants. This finding is inconsistent with several other studies that suggest women tend to have significantly higher fixed mindset compared to men [12]–[14]. Since [18] found that female students with a growth mindset were more resilient to negative stereotypes, we expected the female engineering and computing students (in male-dominant majors) have higher growth mindsets than male students.

TABLE IV. MULTIPLE REGRESSION ANALYSIS OF GROWTH MINDSET BY RACE/ETHNICITY AND GENDER WITH INTERACTION

Variable	B	SE B	t value	Pr(> t)	Sig.
(Intercept)	2.71	0.05	58.79	<.0001	***
Asian	0.21	0.11	1.89	0.06	.
Black	-0.67	0.24	-2.83	<.001	**
Latinx	-0.38	0.20	-1.87	0.06	.
Middle Eastern	-0.39	0.29	-1.34	0.18	
Female	-0.07	0.09	-0.87	0.38	
Asian:Female	-0.04	0.20	-0.18	0.86	
Black:Female	0.03	0.47	0.07	0.94	
Latinx:Female	0.05	0.33	0.15	0.88	
Middle Eastern:Female	0.12	0.50	0.25	0.80	

$R^2 = .0172$ ($n = 1464$)

TABLE V. MULTIPLE REGRESSION ANALYSIS OF FIXED MINDSET BY RACE/ETHNICITY AND GENDER WITH INTERACTION

Variable	B	SE B	t value	Pr(> t)	Sig.
(Intercept)	2.81	0.05	57.35	<.0001	***
Asian	0.46	0.12	3.95	<.0001	***
Black	-0.38	0.25	-1.55	0.12	
Latinx	-0.19	0.21	-0.92	0.36	
Middle Eastern	-0.26	0.31	-0.85	0.40	
Female	-0.02	0.09	-0.20	0.84	
Asian:Female	0.19	0.21	0.89	0.38	
Black:Female	-0.41	0.50	-0.82	0.42	
Latinx:Female	-0.57	0.35	-1.65	0.10	
Middle Eastern:Female	-0.06	0.53	-0.11	0.92	

$R^2 = .0335$ ($n = 1464$)

The interaction between race/ethnicity and gender is not statistically significant for any combination of gender-by-race/ethnicity. This finding is not surprising given that, in this survey, female students were not significantly different than male students for both growth and fixed mindset. More specifically, the interaction term only accounts for an additional .01% of the variance in growth mindset and an additional .30% of the variance in fixed mindset. When accounting for gender, only male Black participants have significantly lower levels of growth mindset than male white participants. On the other hand, only male Asian participants have significantly higher levels of fixed mindset than male White participants. We also found that the interaction terms indicate no significant differences between female participants of each non-white race/ethnicity compared to female White participants.

Since the interaction terms do not provide additional insights into engineering students' fixed and growth mindsets, we conclude that gender does not moderate the relationship between race/ethnicity and growth or fixed mindset for our limited sample. There are several potential explanations for these findings. One possible explanation for these results is because women who stay in the major already conformed to norms in engineering departments [19]. Thus, our results are unique to our sample of students who already identify as undergraduate engineering students. Another potential explanation might be the overall low numbers of underrepresented minority participants in our sample. We recognize that these results could change if we had more minority participants.

IV. LIMITATIONS AND FUTURE WORK

There are several limitations to this study that warrant caution when interpreting the generalizability of our findings. First, our analyses do not compare differences between the underrepresented minority groups because White participants were set as the reference group. Since most of the participants in our study were white males, most of the underrepresented minority groups that were compared to the white students contain fewer participants and might not be as representative of the minority group. This finding strongly suggests the need to grow our database of participants in order to increase the

statistical power of our analysis. Second, this dataset examines undergraduate engineering students cross-sectionally and does not allow for longitudinal or causal conclusions to be drawn from the results. Third, although we found statistically significant race/ethnicity and gender differences, race/ethnicity and gender account for at best 3.4% of the overall variance in mindset, which limits the practical significance of these findings. From a practical perspective, more research is needed to explore other factors that might play more important roles in developing undergraduate students' growth and fixed mindsets. More specifically, future research can include determining how our mindset questions interact with the other non-cognitive factors that we measured.

Statistical studies of intersectionality are uncommon, especially regarding how race/ethnicity and gender intersect to affect non-cognitive outcomes for undergraduate engineering students. Thus, future research should explore students' racial/ethnic and gender differences on various non-cognitive factors and their relationship to academic performance as well as the diversity and inclusion of undergraduate engineering programs.

V. CONCLUSION

Diverse and inclusive environments develop from a foundation of shared awareness, understanding, and appreciation of individual differences. In academic settings, especially in traditionally male-dominated engineering disciplines, there is a need to include success measures that go beyond tradition academic measures such as GPA. This study provides a starting point on whether students' non-cognitive competencies differ along the intersecting axes of race/ethnicity and gender, rather than academic performance. We suggest that, if non-cognitive factors are adopted to measure achievement, findings from research on these non-cognitive factors could complement, rather than replace, the traditional practices and success metrics in engineering education. We acknowledge that effective engineering education requires a solid curriculum and strong technical focus to develop technical competency. But once the strong technical foundation is in place, engineers of the future will need to understand and appreciate the value of diverse and inclusive work environments in order to thrive in a more diverse society.

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