

Highlighting altruism in geoscience careers aligns with diverse US student ideals better than emphasizing working outdoors

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A common approach to attract students in the United States to the geosciences is to emphasize outdoor experiences in the natural world. However, it is unclear how successful this strategy is. Specifically, the geosciences have been less successful than other sciences at recruiting a diverse workforce that reflects different perspectives and life experiences. Here we present a survey of students enrolled in College Algebra at a Hispanic-serving institution in the southwestern United States where, of 1550 students surveyed, 55.3% identified as an underrepresented minority (URM). We find that surveyed students care little about working outdoors. Instead, they rate altruistic factors, such as helping people or the environment, as most important. Female respondents rate these factors higher than male respondents. We also find that many respondents know little about what a career in geoscience entails. We argue that better informing students about the altruistic potential of geoscience careers would be an effective strategy to broaden recruitment.

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Over the past several decades, there have been considerable efforts made toward broadening the participation of underrepresented students—women and underrepresented minority (URM) students—within the geosciences. These efforts have been met with mixed success. Although there has been a significant improvement of gender imbalances, ethnic and racial diversity in the Earth and physical sciences as defined by the US National Science Foundation¹ remains the lowest among STEM majors at all degree levels^{1,2}. Less than 16% of geoscience Bachelor's degrees in the US were awarded to Hispanic, Black, African American, or Native American students in 2019³. Furthermore in 2019, fewer than 7% of geoscience PhDs in the US were awarded to Hispanic, Black, African American, or Native American students³, and in 2012 only 3.8% of tenured or tenure track faculty positions were held by Hispanic, Black, African American, or Native American scientists⁴. In particular, Hispanic, Black, African American, or Native American women are vastly underrepresented, making up ~1.46% of geoscience doctorates awarded in over 40 years².

Diversity and inclusion within STEM are beneficial not only from the perspective of equity and social justice but also to scientific advancement as a whole. Different perspectives and life experiences spur innovation and novelty⁵, and collaborations among diverse groups produce more creative solutions to problems and lead to a higher level of scientific motivation⁶. Furthermore, increasing diversity in the geoscience field is necessary to meet future US workforce needs⁷. Projections suggest that the United States will be a majority-minority country by 2050⁸. Therefore, in order to grow Earth Sciences degree programs and the geoscience workforce, it is necessary to ensure the geosciences attract and support students from diverse backgrounds⁹. To ensure the geoscience workforce is a valuable and trusted member of the scientific community, we must welcome and include scientists from all parts of society⁹.

Our study tests (i) whether altruistic factors, personal achievement, or work environment are most important to college students (early in their undergraduate program) for their future careers, (ii) whether the ratings of these ideals differ between male/female, URM/non-URM, and first-generation/non-first-generation college students, and (iii) how student perceptions of the geosciences regarding those ideals compare to other STEM fields. We suggest that in order to more successfully recruit (and retain) underrepresented students into the geosciences, it is important to understand what prospective students value most in an ideal career early in their college experience. Current recruitment to the geosciences is characterized by an emphasis on experiences in the natural world (e.g., field photographs in beautiful and exotic places)^{10,11}. Our results suggest instead that recruitment and outreach efforts should be tailored to highlight the altruistic outcomes of careers in the geosciences, thereby better aligning with students' ideals and bringing more underrepresented students into the geosciences, retaining these students, and increasing diversity in the geoscience education community and workforce.

Results and discussion

We surveyed students enrolled in College Algebra at a large, urban, Hispanic-serving, R1 public university in the southwestern United States (see “Methods” section and Supplementary Methods). This class typically has a high percentage of STEM-intended majors (59.4% of students surveyed) and is one of the first courses for many students in college (on average students surveyed have completed less than two semesters of college and the average age was 19.8 years [SD = 4.1]). The data span five semesters, from Fall 2018 through Spring 2020 (Supplementary Data 1).

The survey was composed of demographic questions as well as questions using the Likert scale, in which students rated how much they agreed or disagreed with a particular statement regarding descriptions of their “ideal career.” Students were also asked to rate statements about careers in different science fields and engineering. Demographic questions were included at the end of the survey in order to mitigate stereotype threat¹². Due to the nature of how the data were collected in this study, there are inherent limitations to the conclusions that can be made. This was a multiple cohort one-shot survey, which assessed students' perceptions of their values in single-item measures. No data were collected on future behaviors of students to determine if their values align with career choice. Single-item measures also limit measurement error quantification. Additionally, the study surveyed students at a single US institution enrolled in College Algebra, which may not be representative of university students in general.

A total of 1550 student surveys are included in the statistical analyses with 50.0% identified as female and 50.0% as male. Of these students, 33.7% identified as Hispanic, 29.3% as White, 19.5% as Black or African American, 13.9% as Asian, 3.4% as other, and 0.2% as Native American (Fig. 1). Although problematic¹³, we use the abbreviation URM for underrepresented minorities in STEM following the definition by the US National Science Foundation. URM students belong to minoritized groups including Hispanic, Black or African American, or Native American (53.4%, or 828 students), and non-URM or overrepresented students identified as White or Asian (44.7%, or 670 students). Although a minority group, Asian students as a whole are not underrepresented in science and engineering, because this group is not present in a lesser proportion than in the general population¹. Those identifying as “other” were not included in URM/non-URM comparisons. When considering the intersection of gender and ethnic representation, 29.0% identified as female URM, 24.5% as male URM, 19.2% as female non-URM, and 24.0% as male non-URM students (Fig. 1). Of the students considered in the survey, 51.7% (or 801 students) were first-generation college students, another underrepresented group in STEM¹⁴.

The ethnic demographics of the population in our dataset are unique compared to previously published data due to a large number of Hispanic students and a large sample size allowing for robust comparisons between all groups except Native Americans. Due to the ordinal nature of the survey items (Likert scale questions), we use standard nonparametric statistical techniques to report differences amongst populations, namely Spearman's rank-order correlations (Spearman's ρ or r_s) and the Mann–Whitney U -test (see Supplementary Statistical Results). There are six “career ideal” questions analyzed, which are not designed to be combined into a single item as they evaluate different ideals. Indeed, Cronbach's α -value for the six questions was low, 0.45, indicating the items should not be grouped. However, items are combined based on the level of correlation using Spearman's ρ , discussed in further detail in the next section. To evaluate statistically significant differences between student perceptions of geoscience and the other STEM fields, Friedman tests were performed. Within each family of tests, significance levels were corrected for multiple tests using a Bonferroni correction.

The reported demographics of the student population in this study are very similar to that of the university where the study took place (data from 2018), which has been designated a Hispanic-serving institution since 2014. Although the university has a diverse student body (~55% URM), this is not reflected in students majoring in Earth and Environmental Sciences (EES) at the university. Only 35% of EES majors were URM students in fall 2018 (Fig. 1). The large disparity between EES and university

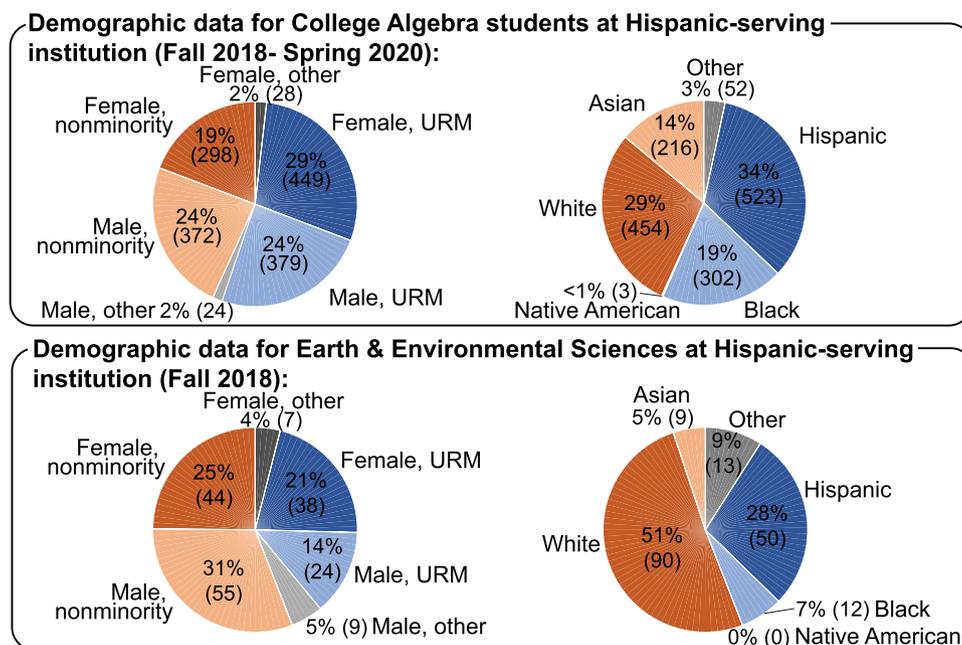


Fig. 1 Student demographics from 1550 surveys of students enrolled in College Algebra compared with those in Environmental and Earth Sciences at a large, urban, Hispanic-serving, R1 public university in the southwestern United States. In all graphs, underrepresented minority (URM) students identify as Hispanic, Black or African American, or Native American and are shown in shades of blue, overrepresented or non-URM students identify as White or Asian and are shown in shades of orange, and students who identified their ethnicity as “other” in gray.

student demographics reflects the ongoing issue of persistent underrepresentation of minoritized Hispanic, Black, African American, or Native American students in the geosciences².

Factors for an ideal career. Students enrolled in College Algebra at this university were asked to state how much they agree with the importance of six factors in describing their ideal career, on a five-point Likert scale (Fig. 2). Two factors, “helping people and society” and “helping the environment” are rated the most important (i.e., students chose “strongly agree” or “agree” in the highest proportion). These two factors deemed the altruistic factors, represent the desire for student survey respondents to have meaningful careers that give back to their communities and align well with “communal goals” (e.g., intimacy, affiliation, and altruism)^{15–17}. The factor that was most important (i.e., students chose “strongly agree” or “agree” in the highest proportion) was “helping people and society,” with 96.8% of students reporting “strongly agree” or “agree” (SA/A), 3.0% “neutral” (N), and only 0.1% “strongly disagree” or “disagree” (SD/D). This is followed closely by “helping the environment” (92.6% SA/A, 6.8% N, 0.6% SD/D). There is a moderate to a strong positive correlation between these two factors ($r_s = 0.478, p < 0.001$) meaning student respondents tend to rank these two values with correlatively high importance. Due to the correlation and similarity of these two factors, they are combined in further statistical analyses.

The importance of personal achievement is represented by the next two factors, “making a lot of money” (67.1% SA/A, 28.4% N, and 4.5% SD/D) and “having prestige” (54.3% SA/A, 35.2% N, and 10.6% SD/D), which are highly rated by survey respondents, though not as high as the first two (Fig. 2). These two factors align well with “agentic goals” (e.g., power, achievement, and seeking new experiences or excitement)^{15–17} and had a moderate positive correlation between them ($r_s = 0.382; p < 0.001$). They were therefore combined in further statistical analyses. The final two factors represent the importance of the work environment and were largely the lowest-rated factors, with a much higher percentage of student respondents reporting neutral. These two

factors were “working outdoors” (30.4% SA/A, 51.0% N, and 18.6% SD/D) and “working in an office” (20.1% SA/A, 53.6% N, and 26.3% SD/D). The work environment factors did not correlate with any other factors and thus were not combined.

These results show that, on average, student survey respondents of all backgrounds largely rate altruistic factors as most important in their ideal career—in agreement with findings from prior work that communal goals are typically highly endorsed (e.g., ref. 18). The student survey respondents in this study care least about the physical environment in which they work. Recruitment efforts in the geosciences highlighting experiences in the natural world may therefore not be the most effective technique for attracting students. Although positive field experiences and outdoor interests tend to be a commonly reported influencing factor among students currently in Earth Sciences in their choice of a major^{19,20}, this does not reflect the priorities of the majority of prospective students when considering their future ideal careers, according to the sample of students included in this study. In other words, recruiting students based on the allure of the great outdoors may be an inherently self-selecting strategy that leads to the persistent underrepresentation of female and minority students in Earth Sciences. Since a majority of student survey respondents do not value careers in the outdoors, we are missing the opportunity to promote the inclusiveness of students with a diversity of backgrounds. There are many facets of the Earth Sciences that do not take place outdoors, relying on computational or laboratory techniques across a range of workplaces. The results of this study suggest that showcasing the variety of activities in which earth scientists are involved—and emphasizing altruistic outcomes and therefore one’s ability to help people, society, and the environment—promise to promote inclusiveness and improve recruitment of a more diverse student body. Career aspirations of adolescents are thought to be a good predictor of the jobs they have as adults, but new work suggests that vocational interests may change between STEM careers over time²¹. Furthermore, opportunities that involve collaboration, helping, and altruism are likely necessary

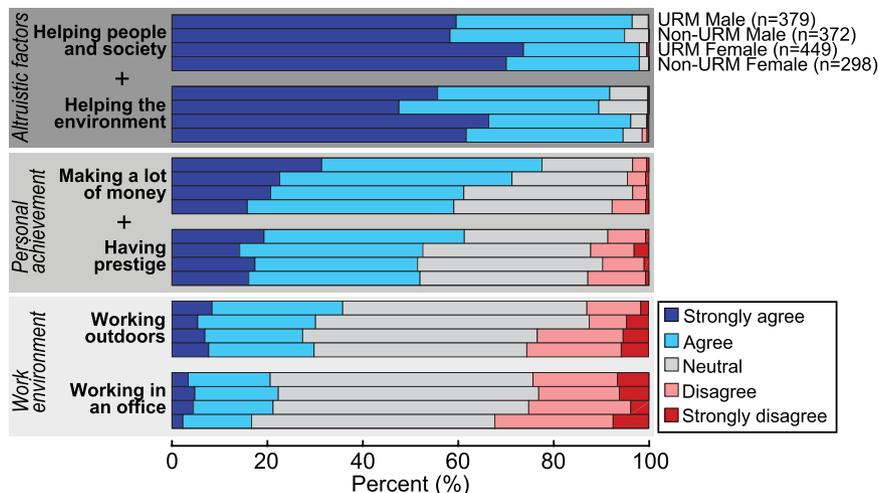


Fig. 2 Survey results from six questions regarding descriptions of their “ideal career” using a five-point Likert scale, in which students rated how much they agreed or disagreed with a particular statement. Comparison of results from URM (Hispanic, Black or African American, or Native American) and non-URM (White or Asian) students separated by male and female.

Table 1 Differences in average responses from student respondents.

	All male (n = 775) – All female (n = 775)	Female: Non-URM (n = 298) – URM (n = 449)	Male: Non-URM (n = 372) – URM (n = 379)	First-gen (n = 801) – Non-first-gen (n = 749)
Altruistic factors ^a	–0.16 ^b (0.16)	–0.05	–0.07	0.02
Personal achievement factors ^c	0.14 ^b (0.10)	–0.07	–0.18 ^b (0.12)	0.00
Working outdoors	0.19 ^b (0.11)	0.01	–0.11	0.06
Working in an office	0.07	–0.16	0.05	0.11

The numbers shown are the difference in the mean of groups designated. Positive numbers indicate that the first group rated the question more important. When there was a significant difference between two groups, an effect size was calculated and is shown in parentheses. The larger the number, the larger the effect. A large effect is shown by a value of 0.5, a medium effect by 0.3, and a small effect by 0.1³⁷.

^aCombined “helping people and society” and “helping the environment”.

^bIndicates a difference significant at the 99% level between groups using Mann-Whitney U-tests. Significance levels were corrected for multiple tests using a Bonferroni correction.

^cCombined “making money” and “having prestige”.

to retain individuals who are motivated by altruism and communal goals (e.g., ref. 18,22) and are important to include within the Earth Sciences.

Altruistic values motivate underrepresented students. Although most student respondents value the first two factors the highest, there are significant differences between male and female respondents for all factors, except “working in an office” where male and female student respondents tended to respond similarly (Table 1 and Fig. 2). Overall, female respondents place a higher importance on altruistic factors and less importance on personal achievement factors and work location (especially working outdoors). The largest effect is for altruistic factors, consistent with prior work investigating gender differences between communal vs agentic goals¹⁸. While the prior study surveyed less diverse student populations, male respondents in that study rated agentic goals higher than female respondents¹⁸, consistent with our findings.

When examining ethnicity, URM and non-URM female students included in this survey responded similarly for all factors (Table 1 and Fig. 2). There is one significant difference between responses of the male URM and non-URM students. Male student respondents who identified as URM rated personal achievement factors as more important than did non-URM male student respondents (Table 1 and Fig. 2). There was no significant difference between URM and non-URM male student respondents in their ratings of altruistic factors or the importance of

work location. In addition, there was no significant difference between responses of students who were first-generation or non-first-generation in their ratings of any factor (Table 1). This result suggests that the education level of a student’s parents does not impact the students’ ideals with regard to careers.

These results show that although survey respondents of all backgrounds place high importance on altruism in their future ideal careers, these factors are particularly important to female respondents, both URM and non-URM. Female survey respondents do not place as much importance on personal achievement or working outdoors as the male respondents. Again, the altruistic outcomes of the Earth Sciences are important to emphasize in order to appeal to underrepresented (women and minority) students. Prior work shows that gender imbalances in science fields and careers can be partially accounted for due to differences in goal congruity—when women perceive science to have a greater affordance for social and altruistic goals, they report a higher interest in science careers^{17,23–25}. When analyzing survey data, our results highlight the importance of considering gender as well as ethnic demographics, as the largest differences in our study are within gender and not ethnicity. Furthermore, having large sample sizes is necessary for this study so that robust comparisons can be made between groups of students.

Recruiting underrepresented students into the Earth Sciences.

To determine if the career ideals of student survey respondents line up with their perception of careers in the geosciences, we

asked questions about careers in the geosciences and compare responses to the same questions about other STEM fields. For each question asked, geoscience is less positively perceived compared to biology or engineering (Fig. 3 and Table 2). Although careers in the geosciences are, on average, rated positively by the surveyed students for their ability to achieve the altruistic factors, students agree more strongly that careers in biology and engineering align with those goals (Fig. 3 and Table 2). Because certain goals are believed to be more strongly associated with certain careers^{17,21}, the idea that geoscience careers do not help people or the environment as much as other science fields could result in students choosing other careers that allow them to fulfill their goals. Today, science fields that draw the most women are those fields (e.g., biology) that are most recognizably related to careers which help people²⁶.

Student survey respondents also rate the geosciences less positively regarding one's ability to make a lot of money compared to other STEM fields (Fig. 3 and Table 2). The personal achievement factors, though not rated as important as the altruistic factors, were rated highly by a majority of student respondents, and especially by URM male students. However, there is little evidence that low salaries repel men from occupations or attract women²⁷. Additionally, very few of these same students know what careers exist in the geosciences (only 13.1% responded strongly agree or agree), in contrast to careers in biology (58.8% responded strongly agree or agree). Most students, largely uncertain of what career opportunities exist in the geosciences and whether or not these careers align with their goals¹⁷, will likely not choose geosciences as a major, and this represents a potentially important area of improvement for future recruitment.

Programs that introduce high school students to the geosciences, with an intentional focus on highlighting career opportunities, found students more likely to choose geoscience as a college major, and have been successful in the recruitment of underrepresented students to the geosciences^{28,29}. Partnerships between minority-serving institutions and research universities have also proven successful gateways in other physical sciences disciplines³⁰ and may increase pathways into the Earth Sciences⁹. Other successful avenues for diverse student engagement and recruitment include place-based courses (focused on connecting concepts with history, environment, and culture of a specific

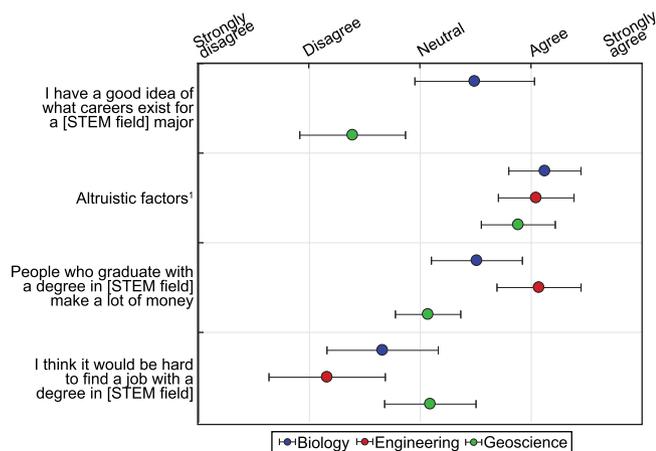


Fig. 3 Perception of the geoscience by survey respondents compared with other STEM fields. The points show the average response of the entire survey population. The error bars show the standard deviation of the average response. ¹Altruistic factors include a combination of the two items “[STEM field] careers offer opportunities to help people and society” and “[STEM field] careers offer opportunities to help the environment”.

Table 2 Differences in student perception of geoscience and other STEM fields.

	Friedman test		Pairwise comparisons	
	Biology, Engineering, Geology		Biology - Geology	Engineering - Geology
I have a good idea of what careers exist for a [STEM field] major	-		1.10 ^a (0.45)	-
Altruistic factors ^b	(0.05) ^a		0.24 ^a (0.23)	0.16 ^a (0.15)
People who graduate with a degree in [STEM field] make a lot of money	(0.43) ^a		0.44 ^a (0.32)	1.00 ^a (0.52)
I think it would be hard to find a job with a degree in [STEM field]	(0.26) ^a		-0.42 ^a (0.25)	-0.93 ^a (0.42)
				Biology - Engineering
				0.08 ^a (0.08)
				-0.56 ^a (0.36)
				0.51 ^a (0.28)

Numbers shown under pairwise comparisons are the difference in the mean of geology and the other designated field. Positive numbers indicate that survey respondents agreed more with the statement in regard to the first field compared to the second. For tests that reported a significant difference, an effect size was calculated and is shown in parentheses. Effect sizes for Friedman tests are Kendall's τ^b . Effect sizes for pairwise comparisons are r values³⁷. The larger the number, the larger the effect. A large effect is shown by a W or r value of 0.5, a medium effect by 0.3, and a small effect by 0.1³⁷. ^aIndicates a difference significant at the 99% level. Significant differences between the perception of geoscience and two other STEM fields, biology and engineering were determined using Friedman tests and post hoc pairwise comparisons with significance levels corrected for multiple tests using a Bonferroni correction. ^bCombined “[STEM field] careers offer opportunities to help people and society” and “[STEM field] careers offer opportunities to help the environment”.

location such as “Geology of Mexico”) in college at the introductory level which positively increase attitudes toward, and understanding of, geology as a career path in an ethnically diverse classroom³¹. However, based on results from this study, we suggest programs that aim to increase recruitment of students into the Earth Sciences should rely less on the allure of the great outdoors and more on the altruistic endeavors of Earth Science careers.

In other STEM fields, URM doctoral students are more likely to be motivated by altruistic values and a desire to give back to their community than their non-URM peers^{32–34}. The results shown here suggest this desire is strong in most all undergraduate students surveyed and clearly demonstrate that these students early in their college coursework, particularly students who are underrepresented in the Earth Sciences, value careers with altruistic outcomes. Future work is needed to test whether shifting emphasis away from personal achievement, seeking new experiences, and excitement and moving to highlighting opportunities for altruistic endeavors and fulfillment of communal goals in Earth Science careers will increase recruitment and retention of a more diverse workforce. We must not overlook this collective desire to help people, society, and the environment in our college students if we are to attract a diverse workforce in the Earth Sciences.

Methods

An online survey was administered to the College Algebra students at the beginning of each semester during the first week of classes in the computer lab. The survey took the average participant 10 min to complete. The survey administered in the College Algebra class was not mandatory, nonetheless, 79.5% of students enrolled in the course took the survey. That is, over the five semesters included in this study, a total of 2026 students were enrolled in the course and 1611 students took the survey. Students received extra credit for completing the survey but were not penalized for opting not to take the survey (other extra credit options were available). Previous research has found that students who score higher on measures of academic performance are the students that tend to participate in voluntary research that uses extra credit as an incentive, potentially reducing the generalizability of research findings³⁵. However, this study had a very high rate of participation amongst students, with a demographic distribution similar to that of the university as a whole (described in Supplementary Student Population), suggesting a representative sample.

Of the 1611 surveys completed, 61 of these were excluded from statistical analyses because respondents provided invalid responses consistent with minimal engagement in the survey (e.g., rating the same value across all questions). The 61 excluded students were majority male (70.5%, or 43 students), however, the ethnicity demographics of the excluded students were similar to those of the course as a whole.

The online surveys were made up primarily of questions using a five-point Likert scale in which students rated how much they agreed or disagreed with a particular statement (see Supplementary information Appendix S1 for survey questions). Responses could vary from “strongly agree” (with a rating of 5) to “strongly disagree” (with a rating of 1) with “neutral” in the middle (with a rating of 3). Statements related to STEM fields revolved largely around how students felt about classes and careers in these fields. Questions were chosen from similar surveys^{29,31,36}. In addition to Likert scale questions, there were also questions regarding demographics such as gender, ethnicity, age, declared college major, mathematics background, and parental level of education (Supplementary Fig. 1).

Descriptive statistics for each of the groups were examined (see Supplementary Tables 1, 2, 4 and Supplementary Figs. 2–6). These results show the average response for each question by different gender (male/female), ethnicity groups (URM and non-URM), and whether the student was a first-generation college student or not. To examine differences between male and female students and different ethnicity group responses, Mann–Whitney *U*-tests were performed (Supplementary Table 3). Significance levels were corrected for multiple tests using a Bonferroni correction of 4 for each family of career ideal tests. There were significant differences between URM and non-URM student responses; however, these results are skewed due to the fact that the relative percentages of male and female students within each ethnicity group were not equivalent. Because there are such large differences between male and female responses identified previously, the differences seen between URM and non-URM students is likely affected by the gender imbalance between the groups. Therefore, further *U*-tests were performed by splitting male and female students and comparing ethnicity groups within each. Effect sizes for the Mann–Whitney *U*-tests are *r* values³⁷, calculated using $r = \frac{Z}{\sqrt{n}}$ where *Z* is the standardized value for the *U* value and *n* is the sample size

(Table 1). Effect sizes for Friedman tests (Table 2) are Kendall’s *W*³⁸, calculated using $W = \frac{\chi_w^2}{\sqrt{n(k-1)}}$ where χ_w^2 is the Friedman test statistic value, *n* is the sample size, and *k* is the number of measurements per subject. Effect sizes for pairwise comparisons are *r* values³⁷ calculated using $r = \frac{r}{\sqrt{N}}$ where *N* is the number of observations (sample size x 2). The larger the number, the larger the effect. A large effect is shown by a *W* or *r* value of 0.5, a medium effect by 0.3, and a small effect by 0.1³⁷.

To determine if the differences between student responses were robust, we also performed chi-square tests of independence to ensure students responses in different semesters did not respond significantly different. For each factor, the chi-square test is not significant, showing there is no evidence for differences in student responses and the semester in which the class was taken. For additional details see Supplementary Table 5 and Supplementary Fig. 7.

The university institutional review board (IRB) at The University of Texas at Arlington approved all study procedures (IRB# 2017-0717.3).

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The complete survey data generated during the current study is available on Zenodo, <https://doi.org/10.5281/zenodo.5140552>.

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Author contributions

All authors wrote the manuscript, led by S.C.C., T.A.J. collected the survey data. S.C.C. processed the data and performed the statistical analyses with the assistance of K.G.C. E.M.G., W.A.G., and T.A.J. conceived of and coordinated the work and interpretative framework.

Competing interests

The authors declare no competing interests.

Additional information

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