Student Career Goals and Science Attitudes at an Urban Community College

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Abstract: An equity gap exists in the STEM workforce, and there is a lack of published data on student motivation and career goals at the two-year college level. We collected data on student motivations for choosing a career in STEM and found a similar equity gap in student career goals at our college. In addition, we provided faculty mentoring and career development to increase student knowledge and awareness of STEM careers. Our data show participation in these activities correlated with increased interest in STEM careers. Others can use this information to help build programs and recruit students into STEM fields and STEM careers.

Keywords: Community colleges, self-efficacy, science identity, intrinsic motivation, STEM, health career goals

Introduction

A challenge for the STEM field is that the STEM workforce does not reflect the demographics of the country's workforce [1]. This is an equity gap, and it implies significant barriers to the participation of underrepresented groups in a STEM career. The STEM workforce includes those fields that require significant experience in the science, technology, engineering, and mathematics fields and represents 23% of the total workforce in the U.S. [1]. It should be noted that the STEM workforce is different than the healthcare workforce, which includes nurses, physicians, and others who regularly care for patients and accounts for 9.3% of the total workforce in the United States [2].

For example, women comprise 52% of the U.S. workforce but only 34% of the STEM workforce [1]. However, almost 80% of workers in the healthcare professions are female, compared with roughly half of the overall workforce [2]. Women are underrepresented in STEM careers but overrepresented in healthcare careers. We also see an equity gap in black and Hispanic participation in STEM careers [1]. There are likely multiple reasons for such gaps to exist. For example, there is a possibility that undergraduate students do not differentiate between the STEM and healthcare fields, even though the fields are different and require different skill sets and training. We acknowledge that there are also systemic barriers to entry into STEM career fields.

Saint Paul College (SPC) is well-situated to study this equity gap. SPC is an urban community and technical college with a high percentage of students of color (66%), first-generation college students (62%), and low-income students as determined by Pell Grant eligibility (65%). SPC also has programs that can help increase participation in STEM. In 2016, SPC established a Science and Engineering Technology program aimed at placing STEM students directly into the workforce or transfer programs. Most educational research data comes from 4-year institutions [3], yet 50% of STEM undergraduates begin their scientific studies at community and technical schools [1]. Therefore, understanding career motivations at the community college level is important.

Disparities seen in the workforce could be addressed by increasing students' awareness of STEM careers and career readiness through high-impact practices (HIPs) [4]. Star and Minchella's work noted that "to attain 'great jobs and great lives', [students] require high impact experiences inside and outside the classroom" [5]. A 2017 study of engineering students at a university found that students who participated in co-curricular activities gained more career and interpersonal skills than non-participants [6]. HIPs such as scholarships and support services also increased direct measures of student success, including retention, persistence, and graduation rates [7, 8, 9]. Mentoring experiences increased the persistence and retention of students of color, and participation in research was correlated with increased graduation rates [10]. HIPs have a greater impact on underrepresented students' success, and promote underrepresented students' access to STEM [4].

The studies highlighted above took place at four-year universities. Community and technical colleges serve a different population of students, but we would expect that HIPs would have similar impacts. A minority of studies looked specifically at the success of HIPs at community colleges. Berchiolli *et al.* note that projects at community and technical colleges provide opportunities that are "especially meaningful for students who have expressed an interest in STEM but are not engaged by the traditional large lecture and laboratory environment central to large research universities" [11]. A 2018 study found that participation in undergraduate research at a community college increased the proportion of students who transferred into a four-year STEM program [12]. To better engage students on career goals and promote their success, we employed three HIPs: (1) faculty mentoring, (2) science-related campus events and career-building workshops, and (3) undergraduate research projects.

Several studies suggest that students who participate in research experiences have increased science identity, self-efficacy, and science abilities [13, 14]. Hanauer *et al.* [15] and *Pinelli et al.* [16] found that career awareness activities and faculty connections increase awareness of science careers and increase the proportion of students who transfer or are employed in science. In addition, Stets *et al.* found that increased science identity correlated with science as a career choice [17].

We hypothesize several reasons for the equity gap in the STEM workforce. First, science attitudes and identity may correlate with career choice, and the demographics underrepresented in STEM would then show lower science attitudes and identity. Second, there may be a lack of awareness of careers in the STEM fields and heightened awareness of careers available in the healthcare sector. We believe that employing HIPs will improve awareness of STEM careers for our students.

Methods

Survey Tool

We created a "Science Attitudes and Career Goals" survey using validated survey instruments introduced in two principal articles: Chemers *et al.*, 2011 and Glynn *et al.*, 2013 [18, 19]. We only included sections of each instrument relevant to our research and community college students. Because we used questions from these validated survey tools, some Likert scales were 4-point, and some were 5-point. We used the questions related to the following factors: commitment to a science career, science identity, intrinsic motivation in science, and science self-efficacy. The career and academic goals list was taken from the PRiSE survey, which assessed Persistence in Science and Engineering [20]. After the consent section, we asked questions about the student's ID, participation in co-curricular activities, and scholarship status. See Supplemental Material 1 for details of survey design and survey questions.

During analysis, we renamed the health career choices as follows: "Medical professional (e.g. doctor, dentist, veterinarian)" became "Med/Vet/Dent" and "Health professional (e.g. nurse, pharmacist)" became

"Nursing/Health/Pharm." We grouped the following career choices in a category called "Scientist": "Biologist," "Earth/Environmental scientist," "Astronomer," "Chemist," "Physicist," "Computer scientist," "Social scientist (e.g. psychologist, sociologist)," "Other scientist," "Mathematician," "Science teacher," or "Math teacher." The "engineer" choice on the survey retained its name throughout the analysis. The following career choices were combined into "All others": "Business person," "Lawyer," "English/Language Arts specialist," or "Other non-science-related career." A "Not sure" career choice selection was not included in the analysis.

Recruitment of Students and Data Collection

The student survey was open for several weeks in the middle of each semester. Faculty announced through the online course management system: "You are expected to take a reflection survey as part of normal course assessment. The survey is a self-assessment of your own skills and attitudes with no correct or incorrect answers. You will have the option of having your survey answers used in a research study on student attitudes and abilities. More details are provided in this survey link."

The survey was administered in General Chemistry 1, Organic Chemistry, and Genetics. General Chemistry 1 is a gateway science course required for students pursuing science, engineering, and health careers. Organic Chemistry and Genetics are second-year science courses at our college. They have science course prerequisites and are also required for students pursuing both science and health careers.

We had 514 responses from General Chemistry 1 from 2019-2023, which was a response rate of 31%. The survey was also given in second-year science courses from 2021-2023 (Organic Chemistry and Genetics) (n=203), with a response rate of 36%. The responses had similar demographics to the course demographics. 61% of responses were female (29% male), and these courses were composed of 66% female (34% male). The racial demographics of the courses were 20% Asian, 41% Black, 7% Hispanic, and 31% White. The respondents demographics were 20% Asian, 37% Black, 10% Hispanic, and 34% White. A subset of these students also received scholarships and faculty mentoring as part of the Science Scholars Program (started in Spring 2022) or participated in SciCAP (started in spring 2021), a career exploration and faculty mentoring program (n=52). We paired survey data with demographic and academic data and removed data from non-consenting students and students under 18 years of age.

Analysis

Data were aggregated into a single dataset for statistical analysis. Factor scores were calculated for commitment to a science career (CarSci, 4-point Likert-scale), science identity (SciID, 4-point Likert-scale), intrinsic motivation in science (SciMot, 5-point Likert-scale), and science self-efficacy (SciSE, 5-point Likert-scale). Binomial outcomes (Yes/No) were created for certain categorical dependent variables (Science Career Choice, Participation in scholarship program, faculty mentoring, or career guidance). As in our previous work, categorical and binomial outcomes were analyzed using mixed-effect generalized linear models (GLMs) with logistic regression. Continuous variables, including factor scores, were analyzed with GLMs with a logit link function and a beta distribution for the response to account for the fact that the dependent variable was bound between 0 and 1. Logistic and beta GLMs were performed using the *lme4* and *glmmTMB* packages [21, 22, 23], respectively, in R Statistical Software (v3.2.4).

Variables were first screened in univariable analyses with either logistic or beta GLMs. All variables were included in a full model for multivariable regression, which was then backward-selected until a minimal univariable model was reached. Model comparisons of multi- and univariable models were performed to select the best-fit model using the Akaike information criterion corrected for small sample size (AICc). Models with AICc values within 2.0 of the model with the lowest AICc were considered equally good fits for the data [24]. The purpose of model selection was to find the model that best explains the data, and variables that are dropped from the best-fit model can be considered to have a statistically insignificant influence on the outcome of interest.

Independent variables that were examined for their effects on science career choice included course level, race, Pell eligibility, gender, first-generation status, credit load, science identity, intrinsic motivation, science self-efficacy, and commitment to a career in science. We also analyzed if course level (general chemistry 1 vs. second-year science courses (organic chemistry or genetics), race, Pell eligibility, gender, first-generation status, or credit load correlates with scores for science identity, intrinsic motivation, science self-efficacy, and commitment to a career in science. We also examined if receiving mentoring correlated with scores for science identity, intrinsic motivation, science self-efficacy, commitment to a career in science, following semester credits, or career in science.

Results and Discussion

Student career goals correlate with demographics

To explore the hypotheses presented above, we began analysis of the data by exploring a correlation between student career goals and demographics. Our multivariable model concurrently considers race and gender, as well as whether a student was a first-generation college student, whether the student was taking a full-time or part-time credit load, and whether a student was Pell eligible. This means it looks at the effect of gender after controlling the other variables, or the effect of race while accounting for the effects of other variables. In addition, the model is additive, so if a student's identity intersects (ex., Asian and female), then the predicted outcome is the effect of being female added to the effect of being Asian. A graphical summary of the racial and gender data is presented in Figure 1, and the modeling statistics are presented in Table 1.

Students who identify as Black or African American, Hispanic, or female are underrepresented in the STEM workforce [1]. Our multivariable model shows that those same students are significantly less likely than students identifying as white or male to select a science or engineering career goal (Figure 1, Table 1). Instead, these groups are more likely to pursue a career in health. The correlation between racial and gender demographics is consistent with the equity gap observed in the STEM workforce. Asian students are not underrepresented in the STEM workforce [1]. However, we find Asian students are significantly less likely to select a science or engineer career goal (Table 1). This inconsistency with national data is likely because the Asian population in Saint Paul is not the same as in much of the country. Minneapolis and Saint Paul have one of the highest populations of Hmong in the country and are the most populous Asian subgroup in Minnesota [25]. These Southeast Asian recent immigrants may have different career goals and motivations than the Asian demographic over the entire country.

The exact reason for the correlation between racial demographics and career choice is unknown, but we hypothesize that science and engineering careers are unknown to students, especially student groups that are already underrepresented in STEM. Students might also find the path toward a science career less clear. Again, with fewer role models in STEM in their racial groups and genders, students are less likely to hear about how to become a scientist. Third, students may perceive that STEM careers do not align with their desired career values. For example, some students may see STEM as an individual focus instead of being community-minded. There is some literature support for this idea. One study from Australia found that students from collectivist cultures highly value a sense of belonging and peer/parental influence in career choice. In contrast, students from individualist cultures highly value aptitude for a particular career [26]. A second study by Eccles and Wang investigated why males and females pursue math and science careers. They found that females who valued altruism and people orientation were more likely to pursue biology or medical careers [27].

No significant correlation was found between career choice and course load (part-time versus full-time) or first-generation status. Additionally, a student's grade in their science course was not correlated with career choice, nor was the level of the course (first-year course, second-year course, etc.).

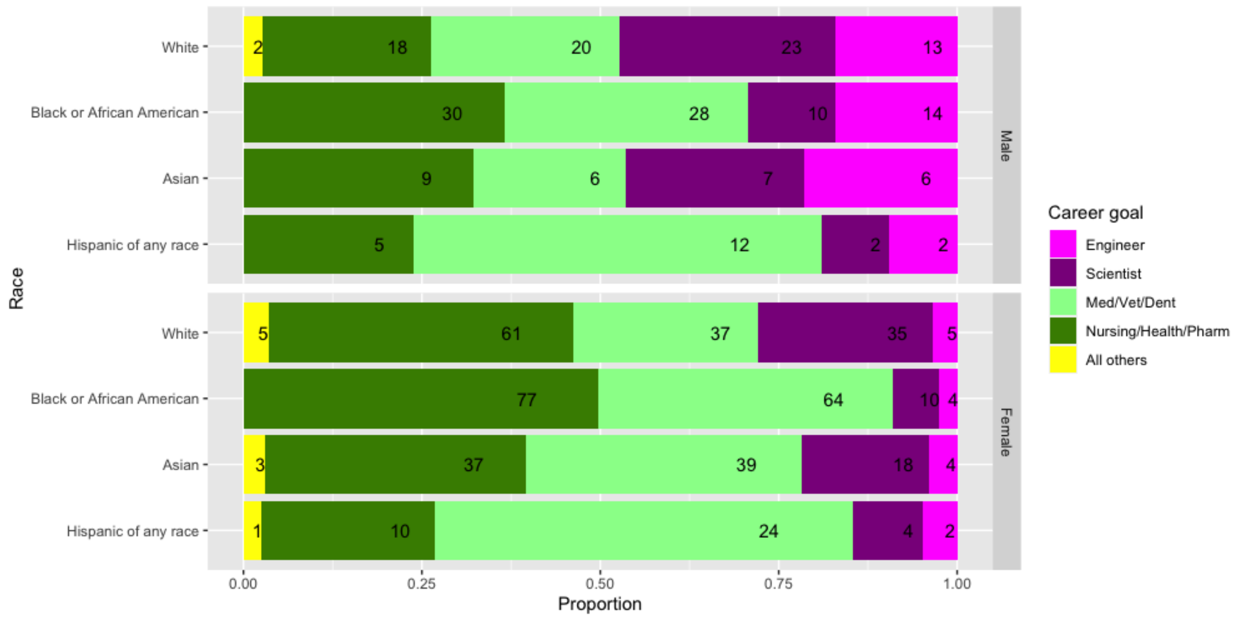

Fig. 1. Career Goals by race and gender. Numbers listed above indicate the number of survey respondents in each category. Black, Hispanic, Asian, and female students are significantly less likely to select a career in STEM than white or male students. Statistical data supporting Figure 1 are presented in Table 1.

Table 1. Multivariable Model of Demographic and Science Attitudes' Effects on Career Goals

Variable (glm)	Estimate	Standard Error
(Intercept)	-0.93	1.07
Gender Female (ref: male)***	-0.97	0.27
1st Generation (ref: not 1st gen)	-0.55	0.29
Part-time Load (ref: full-time)	-0.23	0.26
Pell Eligible**	0.92	0.31
Race (ref: white)		
Black***	-1.90	0.38
Asian*	-0.85	0.37
Hispanic**	-1.27	0.51
Science Identity	0.46	0.24
Intrinsic Motivation	0.00	0.32
Self-Efficacy	-0.10	0.23
Commitment to a career in science	0.12	0.31

*[a]P-values: * = $p<0.05$, ** = $p<0.005$, *** = $p<0.0005$*

Student attitudes towards science are not associated with career goals.

We also explored correlations between a student's career goal (science/engineer versus other) and their self-assessed science identity, intrinsic motivation, self-efficacy, and commitment to a career in science. Figure 2 shows that science/engineer career goals are not associated with higher scores for commitment to a career in science, science identity, self-efficacy, or intrinsic motivation. Table 1 shows data that support Figure 2. Table 2 shows that although science attitudes are not associated with career goals, science attitudes are correlated with other demographic factors. Students identifying as Black and those in second-year courses report higher science identity than other respondents. Students in second-year courses have higher self-efficacy; Asian students have lower self-efficacy. Asian students or students who earned a C have lower intrinsic motivation. Pell-eligible and female students reported having a higher commitment to a career in science (but still chose a science/engineer career less frequently than others). Finally, students who earned a C or DFW (grade of D, F, or W for withdrawal) have a lower commitment to a career in science.

We hypothesized that a science or engineering career goal would be associated with higher scores for self-efficacy, intrinsic motivation, science identity, or commitment to a career in science. This was not the case. This suggests that pre-health and pre-science students are equally engaged, and engagement is not the key to convincing students to pursue science as a career. Also, preliminary data from our focus groups suggest that many students consider health careers to be a science career and a way to apply strong scientific skills. Our data show that females have a significantly stronger commitment to a career in science but are choosing health careers. This might suggest that female students perceive that healthcare better matches their career values [27].

Science identity also did not align with science or engineer career goals (Figure 2). This was in contrast to the finding of Stets *et al.* in 2017 [17], but in line with work from Dou *et al.* in 2021 [28]. Dou *et al.* compared STEM majors and pre-med majors and found that pre-med majors had higher science identity scores than their STEM major peers and equal self-efficacy scores. Together with our study, this suggests that improving students' science identity or self-efficacy would not encourage students to pursue STEM over health.

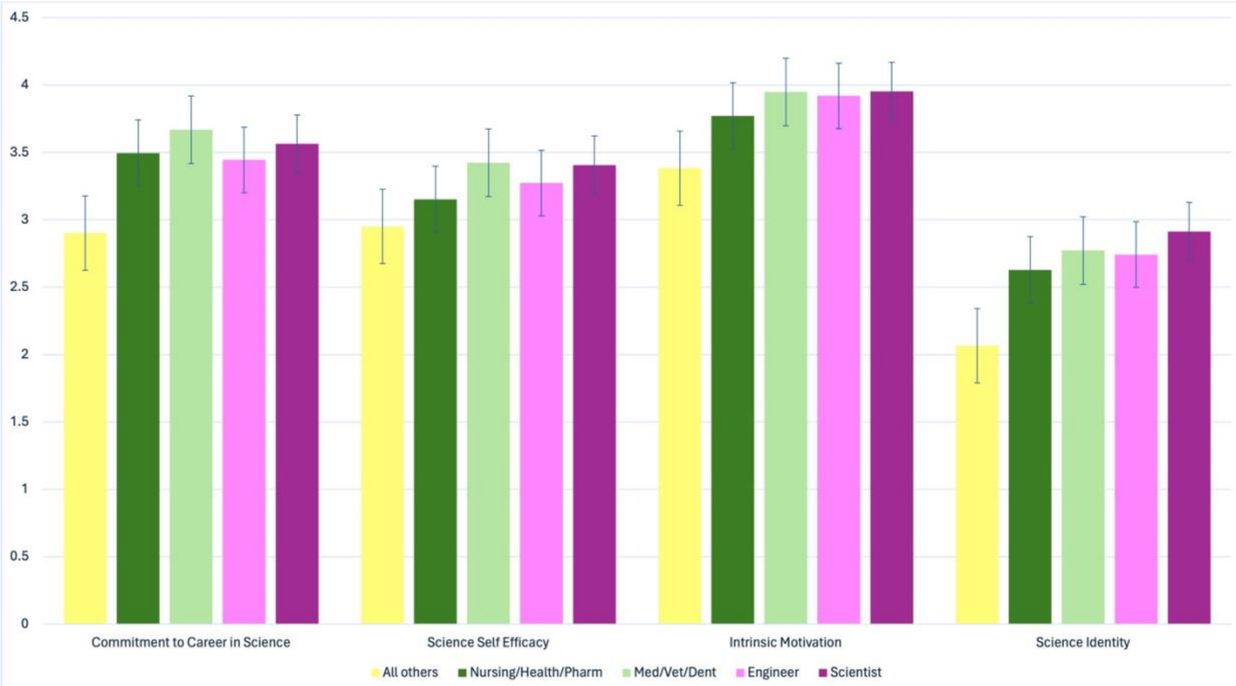

Fig. 2. Science Attitudes by Career Goal. No correlation was found between career choice and scores for commitment to a career in science, science self-efficacy, intrinsic motivation, or science identity. Supporting data are presented in Table 1.

Table 2. Multivariable Model of Demographic Effects on Science Attitudes. Standard error is shown in parentheses, and p-values are marked with asterisks. [a]

Variable (glm)	Commitment to Career in Science Estimate (4 pt scale)	Science Identity Estimate (4 pt scale)	Science Self-Efficacy Estimate (5 pt scale)	Intrinsic Motivation Estimate (5 pt scale)
(Intercept)	3.29 (+/- 0.09)***	2.39 (+/- 0.12)***	3.24 (+/- 0.12)***	3.89 (+/- 0.09)***
Gender Female (ref: male)	0.14 (+/- 0.07)*	-0.05 (+/- 0.09)	-0.07 (+/- 0.42)	-0.01 (+/- 0.07)
1st Generation (ref: not 1st gen)	-0.00 (+/- 0.07)	-0.01 (+/- 0.09)	-0.06 (+/- 0.09)	0.06 (+/- 0.07)
Part-time Load (ref: full-time)	-0.02 (+/- 0.06)	0.05 (+/- 0.08)	0.04 (+/- 0.08)	-0.04 (+/- 0.06)
Pell Eligible	0.16 (+/- 0.07)*	0.17 (+/- 0.10)	-0.00 (+/- 0.10)	0.02 (+/- 0.07)
Race (ref: white)				
Black	0.12 (+/- 0.09)	0.39 (+/- 0.11)***	0.11 (+/- 0.11)	0.10 (+/- 0.09)
Asian	-0.04 (+/- 0.10)	0.05 (+/- 0.13)	-0.36 (+/- 0.13)**	-0.26 (+/- 0.10)**
Hispanic	0.19 (+/- 0.12)	0.23 (+/- 0.15)	-0.05 (+/- 0.15)	0.14 (+/- 0.12)
2nd Year Courses (ref: gen chem)	0.15 (+/- 0.10)	0.27 (+/- 0.13)*	0.27 (+/- 0.13)*	-0.01 (+/- 0.10)
Science Scholar (ref: gen chem)	0.22 (+/- 0.41)	0.62 (+/- 0.53)	0.84 (+/- 0.54)	0.31 (+/- 0.41)
Chem Grade (ref: A Grade)				

Grade B	-0.03 (+/- 0.08)	0.06 (+/- 0.10)	0.06 (+/- 0.10)	-0.07 (+/- 0.08)
Grade C	-0.22 (+/- 0.09)*	-0.05 (+/- 0.12)	-0.08 (+/- 0.12)	-0.27 (+/- 0.09)**
Grade D/F/W	-0.20 (+/- 0.10)*	-0.17 (+/- 0.13)	0.03 (+/- 0.13)	-0.17 (+/- 0.10)

*[a] P-values: * = p<0.05, ** = p<0.005, *** = p<0.0005*

Participation in faculty mentoring and career exploration is associated with STEM career goals

We expected that students who participate in scholarships, faculty mentoring, career planning, and research would choose science/engineering careers more often. We expected this even after discovering that career goals are not associated with science attitudes, as these interventions are focused on coaching and awareness of careers. We found that students who participated in these activities were significantly more likely to choose science and engineering career goals ($p<0.005$; Figure 3). We saw this trend even with the lower *n*umber of students who participated in these interventions.

As we did not see associations between science attitudes and career goals, these interventions must be influencing student career goal choice for other reasons. Possibly, faculty mentorship encourages students to talk about their career goals and forces students to examine why they chose the path they did. This idea is consistent with the 2019 work from Dou *et al*., who found that one big predictor for K12 students to pursue STEM was talking about science with friends and family [29]. Students in our programs are certainly getting exposure to more science career options through guest speakers and career workshops that might open their minds to more career possibilities.

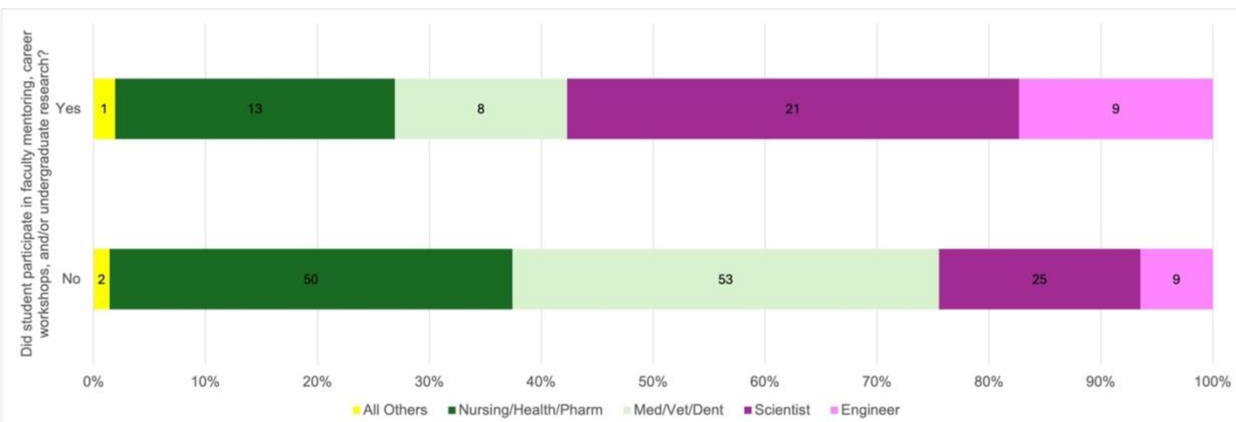

Fig. 3. Career goals by participation in faculty mentoring (with a scholarship), career planning, or undergraduate research. Students who participate in these activities are significantly more likely to choose science and engineering career goals (p<0.005).

Limitations

The authors recognize that there is likely a self-selection bias, as students with science career goals may be more inclined to participate in the Science Scholars, SciCAP, and undergraduate research programs. Additionally, multiplicative interactions (e.g., students who received multiple interventions), could not be accounted for in the analysis. Individual variables (e.g., having a mentor without a scholarship or a scholarship without a mentor), variability in instructors, class, year, COVID, etc. could not be analyzed due to survey limitations.

Conclusion

As a direct result of this project, our college is taking additional measures to give students more guidance on careers. Our Guided Learning Pathways are adding career exploration exercises into courses, so students understand their own reasons for choosing a career and have exposure to many career options. We also expanded our Career and Academic Planning Program (SciCAP) to help students develop a path to their career goals, provide guest speakers in various STEM and health careers, and connect students with a faculty mentor to discuss career and academic plans.

These initiatives give us the opportunity to gather additional data about career choice and understand what interventions motivate students to consider alternative career options. Through surveys and focus groups, we will examine student awareness of careers, career values, and pathways to different careers. This work made us aware that many students have little career guidance, and one method to make a meaningful difference in equity in STEM careers is to give students more opportunities to explore careers during their college tenure.

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