Statistics for STEM Research

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In the Boston Globe article "We need to train more women and minority students for careers in STEM" Zinkevych, 2018 reports that although science, technology, engineering and math jobs are abundant, 1 in 6 high school seniors are interested in studying similar topics in college. The report states that among young women and underrepresented minority students there is talent that has not been cultivated. Simply stated, there are more jobs available than those that can be filled with the current talent pool and a great deal of talent has not yet been recognized because the students who have that talent have not been reached.

The analysis was conducted by used data from several sources. Data from the US Department of Commerce was used to identify that 47% of the workforce in the United States are women. 25% of those women work in computer and mathematical occupations and 15% are engineers. AP Computer Science data was reported from Massachusetts School and District Profiles. This data reveals growth over ten years in the numbers of female and Black and Latino students taking the AP Computer Science Exam. Data from Catalyst: a nonprofit created to inspire workplaces that work for women, was used to identify the number of STEM degrees earned by women of color. In 2014 STEM degrees awarded to women included 2.9 percent, Latinas, 3.6 percent African American and 4.8 percent Asian.

The authors concluded that these statistics are not enough. The numbers are too low. The article emphasizes the need to create more opportunities for students to explore STEM subjects early in their education. The expectation is that for a shift to occur, education, business and government must work together to create solutions.

The analysis is strong. Statistics are provided from resources that are considered to be credible. The data is used to make suggestions for strengthened career planning and coaching in urban middle and high schools. A call to action was made for industry internships and partnerships with schools as well.

The journal article “STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes” suggests STEM faculty have on the participation and achievement of minority students who are underrepresented in STEM. They tested the mindset of faculty (growth or fixed) and examined student experiences, motivation and achievement. The test was conducted using a longitudinal university wide sample of 150 STEM professors and 15,000 students across 13 STEM departments. The results of the study indicated that the mindset beliefs of faculty influence student success.

STEM faculty were invited to participate via email. The survey was completed online and was measured with two validated items. Faculty were identified by number of years teaching, gender, race/ethnicity and age. The relationships between faculty mindset beliefs and racial achievement gaps were examined over 24 months (7 semesters).

Data was collected from STEM faculty self-reporting their mindset belief, student course evaluations and student grades. The mean of the faculty mindset was reported. The interaction between faculty mindset and underrepresented minorities. Standard deviation for fixed beliefs was computed at -1 SD and growth beliefs were computed at +1 SD. The results support faculty mindset belief predicts the racial achievement gap in STEM courses. The mean of the faulty mindset was computed. Fixed mindset fell with -1 SD and growth mindset within +1 SD. The subsequent p values were less than .05 and less than .01. The results indicate that students performed poorly in STEM courses taught by faculty who had fixed mindsets and the association of low performance among Black, Latino and Native American students was greater. The achievement gap between underrepresented minorities and non-underrepresented minorities was greatest in courses taught by faculty with a growth mindset.

The test concluded that the fixed or growth mindset of faculty was a predictor of student achievement and motivation. It is suggested by the study the mindset of faculty has classroom implications for the experiences and achievement of underrepresented STEM students.

Both articles use statistics to communicate a concern regarding the low numbers of women and minorities in science, technology, engineering and math fields. Both offer suggestions to the problem of diversity in STEM study and related occupations. The Boston Globe article presents impressive facts and great recommendations although none of them are new approaches. The science journal article presents findings that have not yet been examined in the way they are examined in the research. I would use the research to train faculty. I would be interested in finding out what the impact of student mindset is in relation to their experience and motivation in STEM courses.

Evidence for the conclusion is strong. The low p value suggests that the results are due to more than chance. Students had more negative experiences in courses taught by faculty with fixed mindsets. Faculty mindset was a large predictor of student success.

Appendix A

We need to train more women and minority students for careers in STEM

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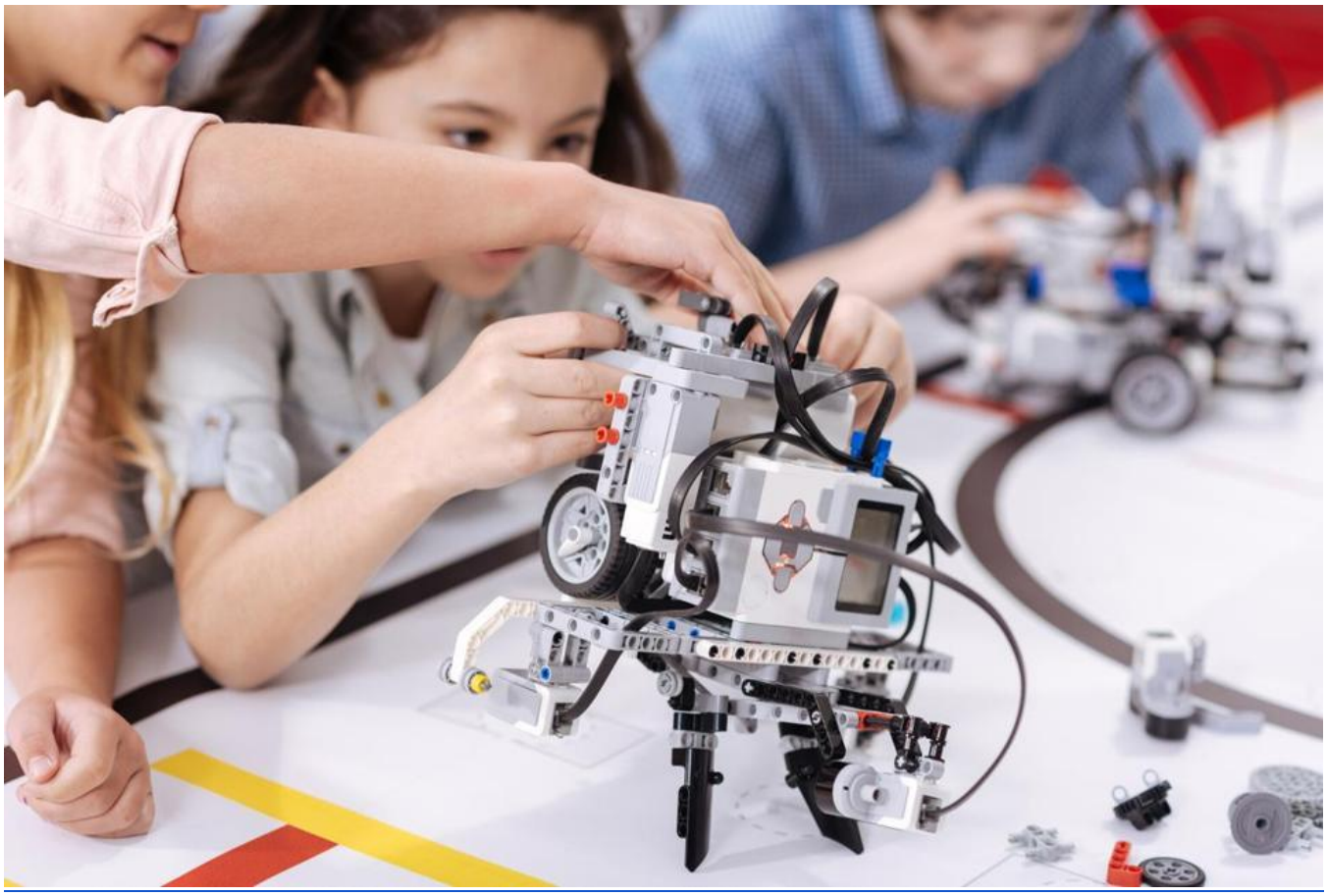

ZINKEVYCH/FOTOLIA

Students in middle school and older are invited to learn about robotics and STEM-related careers at MassRobotics.

By Karyn Polito, Joseph P. Kennedy III and Jeffrey Leiden OCTOBER 22, 2018

Despite an abundance of jobs in science, technology, engineering and math, just 1 in 6 high school seniors nationwide is interested in studying STEM in college. For Massachusetts — which has the most technology jobs per capita in the country — this creates both economic and societal challenges.

As industries like biotech, clean energy, information technology, and advanced manufacturing continue to grow at a rapid pace in the Commonwealth, there is too much untapped potential in our classrooms, particularly among young women and underrepresented minority students.

Although women account for about 47 percent of the workforce in the United States, they hold only 25 percent of computer and mathematical occupations, and just 15 percent of engineering jobs, according to the US Department of Commerce.

As a state, we have made progress over the last decade, with more women and minorities pursuing degrees in STEM subjects. In 2007, just 57 female students and 14 black and Latino students took an AP Computer Science exam in Massachusetts. Ten years later, those numbers grew to 744 and 565, respectively. We still have a long way to go.

Appendix B

STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes

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Abstract

An important goal of the scientific community is broadening the achievement and participation of racial minorities in STEM fields. Yet, professors' beliefs about the fixedness of ability may be an unwitting and overlooked barrier for stigmatized students. Results from a longitudinal university-wide sample (150 STEM professors and more than 15,000 students) revealed that the racial achievement gaps in courses taught by more fixed mindset faculty were twice as large as the achievement gaps in courses taught by more growth mindset faculty. Course evaluations revealed that students were demotivated and had more negative experiences in classes taught by fixed (versus growth) mindset faculty. Faculty mindset beliefs predicted student achievement and motivation above and beyond any other faculty characteristic, including their gender, race/ethnicity, age, teaching experience, or tenure status. These findings suggest that faculty mindset beliefs have important implications for the classroom experiences and achievement of underrepresented minority students in STEM.

INTRODUCTION

Despite decades of research and millions of dollars in federal funding aimed to understand and ameliorate the underrepresentation of diverse individuals in the STEM (science, technology, engineering, and mathematics) pipeline, Black, Latino, and Native American students [underrepresented racial/ethnic minorities (URM)] continue to underperform academically relative to their White peers (1). While these racial achievement gaps are determined by multiple (e.g., economic and structural) factors,

they may be exacerbated by subtle situational cues from STEM professors that reinforce racial stereotypes about which social groups are more or less likely to have ability in STEM (2).

The cues hypothesis suggests that threatening situational cues in STEM settings, such as the diagnosticity of a test (2–4), can cause URM students to become concerned about being judged in terms of ability stereotypes, resulting in a loss of motivation, intellectual underperformance, and larger racial achievement gaps in STEM classes (5–7). This study examines the role of a novel situational cue to stereotype underperformance—STEM college professors' beliefs about the fixedness or malleability of ability (8)—and explores whether these faculty beliefs are associated with URM students' motivation and their academic achievement in those professors' STEM courses.

People's mindsets (also known as implicit theories or lay theories) are their beliefs about the fixedness or malleability of human characteristics like intelligence or personality (8). Faculty members who espouse fixed mindset beliefs endorse the idea that intelligence and ability are fixed, innate qualities that cannot be changed or developed much. In contrast, faculty who espouse growth mindset beliefs endorse the idea that ability is malleable and can be developed through persistence, good strategies, and quality mentoring. Fixed mindset professors are more likely to judge a student as having low ability based on a single test performance (9) and to use unhelpful pedagogical practices, like encouraging students to drop difficult courses (e.g., "not everyone is meant to pursue a STEM career") (9).

Faculty who endorse fixed mindset beliefs think that some students have strong, innate intellectual abilities, while others do not. Which students might those be? Pervasive cultural stereotypes suggest that White and Asian students are more naturally gifted in STEM than Black, Latino, and Native American students. Because these American cultural stereotypes impugn the intellectual abilities of URM students, we predicted that faculty who endorse fixed mindset beliefs may be particularly demotivating to URM students, resulting in lower performance among URM students in courses taught by fixed (versus growth) mindset faculty. Classic findings regarding the influence of teacher beliefs on students' performance demonstrate that when teachers have lower expectations for their students, those students become less motivated and perform more poorly in those teachers' classes (10). These Pygmalion effects are even stronger for URM students (11, 12).

We hypothesized that STEM professors' fixed beliefs about intelligence and ability would lead URM students to experience lower motivation and to underperform relative to their non-stereotyped peers—a pattern consistent with stereotype threat theory. Classic studies that document stereotype threat underperformance effects typically manipulate threatening (versus nonthreatening) situational cues in the learning environment, such as an experimenter's race/ethnicity/gender, and assess students' intellectual performance as the primary indicator of stereotype threat (2, 7, 13, 14). Drawing on this theoretical framework, the present study examines the role of college professors' mindsets as a situational cue that triggers URM underperformance in STEM courses. We argue that if STEM faculty who endorse fixed mindset beliefs engender stereotype threat among URM students, we should observe lower student motivation and substantially larger racial achievement gaps in those professors' courses compared to courses taught by STEM professors who endorse growth mindset beliefs.

The present study investigates undergraduate STEM faculty's self-reported mindset beliefs and their implications for student motivation and performance. Previous research has examined students'

perceptions of faculty beliefs (15), yet no study, to our knowledge, has examined actual self-reported mindset beliefs of STEM faculty as a predictor of student performance. Furthermore, the effects of teacher beliefs have only been examined among young children (16) and have not been applied in undergraduate populations, where career decisions and trajectories are more salient. We test our hypothesis in a longitudinal, university-wide sample of STEM faculty—the largest sample to date of faculty mindset beliefs combined with student records.

RESULTS

To test our hypothesis, we examined the links between faculty mindset beliefs and the racial achievement gaps in those faculty members' courses across seven semesters (2 years) and more than 15,000 undergraduate student records. Using a validated two-item lay beliefs about intelligence measure (8), we surveyed STEM faculty (N = 150; 40.8% response rate) at a large, selective public university (e.g., "To be honest, students have a certain amount of intelligence, and they really can't do much to change it"; $\alpha = 0.91$, M = 3.87, SD = 1.46). All 13 STEM departments (e.g., Astronomy, Biology, Computer Science, Mathematics, and Physics) at the university were represented in the sample. More than half (55.3%) of the sample was tenured, and the average STEM teaching experience was 18.4 years. The percentage of female and URM faculty in the sample was similar to the demographics of STEM faculty nationwide (faculty sample: 26.7% female, 4.7% URM; nationwide: 20.4% female, 5.2% URM) (1).

University records provided course grades for all students [N = 15,466; 7172 women (46.4%); 1685 URM (10.9%)] enrolled in all of the courses (n = 634) taught by the STEM faculty respondents over seven academic terms. Thus, student-level data in this study represent a census (the entire population of individuals in a setting) rather than a sample that is used to estimate the population. A multilevel regression model accounted for the nested nature of the data (students nested within courses, nested within faculty) and controlled for confounding factors such as students' previous achievement (SAT scores) and all available course and faculty characteristics (17). All variables were standardized so that coefficients from the multilevel model can be interpreted as effect sizes (18). Last, we added partially crossed random effects to the model because students could enroll in multiple courses from the same faculty member or in courses from multiple faculty members in the sample across the seven academic terms (19). Table S1 provides fixed effects estimates from the model.

On average, all students performed more poorly in STEM courses taught by faculty who endorsed more fixed (versus growth) mindset beliefs (B = 0.08, P = 0.011). However, consistent with stereotype threat and the cues hypothesis, fixed faculty mindset beliefs were more strongly associated with lower course performance among Black, Latino, and Native American (URM) students (B = 0.12, P = 0.001) than among White and Asian students (non-URM; B = 0.08, P = 0.010; group × faculty mindset interaction: B = 0.04, P= 0.041; Fig. 1). On average, non-URM students earned 0.14 grade point average (GPA) points (on a 4.0 scale) higher than URM students, yet in courses taught by faculty who endorsed more of a fixed mindset (−1 SD), the racial achievement gap grew to 0.19 GPA points (URM GPA = 2.71; non-URM GPA = 2.90). However, in courses taught by faculty who endorsed more of a growth mindset (+1 SD), the racial achievement gap shrank to 0.10 GPA points (URM GPA = 2.96; non-URM GPA = 3.06).

Thus, the racial achievement gap was nearly twice as large in courses taught by college professors who endorsed fixed (versus growth) mindset beliefs about students' ability.

Appendix C

Canning, E. A., Muenks, K., Green, D. J., & Murphy, M. C. (2019, February 01). STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes. Retrieved from http://advances.sciencemag.org/content/5/2/eaau4734.full

Canning, E. A., Muenks, K., Green, D. J., & Murphy, M. C. (2019, February 15). STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes. Supplementary Materials Retrieved from http://advances.sciencemag.org/content/advances/suppl/2019/02/11/5.2.eaau4734.DC1/aau4734_SM.pdf

Zinkevych. (2018, October 22). We need to train more women and minority students for careers in STEM - The Boston Globe. Retrieved from https://www.bostonglobe.com/opinion/2018/10/21/need-train-more-women-and-minority-students-for-careers-stem/c8zaxFETADcQvU5em5MVPO/story.html