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Progress on Longitudinal Study of the Impact of Growth Mindset and Belonging Interventions in a Freshman Engineering Class

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Abstract

Growth mindset and belonging interventions have shown to be effective in increasing retention and performance in some K-12 and postsecondary populations. These interventions hold the promise of cost-effective and scalable interventions. They may be able to boost retention and graduation rates, and close the achievement gap that often exists between underrepresented (URM) students and non-URMs.

A study of the impact of growth mindset and belonging interventions was designed and implemented in the 2015-2016 academic year in an Introduction to Engineering Course typically taken in the freshman year of all engineering and technology programs at a large comprehensive public university. The interventions were adapted from prior successful interventions by established researchers. Preliminary results upon the conclusion of the Spring 2016 semester showed that the interventions had different effects on different demographic groups. The belonging intervention resulted in higher course performance compared to the control group among the men and non-URMs in the study, controlling for instructor, high school GPA, and SAT math score. Curiously, the growth mindset intervention resulted in lower course performance among women in the study, also controlling for the same possible pre-existing differences. Neither intervention appeared to influence the URM students' course performance.

Currently, we have 5 semesters of retention and progress-to-degree data for this cohort (n = 435). Prior work with these interventions have registered long-term effects of subtle interventions, and it is our hope that there will be measurable effects on metrics of student progress and success that linger past the intervention.

Background and Motivation

The ultimate motivation for this work is to examine if minimally-invasive, low-cost interventions fostering a growth mindset and/or feelings of belonging can be effective in impacting retention and graduation rates of engineering and technology majors at a large comprehensive public university with a significant minority population. In our implementation, we integrated the interventions into the assignments of a required freshman course, but they could be embedded in any curricular or co-curricular activity. We published a paper after one year of a longitudinal study describing our preliminary findings, which showed that overall, non-URM students who received the belongingness intervention had higher average class grades than those in the control and growth mindset condition, controlling for instructor, high school GPA, and SAT math scores. Further details of the interventions, study, results, and the literature review conducted up to that point can be found in the paper[1]. There is evidence that subtle psychological interventions can be self-reinforcing under certain conditions, for example, in environments with chronic evaluations (such as school), performance gains can magnify and reinforce the intervention[2].

There has been additional work published on fostering a growth mindset in engineering student populations in the past two years. Freeman et al. described positive outcomes, including

development of a growth mindset, from engineering students being taught in a way that develops the six engineering Habits of Mind[3]. Frary examined if a growth mindset could be fostered through a series of reading assignments and reflections in a junior-level material science course[4]. Henderson et al. studied whether mindsets influence a student's engineering identity over time and to see if this relationship differs by gender[5]. Dringenberg et al. held a series of focus groups on the growth mindset with first-year engineering students, and found that it was useful for students in unpacking and reflecting on past experiences, and for educators in understanding the nature of intelligence[6]. Lastly, Zappe et al. described instructor training to understand the growth mindset and how to promote it when students approach assignments[7].

Fostering a sense of belonging in undergraduate engineering majors has also been a continued topic of research in the past two years, especially in efforts to promote and support diversity. Blackburn published a literature review of women in STEM, and explored stereotypes, biases, campus culture, and sense of belonging, among other areas[8]. Aish et al. explored if a website featuring profiles of diverse role models can foster sense of belonging in minority students and support their success in the program[9]. Pierrakos described the transformation of senior capstone and design courses to value and reward effort, perseverance, persistence, and empowerment, and found that sense of belonging, among other positive traits, were of high practical significance in the treatment group compared to the control[10]. Han et al. created a program for mechanical engineering majors and faculty immersing them in projects with practicing engineers, in which students' sense of belonging, engineering identities, and their persistence in the major were studied[11]. Solomon et al. reported that there is a visible gap in computing education research that does not capture the intersectionality of being a Black woman in computing[12]. Schar et al. explored the classroom belonging experiences with students in their first engineering-specifc class, and found that belonging had two separate sources: academic belonging and social belonging[13]. Al-Qudah et al. embedded small interventions in a course for engineering pre-majors to improve their sense of belonging and self-efficacy[14].

It is the hope that we can build upon prior work and implement a scalable intervention aimed at improving retention and graduation rates in the College of Engineering at San Jose State University.

Research Questions

This paper summarizes our findings two years after the administration of the growth and belonging interventions in our freshman engineering population, and addresses the following research questions.

1. Does either intervention have any impacts on performance, retention, or progress in the program during the two-year period afterwards?
2. Do the impacts differ for any subgroups?
3. Did either intervention influence non-engineering majors at the time of the intervention to become engineering majors?

Methodology

In the prior paper, the impacts of the growth mindset and belonging interventions administered to the student cohort in a freshman engineering course in Spring 2016 were reported. Since that time, it was discovered that there were students who were not freshmen enrolled in the course. Because our interventions were designed to be administered near the beginning of an engineering degree program, all students who were not freshmen during the initial semester were removed from the study. (In an interesting side note, a higher fraction of the belonging group from this semester was comprised of seniors. It is likely that the higher average course GPA attributed to the belonging group was influenced by its composition, as seniors would likely earn higher grades in this course due to the increased knowledge of engineering and design.)

To increase sample sizes, the data for freshmen from the Fall 2015 class was combined with the Spring 2016 class. The fall semester class had the same belongingness and growth mindset interventions administered, along with a control group (and a fourth condition which was removed for the current study). The scales for measuring growth mindset and belongingness were updated since the first semester in the pre- and post-surveys; however, the scales do not bear on the results being reported in this work.

For all of the students who are engineering majors in their initial semester, we have the following numbers in each of the groups that we'll be studying in the current paper:

	condition			Total
	Control	Belonging	Growth Mindset	
URM	46	55	42	143
Non-URM	100	98	94	292
Total	146	153	136	435

Table 1. Number of URM and Non-URM engineering freshmen in each condition

	condition			Total
	Control	Belonging	Growth Mindset	
Female	25	33	29	87
Male	121	120	107	348
Total	146	153	136	435

Table 2. Number of female and male engineering freshmen in each condition

	condition			Total
	Control	Belonging	Growth Mindset	
Pell eligible	54	51	46	151
Non-Pell	92	102	90	284
Total	146	153	136	435

Table 3. Number of Pell-eligible and non-Pell-eligible engineering freshmen in each condition

In addition, there were 24 students in the course who were not engineering majors.

IRB approval was obtained for the study prior to Fall 2015. All students who did not consent to participate in the study or were under 18 years of age during the first semester were removed from the study.

Results

Research Question 1

Analyses were run to determine if there were any impacts on academic performance, retention, or progress in the program during the two-year period after the interventions were administered.

To determine if either or both interventions enhanced academic performance (e.g. Cumulative GPA) or progress in the program (e.g. units completed since initial semester), we performed ANCOVA tests with the condition as the independent variable and the Cumulative GPA as the dependent variable in the case of academic performance and units completed since the initial semester as the dependent variable in the case of progress in the degree. We controlled for high school GPA and SAT math scores in all analyses by including them as covariates. The dependent variables were computed and tested for each of the four subsequent semesters from the intervention. The effect of the condition was not significant for either dependent variable for any of the four semesters following the intervention semester. Results for Cumulative GPA: Semester 1 ($F = 2.01$, $p = 0.14$), Semester 2 ($F = 1.06$, $p = 0.35$), Semester 3 ($F = 0.18$, $p = 0.83$), Semester 4 ($F = 0.51$, $p = 0.60$). Results for Units Completed Since Initial Semester: Semester 1 ($F = 1.72$, $p = 0.18$), Semester 2 ($F = 2.37$, $p = 0.10$), Semester 3 ($F = 1.99$, $p = 0.14$), Semester 4 ($F = 2.18$, $p = 0.12$).

To determine if either or both interventions impacted retention, we performed chi-square tests. Retention was coded as “1” if a student remained enrolled and was still majoring in engineering, and as “0” in all other cases. No relationship was found between condition and retention in any of the four semesters following the intervention semester: Semester 1, $\chi2$ (2, N=435) = 4.22, $p = 0.12$; Semester 2, $\chi2$ (2, N=435) = 1.70, $p = 0.43$; Semester 3, $\chi2$(2, N=435) = 1.74, $p=0.42$; Semester 4, $\chi2$(2, N=435) = 1.03, $p=0.60$.

Research Question 2

The analyses described for Research Question 1 were repeated for each of the following subgroups: URM, Non-URM, Female, Male, Pell-eligible, and Non-Pell-eligible. The URM category was defined as Hispanic/Latino, African American, or American Indian ethnicities.

We found no significant impacts in the URM, female, and Pell-eligible subgroups for academic performance, retention, or progress in the degree in any of the four semesters subsequent to the intervention.

For the Non-URM subgroup, the belonging intervention was associated with the lowest average units completed by the fourth subsequent semester after the intervention ($F = 3.65$, $p = 0.03$).

Pairwise comparisons showed that the average units completed in the belongingness condition (M = 49.8) was significantly lower than in the control group (M = 55.3). The differences between the control and growth mindset conditions was not significant.

For the male subgroup, the belonging intervention was associated with the lowest average units completed by the third ($F = 4.60$, $p = 0.01$) and fourth ($F = 4.29$, $p = 0.02$) subsequent semesters after the intervention. Pairwise comparisons in the third semester after the intervention showed that the units completed in the belongingness condition (M = 36.0) were significantly lower than in the control condition (M = 38.8), with no difference between the control and growth mindset conditions. The same trends occur in the fourth semester. The belongingness condition (M = 49.1) was significantly lower than the control condition (M = 53.1), with no difference between control and growth mindset.

For the Non-Pell-eligible subgroup, the belonging and growth mindset conditions were shown to increase retention in the first semester following the intervention, $\chi 2$ (2, N=284) = 6.83, $p = 0.03$. The retention rates were: Control, 93.5%; Belonging, 99.0%; and Growth Mindset, 98.9%. In the second semester after the intervention, the interventions were trending towards significance, $\chi 2$ (2, N=284) = 5.00, $p = 0.08$. The 2-semester retention rates were: Control, 88.0%, Belonging, 93.1% and Growth Mindset, 96.7%.

<u>Research Question 3</u>

To answer Research Question 3, the 24 students who were not declared engineering majors at the time of the interventions were examined three semesters after the intervention to determine if there was any influence of the interventions on their decision and ability to change their major to engineering. Three semesters was chosen as a reasonable check point because a change of major on our campus requires a track record demonstrating success in our courses and paperwork requiring approval from different levels of review. No differences were found between the control and either intervention group, $\chi 2$ (2, N=24) = 0.05, $p = 0.98$. The average change of major rates into engineering were: Control, 83.3% (5 out of 6); Belonging, 81.8% (9 out of 11), and Growth Mindset, 85.7% (6 out of 7).

Conclusions

We found no effect of either the growth mindset or the belonging intervention university to academic performance, units completed, or retention, up to two years after their administration to freshman engineering majors at a comprehensive, predominantly undergraduate, regional public. This result is consistent with prior work in which the effects are not discernable in data that is not disaggregated. However, it is surprising that the same results were found in URM, female, and Pell-eligible subgroups, because these are the subgroups that are traditionally underrepresented in engineering and hypothesized to benefit more from these interventions than the population as a whole.

There were significant, but weak reduction in units completed associated with the belonging condition in the Non-URM and male subgroups. The reductions were not apparent until the third and fourth semesters after the intervention for the male subgroup, and the fourth semester after

the intervention for the Non-URM group. The magnitude of the reductions range from 3-5.5 units after the fourth semester, and this is small enough to not worry about from an administrative perspective. It is hard to imagine that the belonging intervention would have a mechanism to result in such an effect.

There were mild improvements to the retention rates of Non-Pell-eligible students one semester after the intervention for the belonging condition compared to the control group. The improvements dissipated in the second semester, and were unnoticeable after that.

In conclusion, the use of subtle and self-reinforcing interventions to substantially improve retention, particularly in underrepresented groups, remains elusive for us. There does not appear to be any harm in using them, and possibly some short term gains in retention for some subgroups. The interventions undoubtedly require more intensive programming and/or periodic reinforcement to achieve the results we are seeking. The longitudinal study is concluded at this time with no expectation for further findings.

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