Effect of Student-Centered Programs on Retention of Engineering Students

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His research takes two distinct but interrelated paths focused on elementary students' learning in science and engineering as well as in-service science teachers' professional development. The first focus involves how language as a learning tool improves students' conceptual understandings, literacy, and representation competencies in science. His second research focus is on how in-service teachers develop their knowledge for teaching science and engineering in argument-based inquiry classrooms. This research is aimed at developing measures of teachers' Pedagogical Content Knowledge (PCK) for adopting the argument-based inquiry approach, as well as developing tools to capture the interactive nature of PCK.

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Background/Rationale

Recent research indicates that engineering students tend to leave their major at a rate similar to students enrolled in the humanities, business, and education. However, students who change majors are then far less likely to select engineering as their next career choice.[1] This relative outflow without a balanced influx has created issues of high attrition within engineering schools across the country. Possibly, administrators keep this imbalance in mind as universities enroll far more students in their freshman engineering courses than will graduate from these programs.

Despite this, nearly all future projections call for an increase in the number of students trained in the STEM (Science, Technology, Engineering, and Mathematics) fields, particularly engineering. Even with this growing spotlight, however, studies have still shown how the number of students entering college as STEM majors has actually declined in recent years.[2] This issue of low matriculation combined with growing national attention thus results in a need to place higher priority on the retention of engineering students.

Attrition issues are often ascribed to a variety of factors, including problems with course load, poor instruction in introductory courses, and a student's sense of belonging within the discipline.[3, 4] And while there exists prior research into these various factors, most of the current literature addresses only general retention and fails to be specific enough to examine issues particular to engineering students. Relying upon these general trends thus fails to explain why engineering as a discipline experiences this greater level of attrition when compared to other fields. To fill this gap in knowledge the following study focused on the concept of a student's sense of belonging within engineering, as that has been shown to often be one of the best indicators for future success.[5, 6] In particular, it examines whether reforms designed to address students' belonging could affect retention within the Ira A. Fulton Schools of Engineering at Arizona State University.

Beginning in the late 1990s the Fulton Schools instituted various strategies to address the attrition of its engineering students. Many of these changes mirrored the examples of the "ASEE Best Practices" such as formalizing tutoring opportunities, elucidating programs of study, and adjusting advising procedures. In 2003, the college further supported this effort by revising the graduation requirements for its programs from 128 credit hours to 120 credit hours. This afforded students a reduced workload and more flexibility in their scheduling, making it more feasible for them to graduate within the standard four-, five-, or six-year tracks. This is evidenced by the fact that (while both figures have risen over time), since 2003 the percentage of students graduating in four years has risen far more dramatically than the percentage of students graduating in six years (Table 1). These reforms were not always consistent across the different engineering disciplines (or even classrooms), but even so the college experienced a substantial growth in its retention rates.

Starting in 2007, a much more concerted effort was made with the goal of advancing retention rates even further. Prior to this most reforms implemented were programmatic in nature, and did not specifically target a student's sense of belonging within their major. To rectify this, the college instituted systemic changes to address students' feelings of displacement as first- and second-year engineering students. This new suite of strategies can be broken down as *Co-Curricular Experiences*, *Course Curricular Experiences*, and *Student Support Programs*.

- *Co-Curricular Experiences* include undergraduate research opportunities, engineering summer camps for freshmen, and professional student societies (often specific to a student's major). The intent of these programs is for students to be able to bond with one another and with faculty outside of the classroom, all the while honing their research and professional skills.

- *Course Curricular Experiences* refer to two mandatory courses all engineering students in the college must take. The first is a student success course taken by all entering university students focused on time-management and study skills. The second is a revised introduction to engineering course designed for first-year students, geared toward problem-solving and team-building tasks.

- *Student Support Programs* are many-fold and include upper-division engineering students serving as peer mentors and undergraduate teaching assistants (UGTAs), supplemental instruction made available through an engineering-specific tutoring center, and a student residential community wherein all freshmen engineers live together in a centralized, on-campus complex. Together these policies provide both support and role models for students who may be struggling while also promoting the development of close-knit, supportive cohorts within the greater engineering community.

These different strategies and programs were made available to all Fulton engineering students, regardless of their major. As seen above, however, many of the strategies targeted underclassmen engineers, with the hopes of reinforcing these students' early sense of belonging within the engineering community.

Methods

To evaluate the effects of this suite of strategies that was initiated in the 2007-08 academic year, an interrupted time series approach was utilized. Both enrollment status and retention data for the entire engineering college were available from 1998 through 2013. A quasi-experimental design was employed comparing the retention of incoming freshmen engineering students from their first semester to the beginning of their junior year. As a result, in this study being 'retained' was operationally defined as a student who entered into an engineering program and then remained in that program at the two year mark.

This cutoff was chosen because, at this particular institution, if a student remains in their engineering program for at least two years then they are found to be far more likely to graduate from the college within six years (Table 1). For example, only 50% of the freshmen from the 2007 cohort were retained (still enrolled) in their engineering majors by the fall of 2009. Within this subset that stayed, however, 83.6% of them went on to graduate from the college within six years' time (41.8% of the original freshman class). The largest drop off in student retention occurs early, making the two-year mark a good testing point for a student's likelihood to persist through to graduation.

Table 1: Percent of Student Retained Compared with Percent Graduating in Four and Six Years

Entry Year as Freshmen	Percent of Students Retained at Two Years	Percent of Students Graduating within Four Years	Percent of Students Graduating within Six Years
1998	44.9%	11.0%	34.4%
1999	46.2	9.5	33.6
2000	46.8	11.0	32.7
2001	47.5	9.9	31.6
2002	42.2	12.4	29.8
2003	46.3	11.8	33.8
2004	50.7	18.2	37.9
2005	50.7	15.9	37.6
2006	53.9	24.6	42.5
2007	50.0	26.3	41.8
2008	55.2	31.0	N/A
2009	57.4	32.4	N/A

This decision yielded a set of nine pre-intervention two-year cohorts (the 1998 – 2006 freshman classes) that were then compared to five post-intervention cohorts (the 2007 – 2011 freshman classes). Trends were first examined among the engineering student body as a whole. To determine whether these reforms had additional effects on any particular sub-groups, the results were then disaggregated and analyzed by both gender and ethnicity.

For this study, two aggregate ethnic categories were created. The first was comprised of students identifying themselves as either White or Asian/Asian-American. The other category was then comprised of traditionally underrepresented minorities (URMs) within the field of engineering, namely American Indian, Black, and Hispanic students.[7] These categories correspond with the primary groups historically addressed in American higher education research (i.e., Asian, American Indian, Black, Hispanic, and White).While the experiences of each of these lumped minority groups would be distinct, their small sizes prevent them from being analyzed individually. This classification also filtered out students who did not provide ethnic identification, identified as multiracial, or were listed as international students.

In all cases, retention rate was the relevant measurement. Finally, mean retention rates (i.e., slope) of the different groups were compared and evaluated to determine if change, such as abrupt change or delayed change, had occurred.[8]

Results

It was evident that there existed an overall 14-year upward trend in the proportion of freshmen engineering students who persisted in their program through to the start of their junior year (Table 2). This growth can be seen both before and after the introduction of the new suite of strategies in 2007.

Table 2: Percent of Students Retained in Engineering Freshmen through Junior Year

		Gender		Ethnicity	
Cohort	**Overall**	**Women**	**Men**	**URM**	**Asian & White**
1998-2000	44.9%	39.5%	46.5%	38.5%	46.1%
1999-2001	46.2	48.0	45.6	46.8	45.4
2000-2002	46.8	52.2	45.3	30.2	50.2
2001-2003	47.5	52.8	46.1	42.9	47.2
2002-2004	42.2	40.1	42.6	36.6	42.3
2003-2005	46.3	49.3	45.7	41.8	46.3
2004-2006	50.7	53.7	50.0	45.1	50.4
2005-2007	50.7	46.5	51.7	43.6	51.4
2006-2008	53.9	49.6	54.9	48.5	55.4
2007-2009	50.0	54.2	49.0	37.8	52.7
2008-2010	55.2	53.5	55.6	49.8	56.0
2009-2011	57.4	55.9	57.8	48.0	59.8
2010-2012	57.5	58.9	57.2	53.1	57.1
2011-2013	56.9	54.5	57.5	42.7	58.9

Over the 14 year period, retention rate (as represented by linear regression) increased at an average rate of 1.1% per year (Figure 1). Prior to the new wave of reforms though, this increase in freshmen engineers persisting until their junior year increased at an average of only 0.9% per year (Figure 2). Following the addition of the new strategies, the average increase in retention then jumps to 1.6% per year (Figure 3). This jump occurred while the incoming freshman class simultaneously increased from an average of 774 to 957 students. Part of this observed increase, however, can also be attributed to a drop in the retention of the 2007 cohort (50.0%), allowing the trend line to slope higher for the subsequent years as it jumped back up. As a result, this new strategies seems to be successful in helping to retain a growing percentage of a growing number of students.

Figure 1: Overall Percent of Engineering Freshman Retained

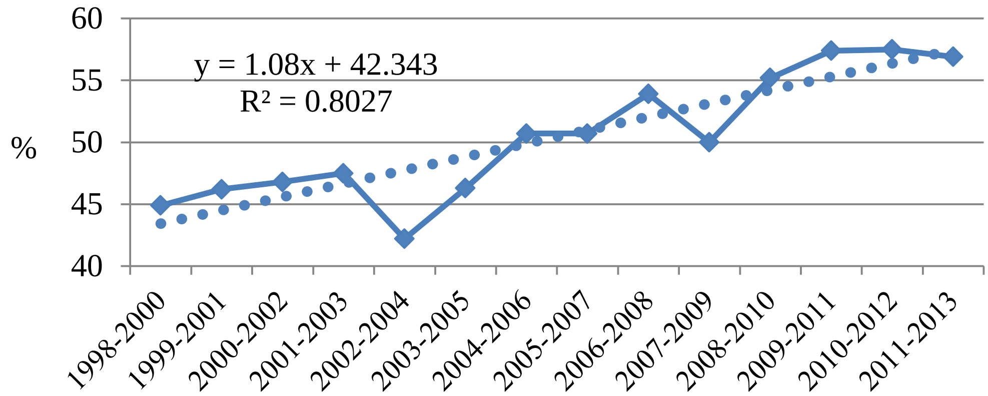


Figure 2: Percent Retained Pre-2007

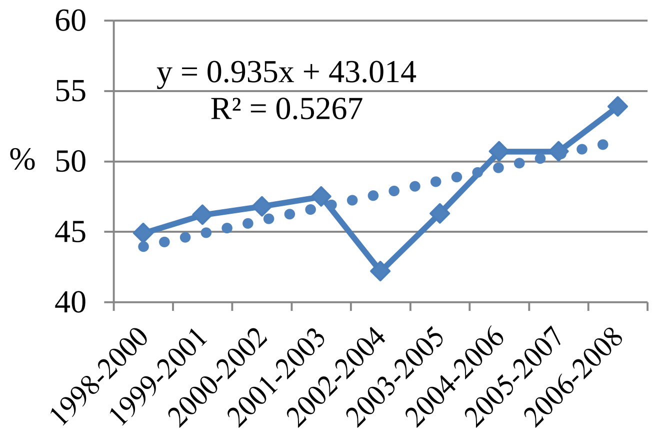
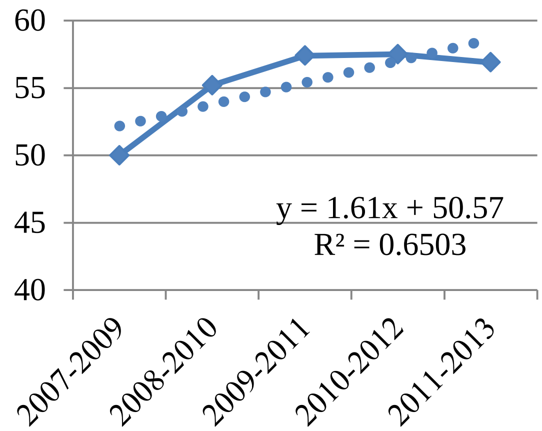


Figure 3: Percent Retained Post-2007



Examination of data based on gender indicates that overall retention rates similarly rose over time for both male and female students (Figures 4 & 5). These strategies addressing belonging, however, seem to have affected the two groups differently. There is a noticeable jump in the retention of male engineering students following the introduction of these new programs, with the extra rate of retention increasing from 1.0% to 1.9% per year. The new strategies had minimal effect on further increasing the retention of female students with the rate of increase remaining level at 0.6% per year.

Figure 4: Percent of Men and Women Retained Pre-2007

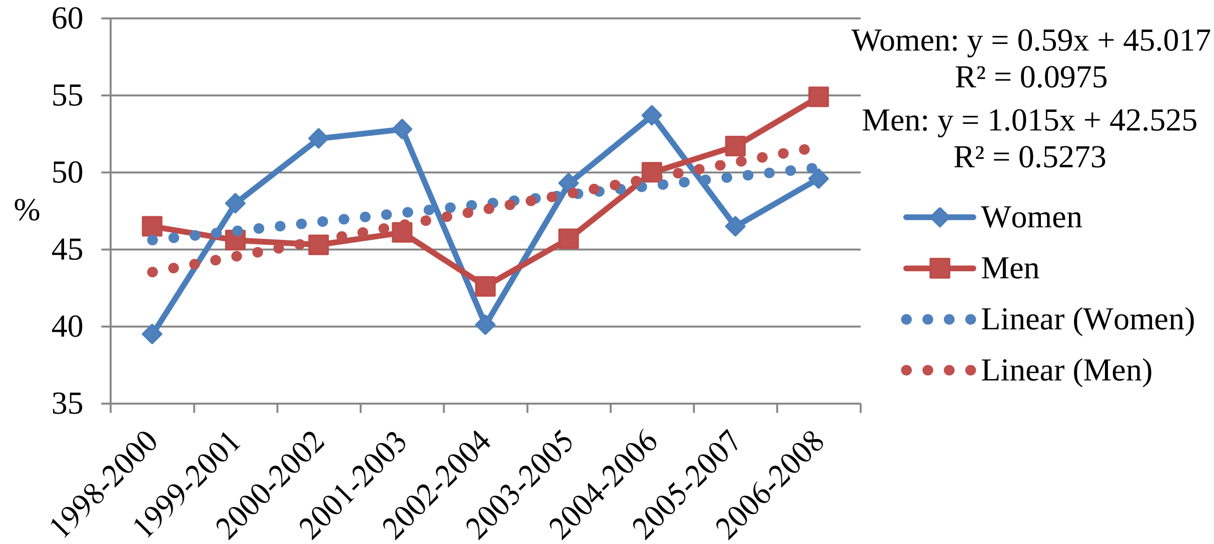
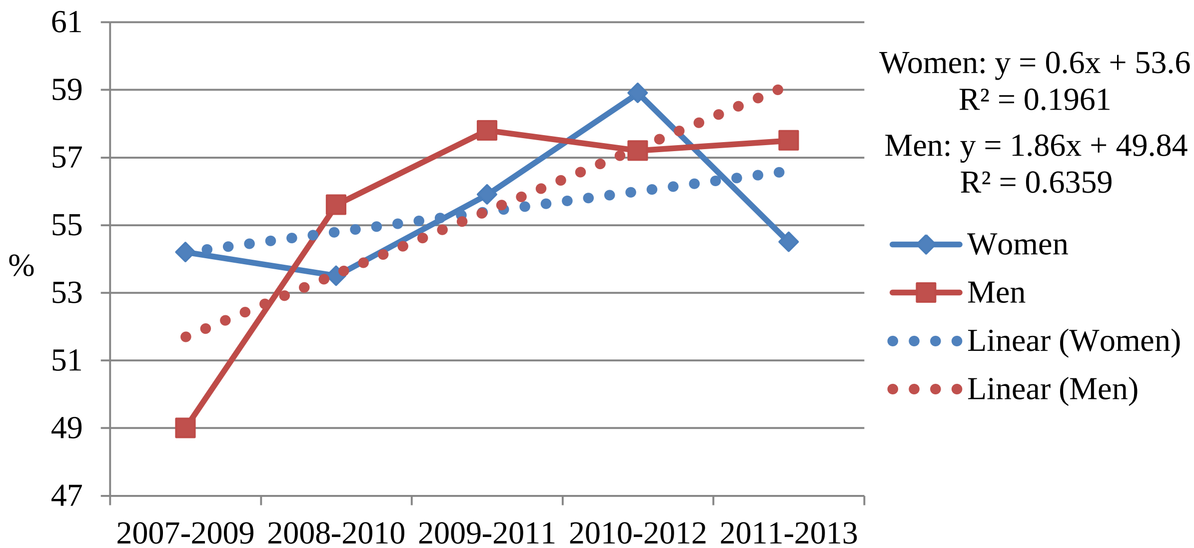


Figure 5: Percent of Men and Women Retained Post-2007



Similarly, retention rates of URMs, along with Asian and White students, continued to exhibit an overall upward trend (Figures 6 & 7). Both of these categories saw jumps in their retention rates following 2007 – from 1.0% to 1.3% for URMs and from 0.9% to 1.4% for Asian and White students. However, as was the case in gender, neither subgroup revealed the same degree of abrupt change as was seen for the aggregate. The retention rate for Asian and White students was also almost universally higher than that for URM students (the 1999 cohort presents the only exception). This consistent discrepancy (not seen in the gender breakdown) suggests a need to place higher priority on the retention of these minority students to better balance out the different groups.

Figure 6: Percent of Ethnic Groups Retained Pre-2007

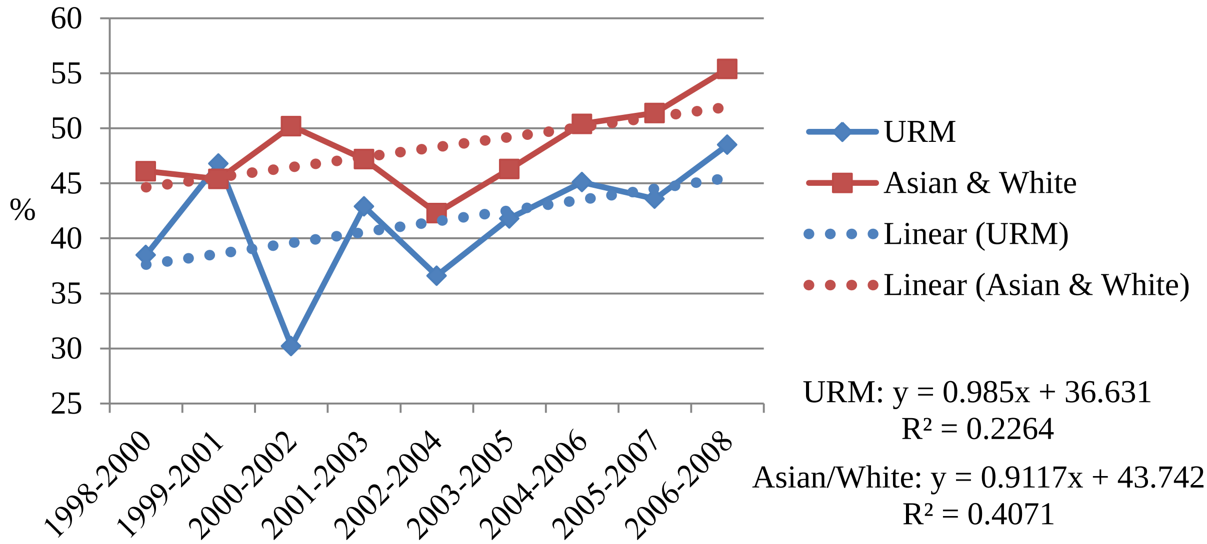
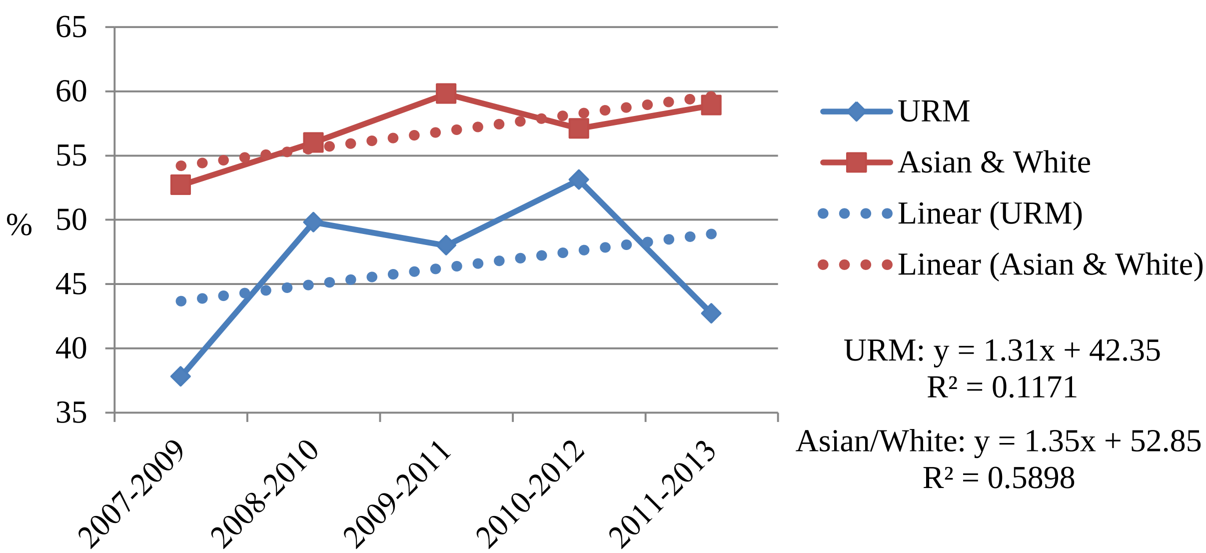


Figure 7: Percent of Ethnic Groups Retained Post-2007



Conclusions

In analyzing the results, it's important to bear in mind that these new programs were not created to address a lagging retention rate. On the contrary, these reforms targeting students' belonging were launched during a period when retention rates had been experiencing an overall steady increase for almost a decade. Instead, the concern from the Fulton schools had been that retention would soon reach a ceiling, if not decline. Keeping that idea in mind, a linear progression toward 100% retention was not the realistic goal of these new strategies. Instead, the objective was to maintain momentum in retention by promoting and supporting students' belonging as engineering students.

As is, analysis of these data provides inconclusive results. While we can say that the retention rates did experience substantial change overall, the initiation year of the interventions (i.e., 2007) did not result in a spline, knot, or polynomial transition for all of the various subgroups. Instead, results are mixed across the different populations, notably seeming to have had a larger positive impact on the retention of males than it did for females. The new strategies also failed to bridge the retention gap observed between White and Asian students and URM students, though doing so was likewise not the purpose of these reforms. Overall, this study points to overall success of the integration of the strategies, while at the same point raising concerns about the differentiated effect among subgroups.

Acknowledgments

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