Why Engineering Fails to Attract Students from Other Disciplines, and What to Do About It

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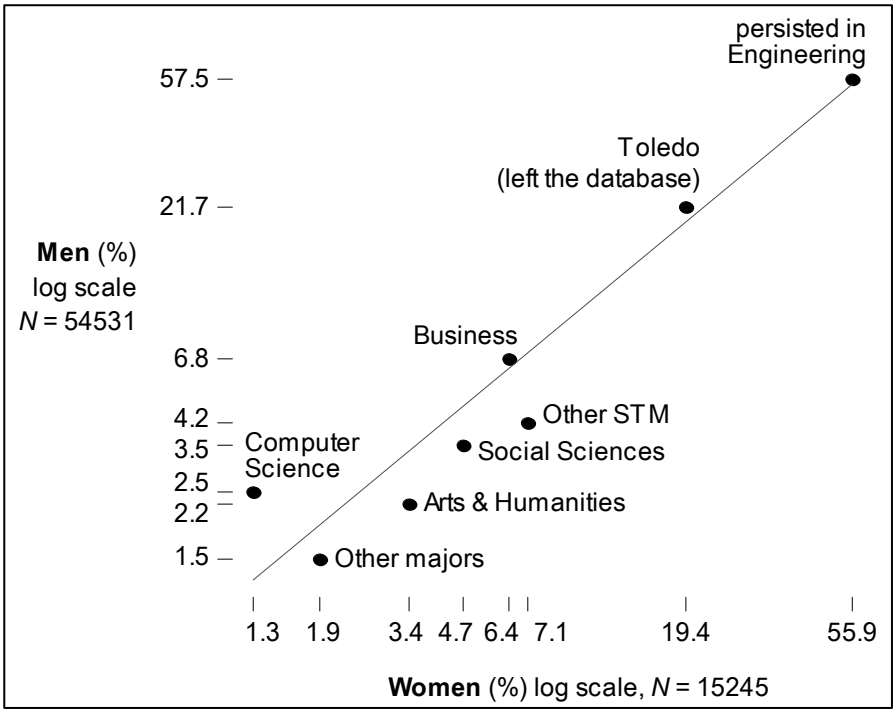
A large and longitudinal data source lends power to our findings. Studies of engineering-student success are best performed using longitudinal data, which are rarely available. Most studies rely on cross-sectional data or in the construction of synthetic cohorts to model outcomes over time, yielding results that can be challenging to interpret. These tentative approximations are not needed in research using the Multi-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD).

MIDFIELD is a rich longitudinal database with student-level records for all undergraduate students at nine southeastern public universities from 1987-2005. The MIDFIELD database contains records for 857,001 unique students, of whom 462,443 received at least one bachelor's degree, and 194,213 were enrolled in science, technology, engineering and math (STEM)—135,860 of them specifically in engineering. Of those, 99,608 received a bachelor's degree in a STEM discipline (71,277 in engineering).

While there are many types of institutions that are not represented in the dataset, because MIDFIELD includes data from multiple large public institutions, the experience of MIDFIELD students is likely to be representative of the experience of a large fraction of U.S. engineering students, so the results may be generalizable on that basis. A more detailed description of the MIDFIELD dataset is available elsewhere,[1] as well as a list of publications and a data dictionary.[2]



There is no gender gap in engineering persistence. A significant recent finding from MIDFIELD is that, in the aggregate, females who enroll as first-time-in-college students, rather than transfer students, to undergraduate engineering programs are retained at the same

rate as their male counterparts.[3] Disaggregating race and gender confirmed this finding in nearly all racial groups.[4, 5]

This agrees with previous longitudinal work using MIDFIELD[6] and a cross-sectional analysis with national data,[7] showing that, on average, women do not have lower retention rates than men. Earlier work[8] shows that the gender gap in STEM degree completion is accounted for primarily by pre-college effects—engineering has low representation of women at matriculation.

The pathways of men and women are surprisingly similar—the top three-eighth-semester destinations (engineering, TOLEDO and business) attract men and women in about the same percentages and represent a combined total of 82% of women and 86% of men. TOLEDO stands for "trajectory of leaving engineering, destination obscure," indicating that a student is no longer found in the database due to transferring, dropping out or stopping out (see figure above).

Engineering is similar to other majors in many ways, but is nearly impermeable to inward migration. MIDFIELD data indicate engineering students are typical of students in other majors with respect to persistence in major, persistence by gender and ethnicity, racial/ethnic distribution at matriculation and grade distribution.

Data from the National Survey of Student Engagement show that this similarity extends to engagement outcomes including course challenge, faculty interaction, satisfaction with institution and overall satisfaction. Engineering differs from other majors most notably by a dearth of female students and a low rate of migration into the major.

The figure below includes a helper line highlighting the percentage of students enrolled in the eighth semester in a major group that started out in that same major group at matriculation. The first column shows students enrolled in engineering in the eighth semester and where they matriculated. Whereas all other groups of majors attract engineering students in noticeable numbers, nearly 93% of students enrolled in engineering after eight semesters had matriculated in engineering.

Other groups of majors attract a large proportion of their eighth-semester majors from elsewhere. Even other STEM and computer science majors attract more than 40% of their eighth-semester student population from other majors.

Undeclared students, the largest population at matriculation, are attracted in large numbers to all majors except engineering. There are early indications that those students who do migrate into engineering are twice as likely to be female as those who matriculate. The characteristics of this population are under study.

Matriculation Major of Students in Various Major Groups in the Eighth Semester

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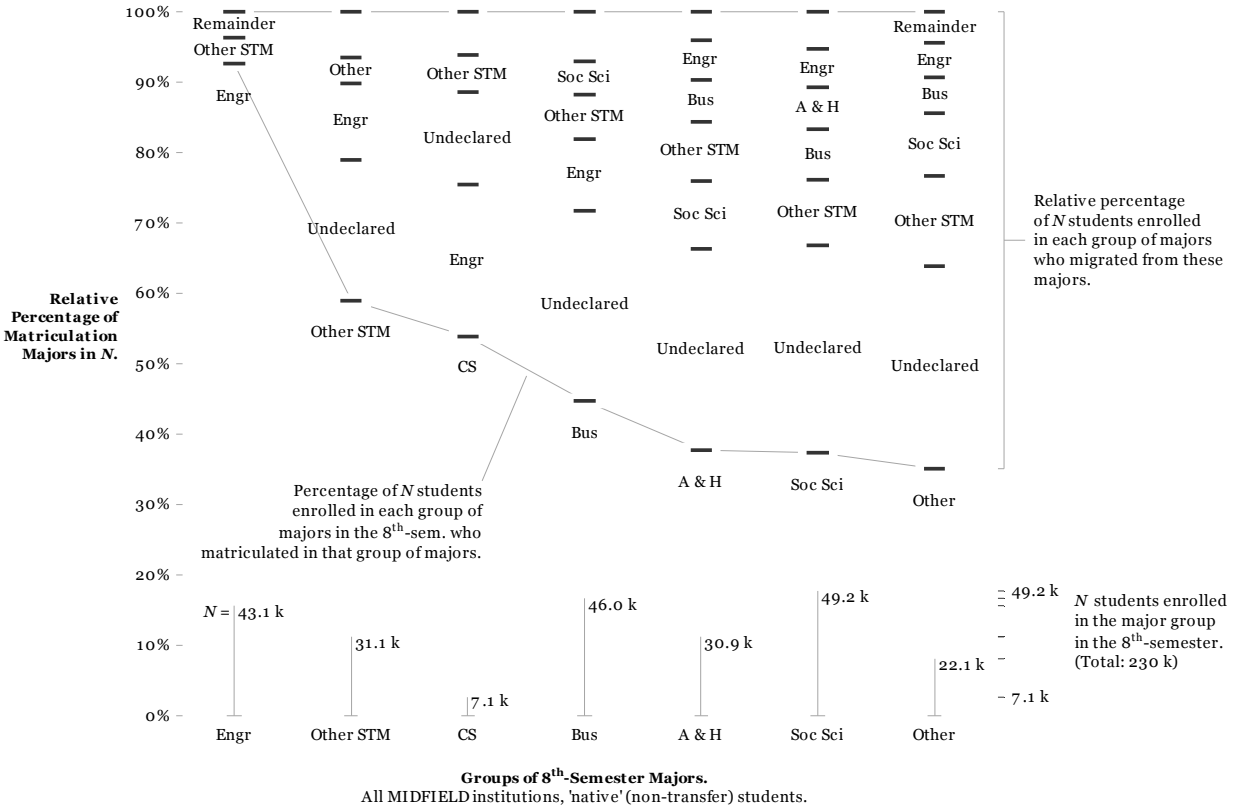

Connecting engineering and communities

Engineering Projects in Community Service-Learning (EPICS) is an innovative engineering-based, design program that uses a service-learning model to meet the educational needs of undergraduates and the compelling needs of the local community.[9, 10] EPICS students earn academic credit for their participation in design teams that solve technology-based problems for not-for-profit organizations in local communities. The teams are: multidisciplinary, vertically integrated, maintaining a mix of first-year students through seniors each semester, and long-term—each student participates in a project for up to seven semesters.

The continuity, technical depth and disciplinary breadth of these teams enable delivery of projects of significant benefit to the community. The EPICS Program, founded at Purdue University, has received national recognition, including the National Academy of Engineering's Bernard M. Gordon Award for Innovation in Engineering and Technology Education in 2005 for its integration of design education with a curricular model that provides long-term technical support for local community service organizations. Its model for design education has shown to be an effective way for students to learn design, as well as the professional skills needed by

today's engineers. It is consistent with models to increase participation and interest among underrepresented students.

Through examining enrollment rates, participation of women in EPICS over a 10-year window was higher than the enrollment rates for women in engineering programs during the same time period. In electrical and computer engineering (ECE) and mechanical engineering (ME), the percent of women in the majors ranged from 10% to 12%, while 20% of ECE and ME students in EPICS were women.[11]

In another period, the enrollment rate in EPICS for women in computer science (CS) was nearly three times the enrollment rate of undergraduate women in CS.[12] Women have also taken on team leader roles at a relatively high rate. For a period when women accounted for 20% of the students in EPICS, women represented 30% of the team leaders. The context of EPICS that places design education within meeting needs of the community is consistent with the literature that discusses ways to broaden participation of women in engineering.[13]

What matters to women

Educational literature suggests that women have different motivational factors for learning and different educational needs than men. Attracting and retaining women depends on understanding these differences and appealing to women through them. An active study is examining the motivation of women to participate in programs such as EPICS through interviews. The soon-to-be-published results are finding that it is not simply that the women are drawn to programs such as EPICS for the connection to helping people. They are clearly choosing EPICS at higher ratesbut also see it as a way to gain valuable experience.

Retention is also important, and studies are suggesting that the context, vertical integration that leads to mentoring and long-term participation can impact retention. Students were asked in EPICS if their classroom participation enhanced their desire to continue in engineering—70% responded positively. Investigation of the 30% who did not respond positively found that many were so committed to engineering that they did not feel they needed any benefit. An active study looking at retention is showing that women who enrolled as sophomores were retained in engineering at a rate of 9% higher than those who did not.

Prior to 2007, first-year students were not enrolled in EPICS. Those who wished to participate in a service-learning project could do so through the Engineering Learning Communities.[14] Qualitative data, including interviews, showed that first-year students found benefits from participating in the service-learning experience. The experiences . The women reported experiences that were consistent their reactions align well with what the other

researches have advocated to increase participation of women, including seeing a connection to people and the community.[15]

An active study is examining retention through graduation. Preliminary findings for the first cohort show a higher female retention rate, but a second cohort, while seeing a similar initial gain, had the gap closed in their junior and senior years. The implication is that an initial treatment in the first year is not sufficient without follow-up experiences.

Impacting the pipeline

The benefits of the EPICS Program seen at the university level motivated an expansion to high schools. A significant barrier to increasing the percentage of women in engineering is that there are not many entry points for young women into a pathway to lead them to engineering. As noted earlier, few students enter engineering in college, and the same can be said for high schools. While there are many precollege engineering programs, there is a dearth of experiences that can excite and engage students about engineering without them thinking they are joining an engineering program.

Three EPICS graduates started an EPICS high school class as a pilot and their successes, including having a majority of participants be young women,[16] had led to an expansion that currently engages 34 high schools in five states. In 2007, a census of the participants found that 50% of the students were female,[17] and in 2008, that percentage was 34%. The change was not a reduction of female participation but an expansion of participation from more traditional pre-engineering classes that adopted the EPICS service-learning context.

The data is encouraging but clearly suggests that the classroom climate, appropriate mentors and the learning environment are as important as the community context of the projects. It is also encouraging that about one-third of the participants joined not intending to be engineers—another opportunity to enlarge the pipeline.

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