



The Effect of Required Introduction to Engineering Courses on Retention and Major Selection

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Abstract

Students who matriculated in undergraduate engineering programs are studied to determine the effects of a required introduction to engineering course on major selection. Requiring such a course appears to affect the way the students sort themselves into majors, particularly students who do not declare a specific engineering major at matriculation. Such courses also seem to enhance retention in engineering programs compared to programs that do not require a common introductory course.

Introduction

According to a national benchmarking study, nearly three-fifths of all engineering programs require all engineering students to take some form of an introductory engineering course or sequence¹. In this study we focus on common courses that expose students to the range of engineering disciplines. This study compares retention rates and major selection patterns in institutions that require all engineering students to take a **common Introduction to Engineering (CITE)** course with those that do not across 11 large public universities in the United States.

This study examines the questions:

1. What are the differences in retention in engineering and at the institution between students in programs with and without a required CITE?
2. Are the differences similar between students who matriculate directly into a discipline and those who start in undesignated engineering?
3. Are students in programs with a required CITE more likely to stay in the first major they select?
4. How does a required CITE course affect the way that students sort into majors?
5. What is the effect of a required CITE course on enrollment in individual engineering majors?

Methods

The Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) contains records for 977,950 unique students at eleven public institutions in the U.S. from 1987/88 to 2009/10 academic years (not all institutions have reported all years). This paper focuses on the subset of students for whom we have eight semesters (or twelve quarters) of data, and those who we know left the institution before completing eight semesters (or twelve quarters). Any semester or quarter in which a student is enrolled is counted, including summer semesters. For a prototypical student, the eighth semester represents the last semester of the fourth year. However, since not all students enroll in every semester, semester counts do not necessarily correspond to calendar time.

While many institutions are not represented in MIDFIELD, the experience of MIDFIELD students is representative of the experience of a large fraction of U.S. engineering students attending large public institutions. A detailed description of the MIDFIELD dataset is available.²

The sample used for the present retention study includes all first-time-in-college students who had an engineering major in their first semester and for whom we have eight semesters (or 12 quarters) of data. Eighth semester is used because it is a good indicator of a student's educational destination and enables us to include more cohorts than would be possible if we used six-year graduation. Ohland, *et al.*³ noted, "Approximately 90 percent of MIDFIELD students in all majors in cohorts from 1987–1997 graduated in the major in which they were enrolled in their eighth semester (total population data). Nevertheless, persistence to eight semesters does not ensure graduation and differences by race and gender may accrue beyond the eighth semester." Ohland and colleagues later confirmed that differences by race and gender do indeed accrue beyond the eighth semester.⁴ Using a graduation measure would tend to exclude groups that typically take longer to graduate. An earlier measure, such as semester 4 would leave a significant number of students in an undesignated engineering major.⁵ By semester 8, most students have either settled into their final major or left. Students who have graduated before semester 8 are considered to have persisted in their graduation major. Because whole population data is used, all differences are real and reported without the need for inferential statistics.

Each institution is classified as either requiring all engineering students to take a CITE or not. Three MIDFIELD institutions have first-year engineering programs that require all students to complete a CITE before declaring their specific major. Three more allow students to select a discipline (or undesignated engineering) but still require them to take a CITE. The remaining five allow students to select a discipline and did not require them to take a CITE during the period represented in our data.

Students are further disaggregated by their designated or undesignated major status upon matriculation. *Designated* students are those who matriculate directly into the engineering major of their choice. *Undesignated* students are those who start in first-year engineering programs; students who are unsure of which discipline they wish to pursue; and students who are conditionally admitted to engineering, but not yet admitted to a specific degree program.

Other definitions relevant to this study are as follows:

First Degree-Granting Major – the first major that a student declares in which they may graduate.

For students who begin as undesignated, this is their second major. Some students may leave the institution without declaring a degree-granting major.

TOLEDO (Trajectory of Leaving Education, Destination Obscure) – The "destination" of students for whom their real educational outcome is unknown. This term is used to describe a student who drops out of the database without receiving a degree. He or she may have transferred to another institution, left higher education entirely, or left temporarily and not returned within the span of our database.

The sample used to study disciplinary distribution includes only those students who are still in an engineering major in semester eight (or the equivalent quarter) or who have already graduated in engineering.

For studying effects by major, logistic regression is used to identify the relationship between the requirement of an introduction to engineering course and the retention of students in the major. Logistic regression is a regression technique that models the probability of a binary outcome (such as retained in engineering or not) using maximum likelihood methods. Two logistic regression models are constructed for each major examined. Both include only those institutions that offer the major. The first includes all students who started in that major and the second includes all students who started in undesignated engineering.

Results and Discussion

Retention

Figure 1 shows the 8-semester outcome of students who started in engineering by CITE requirement. Over half (52.1%) of engineering students who were not required to take a CITE and 55.9% of those who were required to take a CITE were still in engineering (or had graduated in engineering) at their eighth semester. Students who were required to take a CITE were also more likely to graduate from or continue at their institution through eight semesters (78.7% vs. 73.1%). The remaining students are considered TOLEDO; they left the institution without receiving a degree.

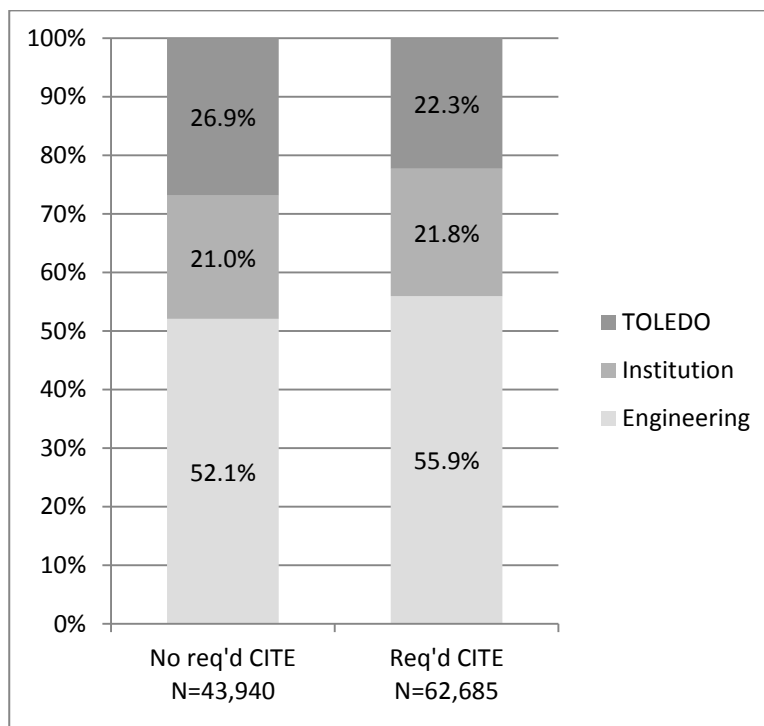


Figure 1. Retention in engineering, and at the institution by CITE requirement

While there are many other variables affecting student outcomes, those institutions that require a CITE course retain more students in engineering and at their institution. We suspect that this may be due to a better sense of connectedness to the institution and to the field of engineering early in their college career. With that in mind, we next examine whether selecting a specific discipline at matriculation has a similar effect.

If connectedness improves retention, then we might hypothesize that students who immediately “connect” with a specific discipline should be more likely to stay in engineering. Comparing students who matriculate without designating a discipline to those who matriculate in a discipline (Figure 2), we see that especially among those who are not required to take a CITE, this is indeed the case. However, for those that do have a required CITE, the difference between designated and undesignated is much less pronounced, only 1% vs. 4.1%. Considering undesignated with no required CITE as the baseline, 4.1% more students who designate a major stay in engineering, and 7% more students who are required to take a CITE stay in engineering. In terms of engineering retention, the combination of the two is most powerful, with an 8% advantage over the baseline. However, students who do not designate a discipline and are required to take a CITE (3rd column) are the most likely to stay at the institution. This implies that something about the CITE course helps students find their place in the institution even if that place is not in engineering.

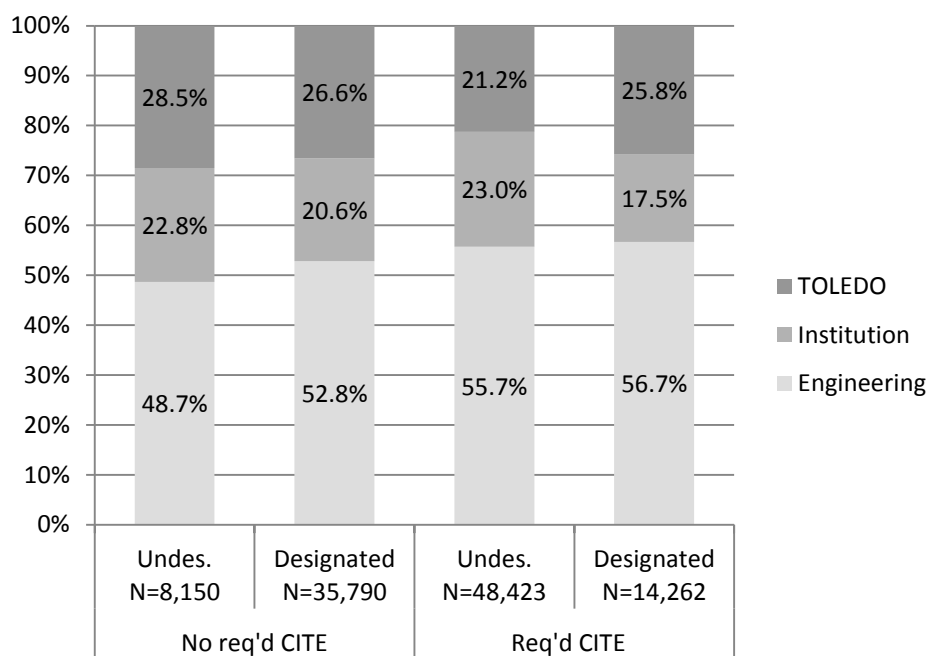


Figure 2. Retention in engineering, and at the institution by CITE requirement and major status

Preliminary analysis of student interview data related to this project appears to show that CITE courses can help students select or confirm their choice of discipline.⁶ In Figure 3, we now divide students who stayed in engineering into two groups: those who stayed in their first degree-granting major until semester 8, and those who stayed in engineering but not in the first discipline in which they enrolled. Even without a required CITE, students who take a semester or more to decide are more likely to remain in their first major choice (41.9% vs. 37.9%, a 4% difference), but a required CITE seems to help them even more (48.8% vs. 39.5%, an 8.7% difference). This difference should be considered conservative—still more of the designated students will remain in their first choice of engineering major even if they realize it is not the best fit to avoid the various transactional costs of changing majors. These patterns may also be influenced by institutional or program characteristics such as the relative ease with which students can change majors. Still, it is interesting to note that even students who selected a discipline at matriculation were slightly more likely to remain in their choice if they were required to take a CITE course.

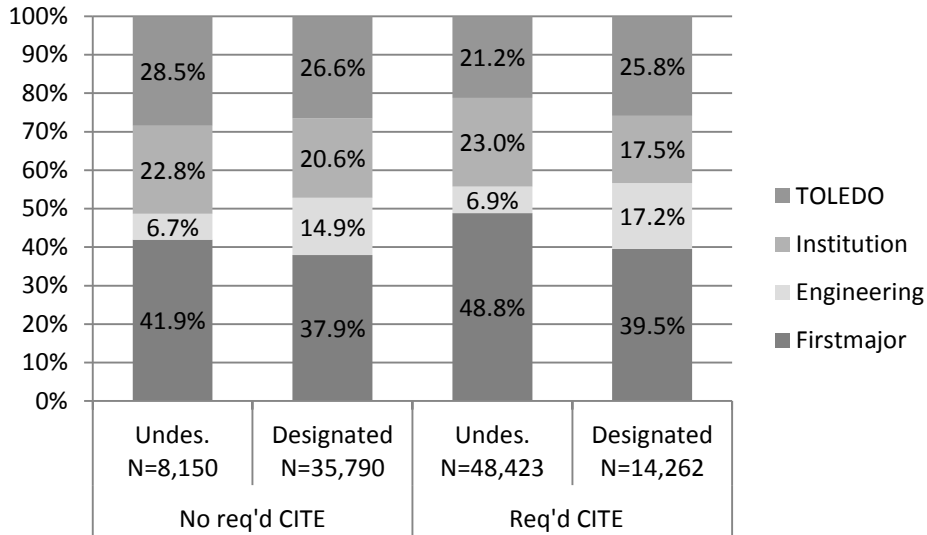


Figure 3. Retention in first degree-granting major, in engineering, and at the institution by CITE requirement and major status

Disciplinary Distribution

Figure 4 is a multi-panel dot plot⁷ of how students who are still in engineering in the eighth semester are distributed among disciplines. Each closed dot represents the percentage of students who matriculated directly into a discipline with a required CITE (N=8,085) or without a required CITE (N=18,907). Each open dot represents the percentage of students who matriculated as undesignated with a required CITE (N=26,978) or without a required CITE (N=3,967). The disciplines are ordered by increasing enrollment across each row and toward the top of the figure. Agricultural/biological has the fewest students, then aerospace, other, computer, etc. to electrical, and finally mechanical. This chart should be interpreted with caution as the distributions are likely affected by the institutional variations in the size, quality, and selectivity of programs. Mechanical, electrical, and civil engineering are offered at all MIDFIELD institutions. Chemical and computer are offered at ten of the eleven. Industrial and systems engineering and agricultural/biological are offered at nine, and aerospace at six. All other majors are grouped into “other engineering”. Other engineering also includes 1,293 students who were undesignated in their 8th semester.

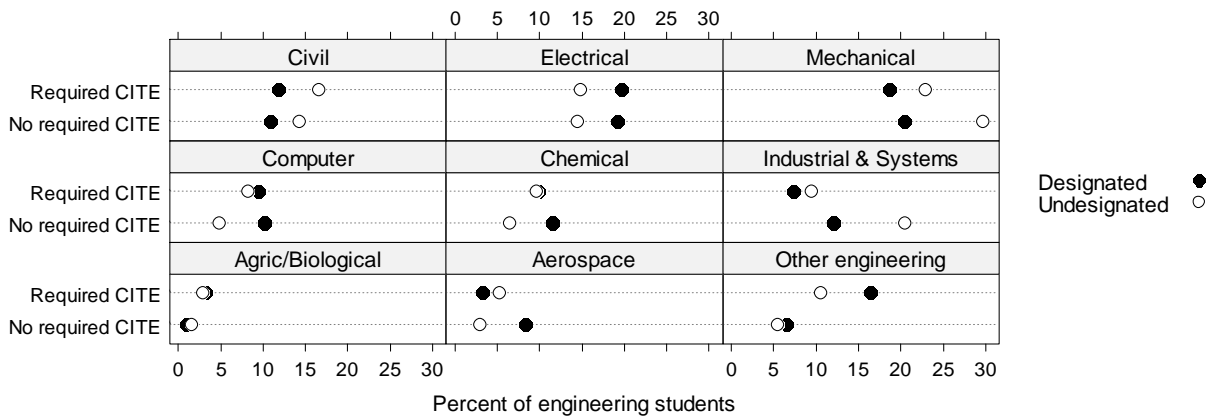


Figure 4. Major Distribution at Semester 8

Undesignated students are more likely to choose mechanical engineering, but that effect is tempered by the presence of an introduction to engineering course. Undesignated students are less likely to choose electrical engineering, and this outcome seems to be unaffected by the introductory course. Civil engineering enrollment is slightly increased by a required course for both groups, and with or without a course, students who wait to decide are more likely to choose it than those who designate at matriculation. Industrial and systems engineering enrollments appear to be decreased by an introductory course, and students who wait to decide are more likely to select it, however, the phenomenon of 20% of undesignated students selecting without an introductory course is largely driven by one institution with a large program. Computer, chemical, and aerospace are similar in that a required introductory course decreases enrollments from the designated group but increases enrollment of students who begin as undesignated.

Effects by Major

To further explore the effect of a required CITE, two logistic regression models are constructed for each major examined. Both include only those institutions that offer the major. The first includes all students who started in that major and the second includes all students who started in undesignated engineering.

The first odds ratio reported in Table 1 indicates the ratio of the odds of a student who started in mechanical engineering and was required to take CITE course being in mechanical engineering at semester 8 to the odds of a student who started in mechanical engineering and was NOT required to take a CITE course being in mechanical engineering at semester 8. In this case, the odds ratio was not significantly different from one. This indicates that students who matriculated directly into mechanical engineering were about equally likely to stay in mechanical engineering whether or not they were required to take a CITE course. The remainder of the column can be interpreted similarly for each major. For aerospace engineering, the odds ratio of 0.433, indicates that the odds of a student who started in aerospace engineering and was required to take CITE course being in aerospace engineering at semester 8 are only 43% of the odds of a student who started in aerospace engineering and was NOT required to take a CITE course being in aerospace engineering at semester 8. An odds ratio much greater than one for agricultural/biological engineering indicates students who were required to take the CITE course were significantly more likely to stay in agricultural/biological engineering.

In the far right column, the odds ratio for students who started in undesignated engineering to select mechanical engineering is 0.871. In this case, an odds ratio less than one indicates that undesignated students who are required to take a CITE course are less likely to be in mechanical engineering at semester 8. Electrical, civil, chemical, computer, aerospace, and agricultural/biological engineering all attract more undesignated students when a CITE is required. Mechanical and industrial and systems engineering are less likely to attract undesignated students when a CITE course is required.

Table 1. Odds ratios of a required CITE vs. no required CITE for logistic regression models of whether or not a student was enrolled in particular major at semester 8.

Major	Students starting in a major at semester 1		Students who started as undesignated engineering	
	N	Odds Ratio of a req'd CITE vs. no req'd CITE	N	Odds Ratio of a req'd CITE vs. no req'd CITE
Mechanical	8,070	ns	56,573	0.87
Electrical	9,351	ns	56,573	1.18
Civil	4,997	ns	56,573	1.36
Chemical	6,215	ns	55,296	1.79
Computer	5,793	ns	56,573	1.98
Industrial and Systems	2,495	ns	52,513	0.32
Aerospace	6,475	0.433	45,551	2.69
Agricultural/Biological	783	2.172	55,296	2.38

ns= not significantly different from 1

Although designated students who were required to take a CITE course showed slightly better engineering retention rates than those who were not, there was little evidence that the course affects the way that these students sort into most majors. Two exceptions are aerospace students, who are less likely to stay in aerospace if they are required to take a course and agricultural/biological, who are far more likely to stay in their major with a required course. Undesignated students, on the other hand, are more likely to choose electrical, civil, chemical, computer, aerospace, and agricultural/biological when they are required to take a course and more likely to choose industrial systems and mechanical when they do not have to take a course. Again we note that with respect to industrial and systems, one institution may be disproportionately influencing the results.

Conclusion

Complementary to single institution studies⁸⁻¹¹, this multi-institutional study finds that a required introduction to engineering course can be beneficial to undecided students in making an informed decision and help retain all students in engineering. Additionally, a required introduction to engineering course has significant effects on the way that undesignated students sort into majors. Future work will incorporate interview data to better understand this phenomenon from the student perspective. We also plan to look at outcomes for students who opted to take an introduction to engineering course when they were not required to do so.

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