AC 2012-4684: USING COLLABORATIVE PEDAGOGY TO RECRUIT TECHNOLOGY STUDENTS FROM FIRST-YEAR ENGINEERING

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Using Collaborative Pedagogy to Recruit Technology Students from First-Year Engineering

Abstract

Universities with engineering programs generally offer a first semester course entitled "Introduction to Engineering" or "Engineering 101." At Central Michigan University (CMICH), this course is team taught by several faculty members including a professor associated with CMICH's technology programs. The academic history of each student who registered for "Introduction to Engineering" was monitored. The primary courses monitored consisted of engineering, technology, and math. From the data collected, having a technology professor involved has increased student enrollment in the technology programs without negatively impacting the enrollment in the engineering programs. The mechanical engineering technology program has had the greatest improvement in enrollment. Developing positive and professional relationships between faculty members across engineering and technology disciplines can be implemented at similar universities to help recruit (and retain) technology-interested students. This paper includes areas in pedagogy change, data collection, enrollment and persistence demographics, and conclusions.

1. Introduction

Student recruitment and persistence are important for any technology-degree department. Enrollment has decreased in most engineering technology, technology management, and technology education programs.[1-3] Students are often unfamiliar with the degree and career opportunities[4], or lump technology programs as a subset of "engineering"[1]. Because of these misunderstandings, technology-interested students often look elsewhere for a major (such as in engineering), only to find that it doesn't match their skills and interests.

Such was the case at Central Michigan University (CMICH). Enrollment in CMICH's technology programs was slowly decreasing while its freshman introductory engineering course was growing rapidly. However, most of the freshman engineering students were not persisting into the engineering programs, often because of student misconceptions and unpreparedness.[5] Nor were the students pursuing technology-related degrees as they had originally intended – they were instead switching to science, business, or other majors.

In many situations, such students would continue to leave the engineering and technology fields. Technology and engineering programs rarely collaborate, and are often viewed as competitors.[6] It is uncommon for faculty and departments to cooperate to improve recruitment from one program to another.

This paper discusses the successful recruitment of many of those uninformed, attriting freshman engineering students to engineering technology and technology management programs. Doing so required a rare collaboration between technology and engineering faculty. Transcript and survey data were analyzed, a technology professor helped teach the freshman engineering course, and the freshman engineering curriculum was updated to better expose students to the range of

and differences between engineering, engineering technology, and other technology-related programs. Doing so improved both programs and significantly increased technology enrollment. The following sections discuss the background, teaching and assessment methods, enrollment and persistence demographics, and conclusions from the longitudinal study. Such improvements can be implemented at similar universities to help recruit (and retain) technology-interested students.

2. Background

2.1 Overview of CMICH's engineering and technology programs

CMICH's technology-degree programs are housed in the School of Engineering & Technology (SET), in the College of Science & Technology (CST). The School is a broad collaboration of engineering, engineering technology, and technology programs. Currently, degrees are offered in Construction Management (CM), Electrical Engineering (EE), Mechanical Engineering (ME), Mechanical Engineering Technology (MET), Industrial Education (IE), Industrial Technology Management: Manufacturing Technology (ITM-Man), and Industrial Technology Management: Mechanical Design (ITM-MD). Thus, the school attracts a wide range of technology-interested students with various math and science backgrounds.

The School is historically a technology department. It first offered engineering technology in 1984, and just recently expanded into engineering in 2004. The ITM degrees are accredited by The Association of Technology, Management, and Applied Engineering (ATMAE); the EE and ME degrees are accredited by ABET.

The engineering students are expected to take EGR120: Introduction to Engineering (EGR120) in their first semester of freshman year. EGR120 is offered both semesters and currently has no pre- or co-requisite. Its syllabus covers introductory engineering material such as the engineering profession, disciplines, courses, problem solving, basic electrical and mechanical concepts, as well as two team-based design projects. For the first three years (2005-2006 to 2007-2008 school years), the course was taught as one section; starting in the fourth year it was broken into smaller multiple sections to enhance professor-student interaction and student learning.

EGR120 consistently draws relatively high enrollment (currently around 170 students per year), with 76% of the students taking the course in the fall. However, only 40-45 of those students persist as engineering majors, or 27%.[7]

Furthermore, in the first four years, very few of the EGR120 students who did attrit did so into the other programs in the department. While EGR120 enrollment was increasing rapidly, the number of engineering majors was increasing slowly and many of the other SET majors were decreasing – more and more EGR120 students majored outside the department. Anecdotally, many of the attrited EGR120 students left after being surprised by the high-level theory and low-level hands-on skills required of engineering majors.

2.2 Relevant research

There have been many discussions into recruitment of students into technology-related programs. For example, Frisbee et al.[8] analyze recruitment techniques with regards to automotive programs. Gray and Daughtery[2], and Isbell and Lovedahl[9], do the same from a technology education perspective. Wicklein[3] found that student recruitment was the top issue facing technology education. Dudeck and Grebski[1] cite many of the challenges of engineering technology recruitment due to student misconceptions, while Cobb and O'Connor[10] discuss successful engineering technology recruitment from industry and high schools. Holling[6] encourages engineering and engineering technology programs to collaborate to offer better programs.

Likewise, many studies analyze techniques to improve technology student persistence, especially via the freshman curriculum. Choi et al.[11] discuss the combining of freshman engineering technology programs to increase persistence. McDonald[12] discusses the creation of a major/non-major introductory technology course to improve first-year recruitment and persistence. Wood and Craft[13] show significant persistence improvement when making freshman technology courses more problem-based.

3. Methods

3.1 Pedagogy change

To retain more of the freshman engineering students into the ET, ITM, and CM programs, EGR120 pedagogy was changed in two major ways starting in the fall of 2009.

First, when talking about the engineering profession, the EGR120 professors increased emphasis on the spectrum of engineering- and technology-related degrees. For example, the job and education of an engineer is now compared to that of an engineering technologist and other technologists (e.g., in terms of math/theory in the education, in terms of ability to work hands-on, and in terms of job roles in a interdisciplinary team). Students are now better exposed to technology-related degree options other than engineering.

Second, a technology professor joined the EGR120 teaching team. The course has since been broken into four curriculum blocks, taught "round-robin" by four professors: an EE section, an ME section, a general engineering profession and projects section, and a hands-on/laboratory (technology-professor) section. The hope is that students who are dissatisfied with engineering will now have a contact and familiarity elsewhere in the School. It should be stressed that the technology professor teaches *engineering* concepts to the students and is explicitly not attempting to "steal" engineering students.

3.2 Data collection

Data were collected for six years in three forms: transcript information, number of majors, and brief in-class surveys. The six years involve twelve semesters: six fall semesters and six spring

semesters. Here, a semester is referred to as the academic year with a "F" or "S" for fall or spring; *e.g.*, the last semester examined was the spring of the 2010-2011 year, or "1011S'".

The transcript information was collected for EGR120 students from 0506F to 1011S, from current transcripts. Data include:
- First semester at CMICH
- Math level – highest math course taken at CMICH before or during their EGR120 semester, including grade. The MathLevel was grouped into five categories: Post-Calculus (higher than Calculus I), Calculus, Precalculus, Pre-Precalculus (e.g., trigonometry, algebra), and Unknown (no math taken at CMICH).
- EGR120 grade
- Current signed major – at CMICH, students may sign a Major (binding agreement) once eligible, or an Intent to Major (non-binding) at any time. Here, they are treated identically.
- Technology (non-engineering) courses taken after EGR120
- Current grade point average (GPA) – students are graded on a 4.0 scale, from A to E (fail; no E+). Students who withdraw from a course are given a "W" which does not affect GPA.
- If currently academically dismissed – a student is academically dismissed if their GPA falls below a variable threshold (between 1.00 and 1.95) defined by their completed credit hours, or if their GPA remains below a 1.99 (below a C average) for three consecutive semesters. If dismissed, a student cannot attend CMICH for at least one year and must apply for and receive rematriculation to do so.
- If no longer attending the university – if not academically dismissed nor registered for the current semester.

In addition, the number of students majoring in each SET program was compiled for each semester. The data were obtained from internal administrative reports and show how many students were currently registered; the reports include students at all academic levels (not just freshman) and ignore students no longer attending CMICH or who had been an SET major but later switched elsewhere. Thus, changes in the number from time to time reflect students graduating (-), stopping attendance at CMICH (-), transferring into CMICH (+), and newly signing their majors (+).

Surveys were also given in EGR120 from semesters 0809F to 1011S. In each semester, Initial surveys were given at the beginning of the course that asked students to rank their top three intended majors ("1" for top choice, "2" for second, "3" for third). In 0809F and 1011F, Final surveys were given at the end of the course asking questions including
- Previous intended major
- Ranking of new top three intended majors
- Why the intended major changed (if applicable).

4. Results: Enrollment Demographics

Enrollment in EGR120 is growing at an average rate of 12.4 students per year, mostly in the fall semester. Overall, 78% of the students are in their first year at CMICH (see Figure 1). These

may or may not be freshmen – transfer students may be in their first year at CMICH. In addition, the upperclassmen students may or may not be interested in majoring in engineering, since a few students are known to take the course for fun, for an elective in their technology major, or because they are interested in engineering-related graduate studies.
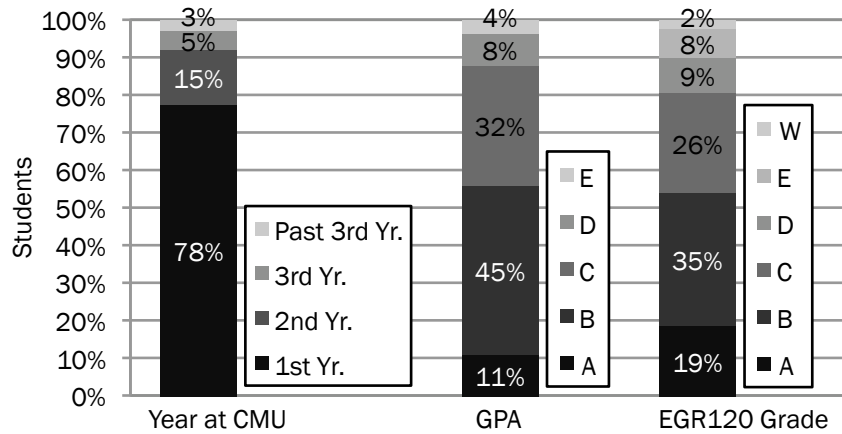

Fig. 1. Miscellaneous enrollment distributions.

Transcripts show that EGR120 attracts a wide range of Math Levels (Figure 1). The academic plan for engineering students recommends taking Calculus before or during the EGR120 semester. However, only 48% of the students do so. 29% of the students have or are taking Precalculus, and 17% are in lower math (such as trigonometry or algebra).

Initial surveys show that EGR120 students are consistently interested in ME, then EE, then MET, ITM/CM, and then sciences (Figure 2, first three columns). In the figure, the fourth column shows total response over all semesters. Half the students come into EGR120 planning on going into ME, a quarter plan on EE, and a quarter plan on doing something else. When the 1-2-3 ranks are inversely weighted and summed as

$$Score = \sum (4 - rank) \tag{1}$$

then the interest is more varied (Figure 2, far right column). 14% of the students are initially interested in MET and 13% in the ITM/CM programs. In the figure, category "(Other EGR)" is student-added engineering disciplines other than ME or EE (that are not offered at CMICH).
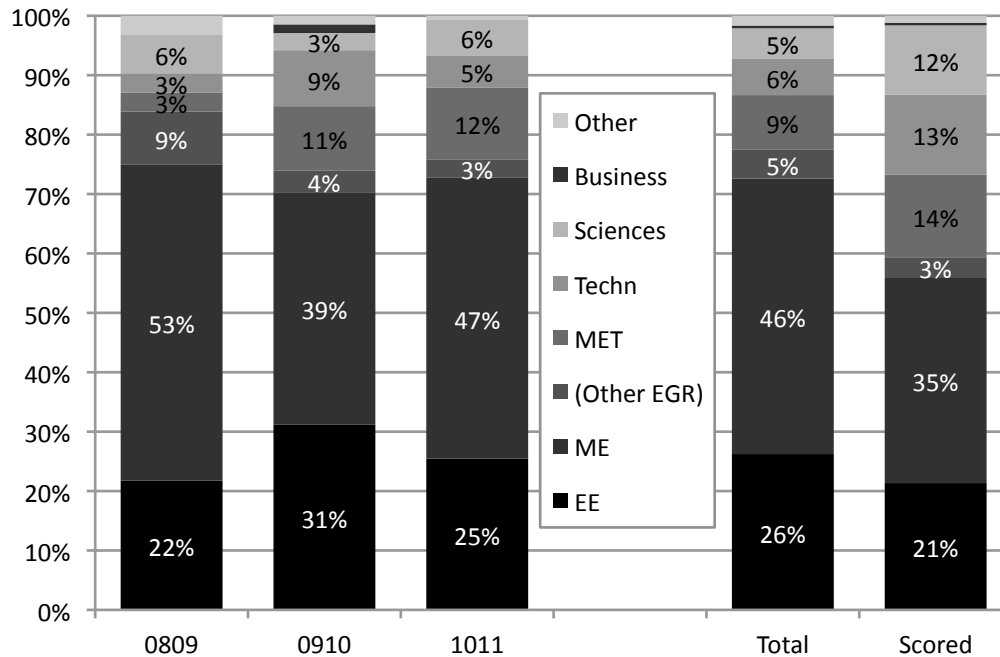
Fig. 2. Student interest in various majors, from Initial surveys. The first three columns show top choices only (vertical axis is percentage of respondents); the last column shows scores based on first, second, and third choices (vertical axis is percentage of total score).

The overall GPAs and EGR120-grades of the students has stayed relatively constant. The cumulative GPAs average 2.52 (Figure 1; standard deviation across semesters (STD) = 0.13). The grades given in EGR120 average 2.48 (Figure 1; STD = 0.19).

5. Results: Persistent Demographics

Here, persistence is defined as continuing in an SET program. Students are categorized into the following groups, filled downward:

- EE/ME = signed an EE or ME major, or took engineering-specific courses
- MET/Techn = signed an CM, ITM, or MET major, or took technology-specific courses
- OtherDept = attritted; signed another department's major
- AcadDism = attritted; undecided major; currently academically dismissed
- NotAtCMICH = attritted; undecided major; not currently attending CMICH (but eligible)
- Unknown = attritted; undecided major; attending CMICH.

5.1 Program persistence

Figure 3a shows persistence rates for each of these categories for before and after the EGR120 pedagogy change. The Unknown category takes two years to resolve because students often wait to sign majors. Some Unknowns eventually become EE/ME or MET/Techn, others eventually sign majors in other departments, get academically dismissed, or leave CMICH. Thus, persistence rates for the After years are conservative – eventually, Unknown students filter into the other categories.
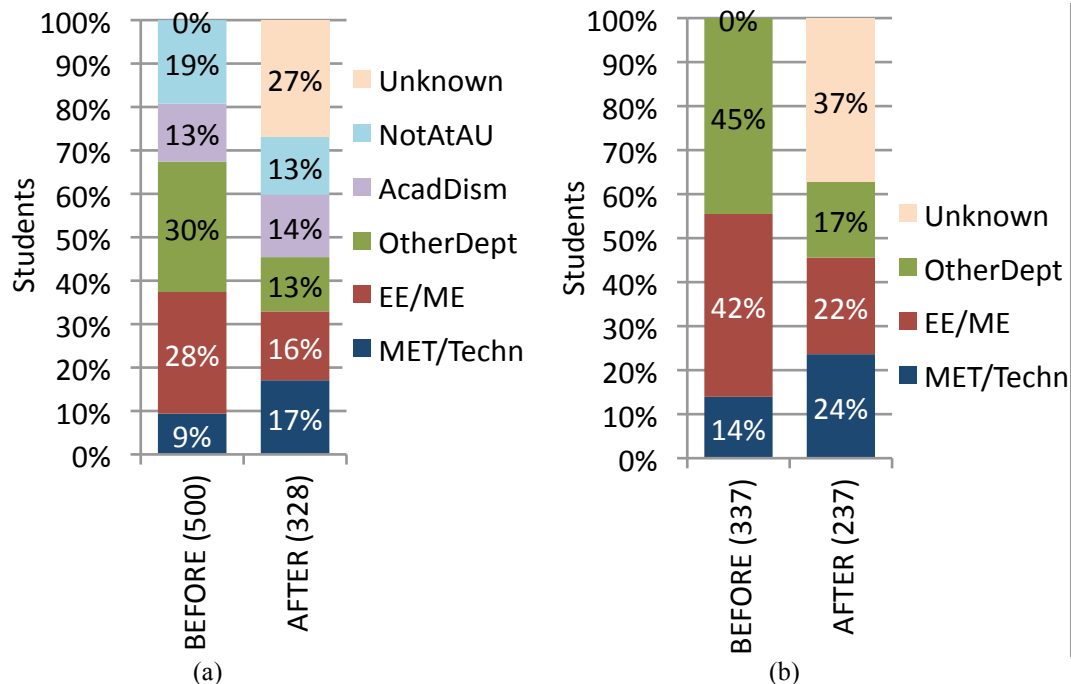
Fig. 3. Persistence rates before and after the pedagogy change, involving (a) all EGR120 students and (b) EGR120 students who stayed at CMICH. The number in parentheses for each horizontal label is the number of students in that block.

CMICH retains 68% of the EGR120 students; CMICH retained 77% of all freshmen over the same time period.[14] Because so many students do not stay at CMICH, the remaining persistence statistics (and Figure 3b) are for students *still attending CMICH* (*i.e.*, the AcadDism and NotAtCMICH categories are ignored).

In terms of technology, recruitment rates from EGR120 have increased by at least 69% (see Figure 3b). Before the change, only 14% of all EGR120 students signed technology majors; since the change, 24% have already done so (and some Unknown will later do so). At first glance, those students may appear to be stolen entirely from engineering, but the plot is misleading in that regard. Surely, a few of the new technology students would have pursued engineering, but engineering requires more prerequisite material before signing a major – more of the Unknowns will become EE/ME than MET/Techn. This can also be seen from currently signed majors (by filtering out the Unknowns category in the right column of Figure 3b): MET/Techn has jumped from 14% of subsequent majors before the change to 38% after the change (24% out of 24+22+17%); EE/ME has only dropped from 42% before to 35% after (22% out of 24+22+17%). The exact outcome remains to be seen.

Figure 4 shows which majors the EGR120 students have been signing, before and after the pedagogy change. Before the change, as many EGR120 students went into the sciences, business, and other university programs as signed MET/Techn majors. Since the change, more EGR120 students have (so far) signed MET/Techn majors than in any of the other department categories. The majority of the increase is in MET majors.
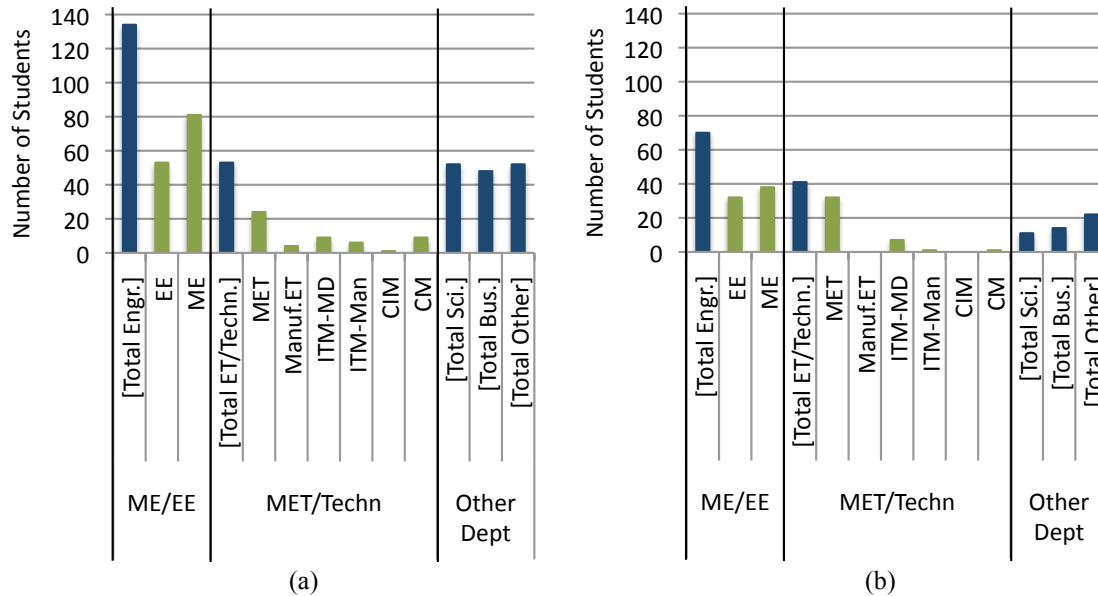
Fig. 4. Current majors of EGR120 students (a) before and (b) after the pedagogy change. The largest increase has been in MET.

The new technology recruits from EGR120 has reversed the downward trend of MET majors – the number of MET majors has doubled in the last year from 23 to 45. Figure 5 shows the number of students enrolled at CMICH each year with each SET major (averaged over the fall and spring semester enrollments). The figure shows the decrease in MET majors until the pedagogy change, and the growth since then. Even with the MET growth, the EE and ME majors are still growing significantly.
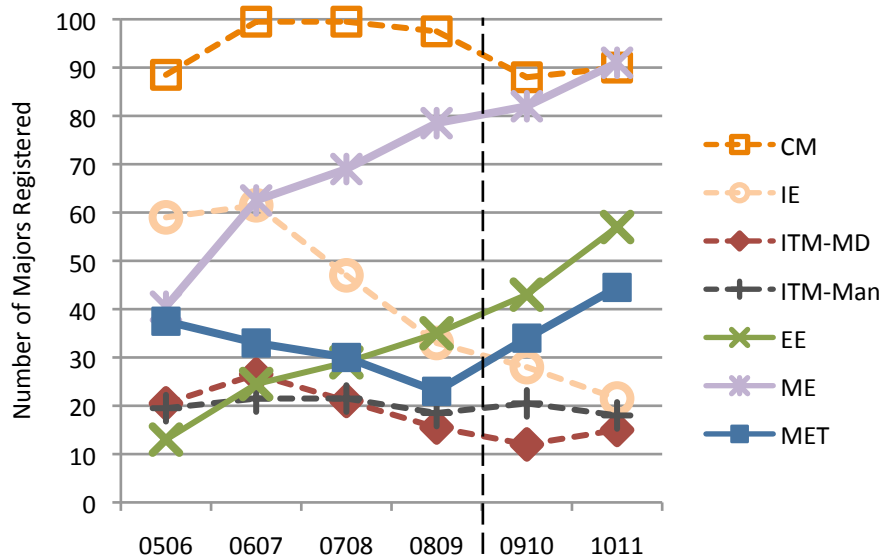

Fig. 5. Number of students registered with each major during each year.

Final surveys from 0809F (before the change) and 1011F (after the change) indicate that much of the switching of majors occurs during the EGR120 semester. Figure 6 shows the majors that the students intend on pursuing, from Initial and Final surveys for the two semesters. The results show that ME interest dropped significantly both before and after. The majority of those

students switched interest to the sciences before the change, but to MET after the change. In fact, at the end of the 1011F semester, there was more EGR120 interest in MET than EE. Note too that the interest here in ME and EE does not match the actual resulting majors shown before; more students leave EGR120 planning to major in engineering than actually take the second-year courses.
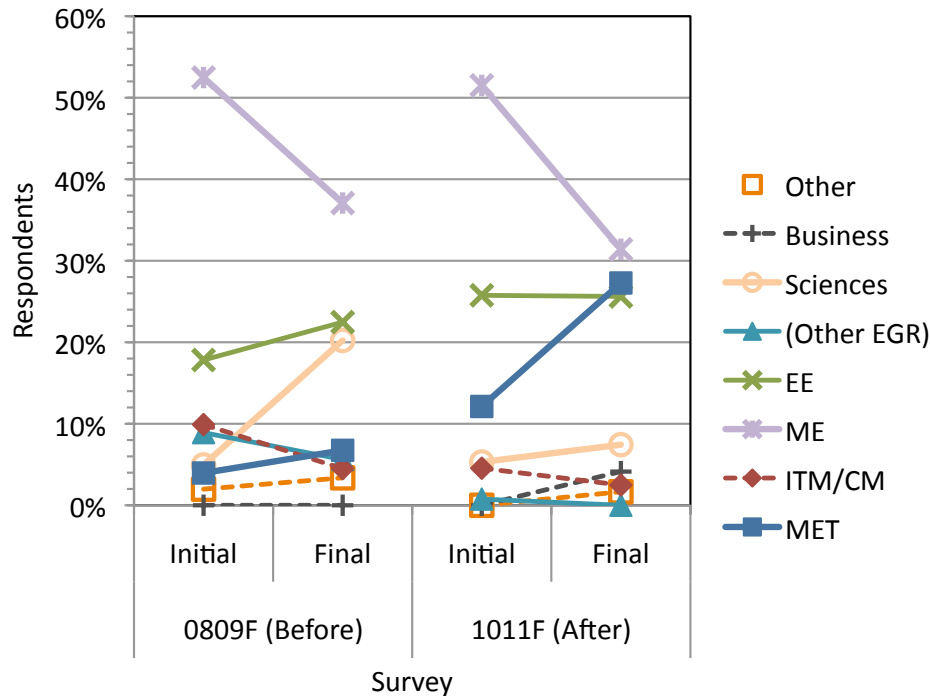

Fig. 6. Comparison of majors intended by students between Initial and Final surveys, for semesters before and after the pedagogy change.

The Final surveys also asked students for hand-written answers to "If you switched majors, why?". Those answers were categorized into the following general responses shown in Table 1 – the most common answers were that the new major better matched students' interest and was more hands-on (presumably going from engineering to technology).

Table 1. Students' hand-written responses on Final surveys to "If you switched majors, why?"

General Answer	Respondents
Matches interests / better fit	15
Want more hands on	10
Want less math	4
Better jobs/advancement	3
Less time required	1

5.2 Math level and EGR120 grade persistence

In terms of math level, MET/Techn has gained its new EGR120 recruits from all math levels except for pre-Precalculus (Figure 7). EGR120 draws a range of students, most with a

Precalculus or Calculus I level. In the past, MET/Techn recruited mainly pre-Precalculus students from EGR120. With the pedagogy change, MET/Techn has already recruited 128% more Precalculus students, 83% more Calculus students, and 100% more post-Calculus students from EGR120. That is, the pedagogy change has helped technology recruit many math-prepared students. The recruitment numbers will increase as the Unknown students sign majors.
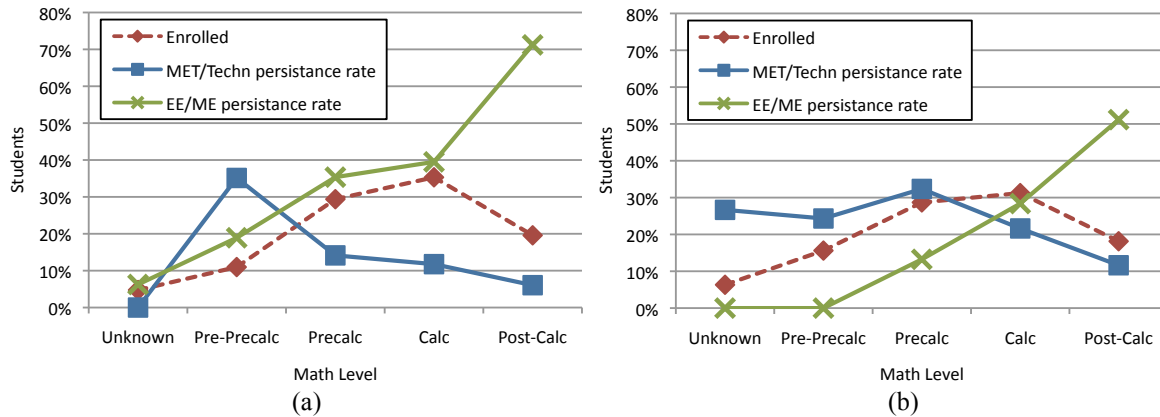

Fig. 7. Math level of students enrolled, and the subsequent persistence rates for (a) before and (b) after the pedagogy change.

Math level is a strong indicator of EGR120 grade (Figure 8). Average grade for a post-calculus student is 3.22 (B+), while average grade for a pre-precalculus student is 1.67 (C-).
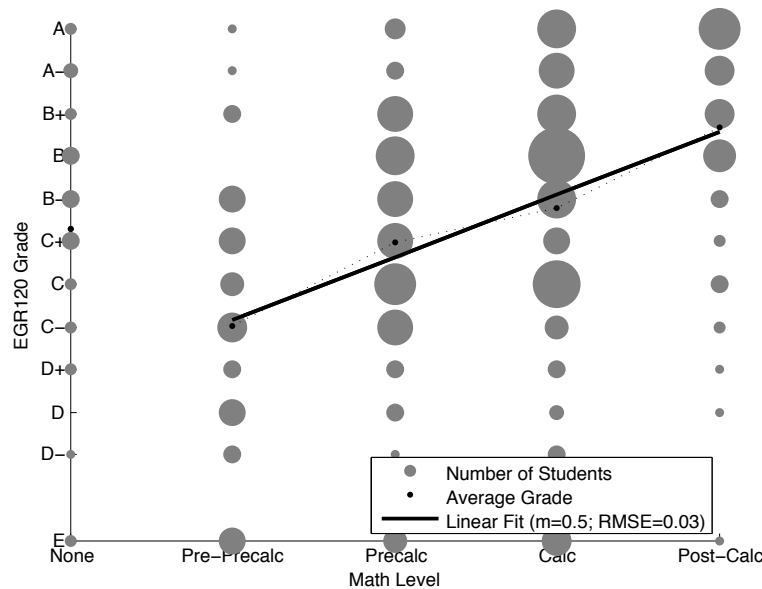

Fig. 8. EGR120 grade versus math level, where marker area corresponds to number of students.

Furthermore, the grade earned in EGR120 is a strong indicator of persistence into ME/EE ($p \leq 0.0001$; Figure 9). For engineering, 75% of the students who receive an A in EGR120 persist in engineering, while only 25% of those who receive a C persist. On the other hand, EGR120 grade is not a good indicator for recruitment into the technology programs. MET/Techn recruits students with various EGR120 grades – if anything, the programs recruit students with average EGR120 grades more than those with high or low EGR120 grades.
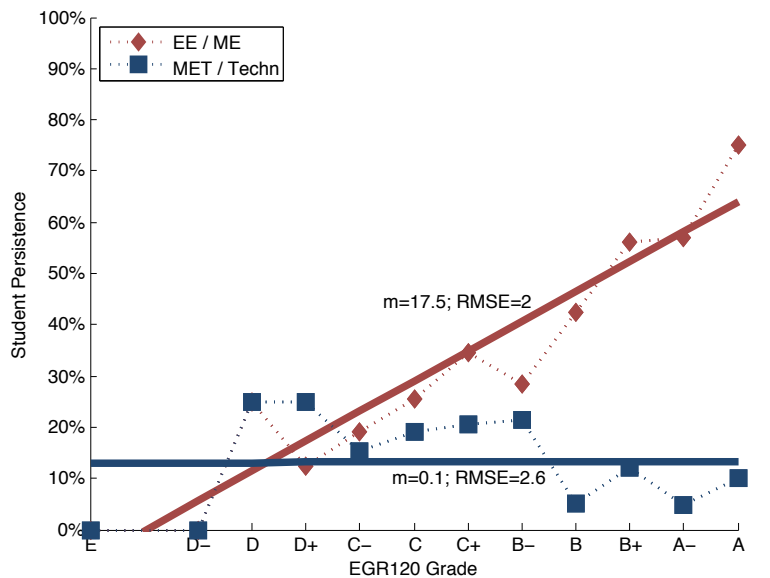
Fig. 9. EGR120 is a significant predictor of engineering persistence, but not technology recruitment.

6. Discussion and Conclusions

It is clear that the pedagogy change in EGR120 has significantly improved recruitment of students into the technology programs and thus persistence of the students within the School's programs. By more clearly explaining the range of engineering and technology programs, and by having a technology professor co-teach the course, students that would otherwise have left the School are now pursuing technology degrees. The initial numbers are encouraging and should increase as the remaining undecided students sign majors.

The strongest growth has been in the MET program, as seen from the transcript data (Figures 3 and 4), the number of signed majors (Figure 5), and the Final surveys (Figure 6). The survey data suggests that students are switching to MET because it better fits their interests and is more hands-on (Table 1), and are doing so rather than switching to the sciences as in the past (Figure 6). The engineering persistence should not be significantly affected.

The pedagogy change is helping attract good (and bad) students to the technology-degree programs. The new technology recruits have a variety of math levels (Figure 7) and EGR120 grades (Figure 9).

The collaboration of technology and engineering faculty in EGR120 has greatly helped the School's programs, and could do so for other universities. By exposing students to the spectrum of engineering and technology and by creating contacts within each program, students are more likely to find a degree of their liking and be comfortable switching to that program. Faculty and pedagogy cooperation between technology and engineering can be mutually beneficial.

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