



The Effect of Cooperative Education and Contextual Support on the Retention of Undergraduate Engineering Students

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The Effect of Cooperative Education, Contextual Support, and Self-Efficacy on the Retention of Undergraduate Engineering Students

Abstract

This study examines the effect of demographic characteristics, cooperative education, contextual support, and three dimensions of self-efficacy and their change over time on the retention of undergraduate engineering students. It is based on a pathways model that links contextual support and cooperative education and other forms of student work experience to self-efficacy as a basis for retention in college and in the engineering major. It is also longitudinal, so it examines measures at three time periods during the students' academic experience: the second, third, and fourth years.

The data pool was constituted of all second-year students in the colleges of engineering from four participating universities: Northeastern University, Rochester Institute of Technology, Virginia Polytechnic Institute and State University, and the University of Wyoming. Student respondents initially filled out a 20-minute survey, among which were assessments of three forms of self-efficacy. They then filled out comparable post-surveys one and two years later (as third and fourth-year students) during which those selecting co-op could have completed their first and second co-op placements.

The findings verified the pathways model. Academic self-efficacy and contextual support in all time periods were found to be critical to retention. Contextual support was found to be particularly important to women and appears to serve as an inducement to stay in school and in engineering. Work self-efficacy, developed by students between their second and fourth years in school, was also an important factor in retention, though it is strongly tied to the students' participation in co-op programs.

Besides academic self-efficacy, the overwhelming critical predictor of retention was the number of co-ops in which a student participated. Among the demographic variables, a relatively high GPA was found to be an inducement to persist in engineering and in school. It was also found, at the second survey point of the study, that a student's prior SAT scores had a measurable effect on retention. Finally, those students who were accustomed to work over a relatively long period of time were especially more inclined to leave the university compared to those who had less work experience in their lifetimes.

Among the contextual support variables, support from friends and from one's college was found to explain retention at the time of the first survey as students reflect on their freshmen year experience. In an unexpected but modest finding, those students who persisted in the major and in school were more critical of their instructors than those who left.

The findings for co-op in this study not only lend support to those who have long asserted that quality co-ops can enhance undergraduate retention but also demonstrate co-op's enduring enhancement of students' work self-efficacy.

Introduction

This study is part of a larger research project, supported by a National Science Foundation Research on Gender in Science and Engineering program grant, designed to determine the effect of self-efficacy and other factors on retention, especially of women in undergraduate engineering programs. These data represent the pre-survey of the study completed in the 2009-2010 academic year (referred to as Time 1), a post-survey follow-up in the 2010-2011 academic year (referred to as Time 2), and a final post-survey completed in the 2011-2012 academic year (referred to as Time 3). Students initially completed a 96-item first survey (not included in this paper due to the proprietary nature of some components) as sophomores. They then completed a 102-item second survey approximately one year later and a final 104-item third survey in their fourth or senior year. The surveys were filled out either in written format or online.

The data pool is from colleges of engineering from four universities: Northeastern University, Rochester Institute of Technology, Virginia Polytechnic Institute and State University, and the University of Wyoming. The first two institutions provide formal cooperative education programs while the third and fourth do not require it. The total number of respondents at the point of the survey for Time 1 was 1637 students. The combined response rate was 67%. The response rate for Time 2 (calculated as the number of respondents from the first survey who successfully completed the second survey) was 54% and represents 886 students. The response rate for Time 3 (calculated as the number of respondents from the second survey who successfully completed the third survey) was 79% and represents 699 students. The Time 3 response rate as a proportion of the full dataset at Time 1 is 43%.

The overarching model for the study proposes that retention is shaped by self-efficacy, which, in turn, is based on the impact of students' demographic characteristics, the effect of work experience – in particular cooperative education, and the contextual support provided by the university as well as by others, such as parents and friends. In this paper, we report the results of the study incorporating these principal variables on retention over three time periods. The dependent variable, retention, is calculated as the number of students who both stayed in their university and in their major. The three efficacy forms consist of work, career, and academic self-efficacy, signifying the confidence that students have in their own success within the workplace, within their chosen engineering career, and within the classroom, respectively. Contextual support was measured as the support provided to students during their college careers through a number of mechanisms, in particular, financial aid, mentors, advisors, family, friends, teachers, profession, campus life, and living-learning communities.

This paper first presents the background, conceptual framework, and methodology of the study. Next, we describe the results of the principal study variables, cooperative education, contextual support, and self-efficacy on retention over the three time periods. We then conclude by reviewing the significance of the results with implications for programs seeking to retain students, especially women, in undergraduate engineering.

Background

Retention

Student persistence has been a longstanding area of research interest not only because of internal reasons for affected universities (e.g., higher tuition revenues associated with lower dropout rates) but because of external reasons (e.g., use of retention measures in annual rankings).¹ The well-known Tinto Model of Institutional Departure² has pointed to the major sources of students' leaving academia; to wit, academic difficulties, irresolution of educational and occupational goals, and lack of integration into the intellectual and social life of the institution. Tinto and many others have subsequently offered a number of suggestions for institutional practices designed to retain students. Among them are: more targeted recruitment, reduction of experience of racial discrimination and prejudice on campus, improved chance for early academic success, better and more frequent advising, more active experiential instruction, more informed career planning, improved social acclimation and student-institution match, and an adequate level of need-based financial aid.^{3 4 5 6 7}

Since the well-known mammoth Astin study in 1993,⁸ which found that engineering students graduated at only a 47% rate in 1993, and in spite of many efforts to counteract this low rate of persistence, graduation rates among undergraduate engineers have not increased much more than 10%.⁹ Meanwhile, demand for attractive engineering graduates continues to grow, perhaps best exemplified by President Obama's call for 10,000 more engineers per year.¹⁰ Part of the President's proposal called for additional internship opportunities made available through the private sector. A recent study¹¹ using data from the National Survey of Student Engagement has seemingly concurred with the President's plans with its finding that students who persisted in the STEM (science, technology, engineering, and math) fields reported more frequent participation in co-op and other related field experiences while dropouts spent more hours working off-campus and expressed belated interest in general education and in reflective learning. The so-called "APPLES" study¹² generally supported these findings and added that engineering students were less satisfied with their instructors compared to students in other majors and also reported lower gains in personal growth and fewer opportunities to study abroad.

The problem of retention among undergraduate engineering students is exacerbated when it comes to under-represented populations, for example, among women. While recent studies show that women may be closing the retention rate gap in college,¹³ they continue to be underrepresented in engineering. In 2011 women earned 18.4% of bachelor's degrees in engineering¹⁴ (having peaked at 20.6% in 2000¹⁵). They also hold only 13% of engineering positions.¹⁶

Although women are as academically prepared and as academically successful as men, they nevertheless lag behind men in academic satisfaction, academic self-efficacy, and self-esteem.¹⁷ Traditional assumptions about career options for women have been reinforced in society and have projected stereotypes that discourage talented women from continuing in engineering careers. This is evidenced by research that found a dramatic drop in women's self-efficacy throughout the course of engineering programs. In an in-depth study of students who switched

out of science, math, and engineering majors, 77.9% of women cited discouragement and loss of self-efficacy as a factor in switching.¹⁸

Self-Efficacy

The concept of self-efficacy has been proposed as a promising conceptual link between practice-oriented learning processes, learning outcomes, and persistence.^{19 20 21} Self-efficacy is defined as an individual's perceived level of competence or the degree to which she or he feels capable of completing a task. It is a dynamic proximal trait that changes over time and can be influenced by experience. Self-efficacy expectations are considered the primary cognitive determinant of whether or not an individual will attempt a given behavior. Bandura²² identified four sources of information that shape self-efficacy: (1) performance accomplishments, (2) vicarious experience, (3) verbal persuasion, and (4) physiological and affective states.

Robert Lent²³ and his associates expanded on general self-efficacy theory to develop a Social Cognitive Career Theory (SCCT), a “conceptual framework aimed at understanding the processes through which people develop educational/vocational interests, make career-relevant choices, and achieve performances of varying quality in their educational and occupational pursuits” (p. 62). In addition to highlighting cognitive-person variables, such as self-efficacy, SCCT emphasizes the role of other personal, contextual, and learning variables (e.g., gender, race or ethnicity, ability, social support, external barriers) that can help shape career trajectories, including the means to remediate any disadvantages from being under-represented in particular occupations.²⁴

SCCT theory has also made an impact on models attempting to explain the withdrawal of students from undergraduate education. Compared to the models cited earlier that stressed the importance of academic performance and other institutional factors, such as student-institution match, SCCT focused more on cognitive-person variables, such as self-efficacy, to reveal the potential for students to exert personal agency in their career endeavors.^{25 26} What is especially important about these variables is that they can be assessed and their conditions altered during the freshman year and beyond in order to enhance students' perceived consequences of succeeding in college and staying in school.^{27 28}

While this study's pathways model (Figure 1) bears some resemblance to Lent's theoretical SCCT model,²⁹ he and his colleagues use outcome expectations and interests as additional cognitive-person variables.³⁰ This study concentrates on self-efficacy since efficacy beliefs are believed to be the most central and pervasive mechanism of personal agency.³¹

Other than Lent's work on contextual factors, there has been some modest research on interventions that may lead to increased self-efficacy. In theoretical pieces, Betz³² and Brown and Lent³³ discussed ways that counselors could increase the self-efficacy beliefs of their clients, such as by structuring successful performance experiences, finding successful role models, providing techniques for anxiety management, offering encouragement and support, encouraging data gathering that might counteract detrimental self-efficacy beliefs, and helping process efficacy relevant data. In one study,³⁴ a three-day problem-based camp experience was found to increase students' self-efficacy for specific tasks as well as general self-efficacy. Hutchison, Follman, Sumpter, and Bodner³⁵ more recently reported a relationship between academic and advisory support

and female students' academic self-efficacy. A pilot study³⁶ was performed by the University of Wyoming's and Northeastern University's Colleges of Engineering to discriminate the effect of co-op versus other competing measures on self-efficacy. Cooperative education was found to significantly predict change in work self-efficacy; prior academic achievement was found to predict subsequent academic self-efficacy; and academic support was found to significantly enhance all three forms of self-efficacy. Finally, in a study using data from this current longitudinal study but with only the first and second time periods, cooperative education and the quality of the co-op placement were found to augment students' work self-efficacy.³⁷ Work self-efficacy was also affected by change in students' confidence in their career orientation.

In exploring whether gender plays a role in differentiating the impact of self-efficacy on undergraduate participation and retention, Hackett and Betz³⁸ were the first to use self-efficacy to explain the career development of women, especially in male-dominated career domains. They suggested that societal factors have created gender differences in gaining access to primary sources of career self-efficacy in male-dominated career fields. In turn, lower self-efficacy beliefs about these careers have resulted in fewer women entering these fields. Since then, empirical studies supported these conclusions about efficacy and gender, finding that college-aged women's self-efficacy within male-dominated fields was significantly lower than their self-efficacy in traditionally female occupations.^{39 40} The one exception to this finding is when women declare an engineering major upon entering school; in this instance their career self-efficacy becomes equivalent to that of their male counterparts.⁴¹ We may conclude, as reported by Vogt, Hocevar and Hagedorn,⁴² that self-efficacy is critical to academic integration and thus needs to be sustained if women are to persist in their undergraduate engineering majors.

Cooperative Education

It has long been established that cooperative education and other related formal work experience programs during the undergraduate experience provide students with opportunities to try out, learn from, and reflect on ongoing work experience.⁴³ As a result, these programs help students transition into full-time work more easily, helping them overcome the "reality shock" attributed to first job experiences for uninitiated novices.^{44 45} In addition, cooperative education can also prove beneficial to students in sustaining their ongoing academic performance and their persistence to graduation.^{46 47 48 49 50} Blair, Millea, and Hammer⁵¹ in a study of undergraduate engineering majors concurred that those who completed three semesters of co-op had superior academic performance, and they also earned higher starting salaries (though it took them longer to complete their undergraduate program). Co-op students have also been found to more successfully adjust to work at the outset of their employment,⁵² were more self-reliant in learning about their organization and work groups, and rated their knowledge of task and role more highly than non-co-ops.⁵³ Finally, as related to the social cognitive stream of research, co-op experience has been found to increase self-efficacy, self-concept, and career identity.^{54 55}

Of the various dimensions of self-efficacy that are likely to be affected by co-op, it appears that work self-efficacy is the construct of choice.⁵⁶ Work self-efficacy measures a range of behaviors and practices - e.g., exhibiting teamwork, expressing sensitivity, managing politics, handling pressure - attending to students' beliefs in their command of the social requirements necessary for success in the workplace. Since efficacy is a malleable property, there are methods by which

student employees may achieve relative success in their jobs as well as learn within the workplace by increasing their confidence in performing many of these work-related behaviors.⁵⁷

Fletcher's theoretical account⁵⁸ made a first attempt to explain how cooperative education experience might enhance self-efficacy and help students make the transition from student to practitioner. Specifically, she suggested that cooperative education increases self-efficacy through performance accomplishments, one source of efficacy information. In this instance, performance accomplishments would be co-op experiences themselves in which students need to use skills, abilities, and coping strategies to perform tasks. Successful experiences can result in a feedback loop where performance accomplishments would lead to increased self-efficacy, which in turn, enhances students' performance, further strengthening their self-efficacy beliefs. The possibility that cooperative education can be a source of efficacy information through performance accomplishments is provocative, given that performance accomplishments are generally viewed as the most potent source of self-efficacy information; that is, of the four sources of efficacy information, performance accomplishments are thought to exert the most influence.^{59 60} Nevertheless, formal workplace experiences also expose students to successful peer models, mentor figures, and verbal encouragement that can provide self-efficacy information through Bandura's vicarious experiences and verbal persuasion sources.

Contextual Support

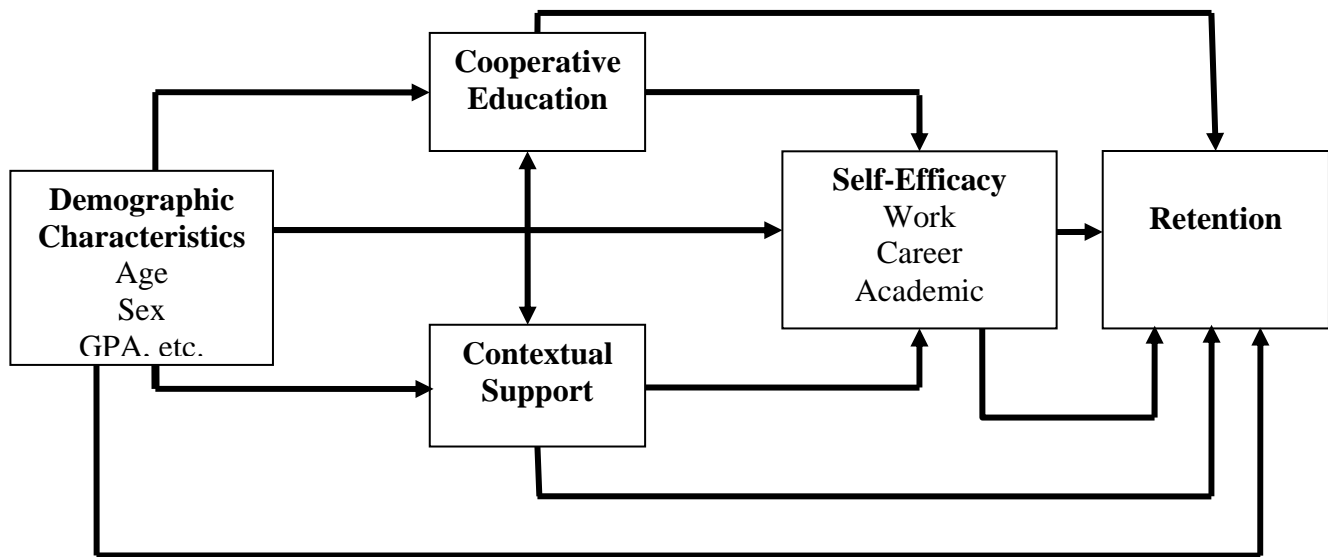
Contextual support (and barriers) have been heavily researched in social cognitive career theory and derive from SCCT's perspective that social influences pervade virtually every phase of career development.⁶¹ What makes these influences contextual is their mediation through the situation at hand, for example, through financial aid to those in need; through modeling and conversation; through the messages that parents, faculty, role models, and peers convey to students about their efficacy at different tasks; and through the career choice encouragement (or discouragement) that students obtain from influential significant others.^{62 63 64} Many undergraduate programs offer traditionally under-represented students a variety of support systems, such as access to mentors and role models, to help them with the transition to college life. The Lichtenstein study⁶⁵ referred to earlier, for example, pointed out that female engineering undergraduates took more advantage of mentors compared to male undergraduates. These support mechanisms along with those cited above have been found to critically affect the retention especially of women in engineering.^{66 67}

Contextual barriers, as defined by Lent et al.,⁶⁸ consist of proximate obstacles to career and academic self-efficacy and to retention. For example, students may face pressure or opposition from their peers or parents in their pursuit of an engineering career. They may also be dissatisfied with the instruction in the field or may encounter financial constraints. This study focuses on supports rather than barriers because Lent's work^{69 70} has found that supports and not barriers were more influential in students' pursuit of an engineering major and in their persistence in engineering beyond their second semester.

Framework

The conceptual framework for this study is depicted in Figure 1 as a set of pathways between five variable clusters. The determination of retention in undergraduate engineering education is based on the impact of students' demographic characteristics, the effect of work experience - in particular cooperative education, contextual support, and self-efficacy – categorized by three forms: work, career, and academic.

Figure 1
Conceptual Framework of the Study



Data

The data pool represents all sophomores, as of the start of the study, in the colleges of engineering from the four participating universities: Northeastern University, Rochester Institute of Technology, Virginia Polytechnic Institute and State University, and the University of Wyoming. Respondents filled out three 20-minute surveys, spaced out over approximately a year. While the Time 1 survey was completed entirely in written form, some 54% of Time 2 respondents and 62% of Time 3 respondents completed their surveys online. All surveys were conducted confidentially, and IDs were used to track students for follow-up purposes and to verify some of the descriptive data against the student record. Since IDs were not associated with names in the data file, the data analysis was conducted in total anonymity. Incentives were used to generate higher response rates and entailed both direct gifts for completion (e.g., coupons to on-campus bookstores or coffee shops) and raffles (e.g., VISA gift cards, iPods). As Table 1 reveals, the

total number of respondents at Time 1 was 1637 students (a response rate of 67%). The response rates for Times 2 and 3 were 54% and 79% respectively.

Besides the expected dominance of males in the sample, 79% at Time 1, 76% at Time 2, and 75% at Time 3, the initial sample was predominantly Caucasian (79.5%) and middle and upper-middle class (83%) in socioeconomic status (SES). The average SAT score was 1269 (math plus verbal scores), based on the original SAT version with a 1600 maximum score. The average GPA was 3.21 at Time 1, 3.12 at Time 2, and 3.10 at Time 3. For all surveys, the most popular major was mechanical engineering (at nearly a third of the sample) followed by civil and chemical. Electrical engineering was the fourth most popular major at Times 1 and 2, but was replaced by industrial and systems engineering at Time 3.

By the time of Survey 3, 100 students (approximately 6.1%) had left their university and 122 students (approximately 7.45%) had transferred out of engineering. The dropout percentages were very similar between men and women, except that slightly more women (+.4%) had left engineering and slightly more men (+.3%) had left the university. Of those who had left engineering, the most popular substitute major was science, followed by math, business, and social sciences in that order. The engineering students in our sample are viewed as hard-working since some 95% of them declared that they were working in some capacity. During their lifetimes, 30% of the sample at Time 3 reported one year or less of total work experience, 51% worked between one and three years, and 19% had worked over three years. In terms of organized school-based work experiences, 665 students (41%) participated in at least one co-op program during the three years of the study and an additional 174 (11%) undertook an internship, be it in their major or not connected to their major.

When asked about their plans following graduation, approximately 70% of respondents indicated that they would seek to work in a job in the engineering field. The bulk of the remaining respondents said that they would plan to attend graduate school in the field or do so part-time while working. By the time of the third survey, 437 students, or nearly 27% of the original 1637 in the full sample, had graduated. The others were either finishing their course credits or had not graduated at the time their status was recorded. Those at the co-op universities (Northeastern and Rochester Institute of Technology) were likely facing one additional year of matriculation.

Table 1
Overall Sample Statistics

School	# Students Completing Time 1	# Students in Data Pool	Response Rate	# Students Completing Time 2	Response Rate	# Students Completing Time 3	Response Rate
Northeastern University*	363	422	86%	325	90%	299	92%
Rochester Institute of Technology*	315	399	79%	174	55%	121	70%
University of Wyoming	128	287	45%	94	73%	77	82%
Virginia Polytech	831	1353	61%	293	35%	202	69%
TOTALS	1637	2461	67%	886	54%	699	79%

* Signify the two universities with predominantly co-op engineering colleges.

Measurement

Principal Study Measures

The measures of the principal study variables are as follows. The retention measure is the number of students who remained in their engineering college over the three-year time period of the study. Those who left the major or university were coded as drop-outs. Given the criticalness of this measure, each student's status as reported in the survey was checked against the student record. Only students who began the survey at Time 1 were counted, eliminating the chance for variation based upon the entry of new or transfer students. Although measures were taken separately of departures by major and university, the combined score provided a larger N necessary to evaluate the precursors to dropout status.

Self-efficacy was measured in three formats due to findings in the literature that suggest segmenting efficacy in determining persistence in engineering (see, e.g., the work of Cech, Rubineau, Silbey, and Seron⁷¹). The new work self-efficacy inventory (WS-Ei), developed by Joseph Raelin at Northeastern University, measures a range of behaviors and practices that relate to the non-technical and social skills necessary to achieve success in the workplace.⁷² The inventory features seven subscales: problem-solving, sensitivity, role expectations, teamwork, learning, pressure, and politics. Career self-efficacy was obtained directly from the short-form of the Career Decision-Making Self-Efficacy Scale of Betz, Klein, and Taylor,⁷³ and academic self-efficacy was derived from the Self-Efficacy for Academic Milestones and the Self-Efficacy for Technical/Scientific Fields surveys.⁷⁴

The numerical cooperative education variable was calculated by determining the number of co-ops that students experienced within the time period of the study, from 0 to 2. The numerical internship variable was similarly derived. As for the contextual support variables, the majority (friends, family, professional, financial) were developed from familiar support scales in use such as the support subscales of Lent et al.⁷⁵ Two variables were drawn from the college students' mattering literature,^{76 77} purporting that the mattering of one's friends and college were key components of social support. From the retention literature, three other important variables were included: the quality of instruction, the involvement of the student in campus life, and the opportunity to be involved in a living-learning community.^{78 79 80 81} Finally, the support of both an advisor and a mentor⁸² was measured by deploying the advisorship and mentorship scales from the rapport and apprenticeship subscales of the Advisory Working Alliance Inventory (AWAI) prepared by Schlosser and Gelso.⁸³ Demographic data, such as SAT scores, major, or GPA, were self-reported by the respondents directly on the survey instrument or obtained from their student records.

Scale Validity and Reliability

The first round of analyses established the validity and reliability of these measures. Factor analyses were conducted on the components of each of these established scales using principal component analysis as the extraction method with eigenvalues set at the Kaiser greater-than-1 rule. The initial solutions for each of the analyses found all the components to load as specified on the first factor. Although not an established scale, an attempt was also made to produce a

contextual support scale made up of each of the support variables. This analysis was not able to secure a single solution; rather, the financial support variable loaded on a separate factor. However, an exploratory factor analysis of all the remaining support variables indeed loaded on a single factor. Thus, a composite social support measure was created with the exception of financial support, the latter being retained as a single-item measure.

Each of the three self-efficacy scales – work, career, and academic – produced high reliabilities, measured by Cronbach’s alpha coefficient of internal consistency:

WS-E: .94

CS-E: .93

AS-E: .91

These scores are above the recommended .70. The advisor and mentor scales also performed well: advisorship at .95 and mentorship at .97. The new social support scale, created from the merger of seven variables (friend, family, and professional support, friends and college matters, involvement, and teaching quality) achieved a sufficient reliability coefficient of .74.

One additional scale was created from the Time 2 data, composed of ten measures used to evaluate the quality of students’ co-op experiences. Research by Blackwell et al.⁸⁴ has highlighted the differential learning and employment effects that can ensue from variety in the provision of undergraduate work experience. For example, some co-ops are better at expressly providing students with an opportunity to learn or in enabling them to reflect on what they are learning. The measures used in this study were based on the work of Fogg and Putnam⁸⁵ and Highsmith, Denes, and Pierre⁸⁶ and include such indicators as whether the placement was intellectually challenging and applied the knowledge used in one’s field, or whether the student worked as part of team of professionals. All ten variables loaded on the same factor and achieved a Cronbach’s alpha of .87.

The three major self-efficacy scales were found to have a high degree of concurrent validity, measured initially by correlations that are high and significant but not so high as to be equivalent. It was therefore determined that each efficacy measure represents a different facet of self-efficacy.

WS-E and CS-E = .67

AS-E and CS-E = .44

WS-E and AS-E = .32

Convergent validity was also established by significant correlations among discriminating variables. For example, academic advisorship and mentorship, provided as part of programs to support women and underrepresented students, were both significantly correlated with the three efficacy measures. Meanwhile, GPAs at all three time periods were found to be highly and significantly correlated with academic self-efficacy at these respective time periods. Academic self-efficacy in all time periods was also significantly correlated with the teaching quality measures at their respective time period and SAT scores overall.

Change Scores

To compute the differences between time periods, three change scores were calculated for each of the scaled independent measures: between Time Periods 1 and 2, between 2 and 3, and between 1 and 3. An initial analysis, using paired sample t-tests, was also conducted to determine if there were significant differences between these respective time periods for the measures involved. Table 2 below depicts just the efficacy change scores. As can be seen, most of the changes are significant in a positive direction. However, academic self-efficacy actually went down between Time 1 and Time 3 and significantly between Time 1 and Time 2. This suggests that student's overall confidence in their academic performance declined after the relative early success of the freshman year and before the rigorous requirements of the major kicked in. There was reason for the slump in academic self-efficacy as the students' GPAs, at Time 2 especially, fell in comparison to their GPAs at Time 1. Regarding the other change scores (like GPA, not displayed in the table), only two differences were lower at subsequent time periods: college mattering and college involvement. Students overall found their universities to care less about them and seemingly responded by decreasing their involvement in campus life. This finding may be a reflection of the oft-reported undergraduate phenomenon known as the "sophomore slump."⁸⁷

Table 2
Changes in Efficacy Scores Between the Time Periods

	N	Time 1 vs. Time 2	N	Time 2 vs. Time 3	N	Time 1 vs. Time 3
Work self-efficacy	885	3.88 vs. 3.93**	704	3.93 vs. 3.94	704	3.88 vs. 3.94*
Career self-efficacy	879	3.76 vs. 3.81**	693	3.80 vs. 3.89**	704	3.77 vs. 3.89**
Academic self-efficacy	871	3.98 vs. 3.91** ⁻	689	3.93 vs. 3.99*	695	4.01 vs. 3.98 ⁻

** Significant at $p < .01$ using two-tailed paired sample t-test

* Significant at $p < .05$ using two-tailed paired sample t-test

⁻ Indicates negative t

Statistical Analysis

The primary purpose of the statistical analysis is to determine the pattern of explanatory variables, representing the study's pathways model, which may account for the retention of students in undergraduate engineering. Since the dependent variable in this study is a categorical measure, the method chosen is discriminant function analysis (DFA). Like multiple regression analysis, the purpose of DFA is to isolate the independent variables which predict a dependent variable, but in the latter case, it is to find the attributes which contribute most to the separation between two or more groups (such as stayers vs. leavers) rather than to isolate the factors to explain the fraction of variance in a continuous dependent variable. What is reported in this paper is the Wilks' Lambda and the canonical correlation statistics and their respective test for significance (Box's M F-score and chi-square respectively). Wilks' Lambda indicates the significance of the discriminant function and the canonical correlation is the multiple correlations

between the predictors and the discriminant function – comparable to the R-square or proportion of variance explained in the more familiar regression model. The order of the predictors is based on each function's discriminant loadings.

Further analysis of the moderating effect of contextual support on the relationship between gender and retention and of the moderating effect of work self-efficacy on the relationship between cooperative education and retention will be conducted using cross-tabulation.

Results

For Change Variables

To determine the impact of the pathways model on retention, separate discriminant function analyses were conducted using the change scores as well as the regular scores during each of the three time periods. Using both the change as well as the component scores was suggested by Edwards⁸⁸ as a way to assess the integrity of the former. The discriminant analyses were also conducted using the components of the retention dependent variable, namely leaving the major and leaving the university, as well as for gender.

Tables 3 and 4 reveal the results of four of these analyses. Table 3 lists the significant discriminating variables on retention for changes between Time 1 and Time 3, and Table 4 lists the discriminating variables for Times 1, 2, and 3. The retention variable is recorded at Time 3, although the heavy majority of departing students (70%) left the major or university at Time 1. Fifteen percent left at Time 2 and the remaining 15% at Time 3.

Examining first the change results, the discriminant model is highly significant with a Wilks' Lambda of .901 and a canonical correlation of .31. The most critical variable predicting retention was the number of co-ops taken by the respondents. Those who stayed in school or in the major participated in more co-ops than those who left. The number of co-ops was ostensibly more important than their quality. Similar, though less robust, results were found for internships. There was also a significant difference for change in academic self-efficacy. Although as already noted, overall academic self-efficacy decreased (along with GPAs) after the freshman year, this form of efficacy particularly plunged for drop-outs compared to those who persisted either in the major or in school.

Another important predictor was the amount of past work experience, but, as foreshadowed in our literature review, those who worked the most were more likely to drop out. There are many possible reasons for this result, but the two most likely hypotheses - given that the relationship was most critical for those who chose to leave the university rather than the major - are that students with a history of consistent work experience need to work to sustain the income to attend school or that they may find academic studies to be less relevant than the rigors of the working world. Another prospective hypothesis is that age may play a role and the findings display a moderate effect; in particular, dropouts over the age of 20 have approximately six months more work experience than dropouts under the age of 20. It should be noted that the "work" associated with this measure could be any reported prior and current employment and

may not reflect ongoing work experience programs offered through one's institution, such as co-ops or internships.

Though not significant, Table 3 also reports the means for change in work self-efficacy, which were far lower for drop-outs than for those who persisted. There was also a near-significant effect for change in teaching quality. Provocatively, those who stayed, especially by Time 3 of the study, were far less impressed with their instruction than those who left the major or the university. One possible rationale for this result might be that those who stayed were more serious students than those who left and thus were more critical of their instructors. Another rationale might be that those who stayed and participated in co-op or internship programs have developed a more critical view of a curriculum and instruction that may not be sufficiently "real-world."

For the Three Time Periods

Looking next at the discriminant analysis results for the separate time periods, all models are significant. It is clear that four variables dominate the explanation of retention, three of which were cited in the change model: number of co-ops, academic self-efficacy, past work experience, and GPA. There is a likelihood that the variable, past work experience, would have appeared in the Time 1 model but it was not included in the first survey. The support composite variable, including the multiple facets of support, also appears in each equation, though not at the same robust level of significance. Clearly, those who stay experience more contextual support across the board compared to those who leave. In the Time 1 equation, the two "mattering" variables – friends and college – appear; thus it seems important that in the early undergraduate experience, students need to develop a rapport with friends at college and with the college as a whole in order to develop a commitment to stay in school. Having the support of friends continues to play a role in retention at Time 2. At Time 2, the demographic variable, prior SAT score, makes its appearance, providing some support to the contention by such authorities as the College Board and ACT that achievement test scores are an indicator of subsequent academic retention as well as performance.^{89,90} Finally, at Time 3, work self-efficacy manifests itself again, this time significantly, in predicting the retention of students. Since most students work in some capacity, those who develop confidence in managing themselves in the workplace tend to stay in school at a higher rate than those who do not.

Conditional Analyses

Separate DFAs were conducted on retention for the components of the retention variable and for gender. In spite of the reduced number of cells for students who left, the pattern of prediction for the dependent variables "left the university" and "left the major" was comparable to the overall retention variable. As for the analysis when separate runs were performed for men and women, the men had a nearly identical pattern as the full population. However, the DFA changed somewhat for women. Although only 45 women were found to have dropped out of either the major or university, the discriminant function for the change scores was found to be highly significant with a canonical correlation of .50. As in the case of the men, the number of co-ops and change in academic self-efficacy from Time 1 to Time 3 were still found to be the significant predictors. However, unlike the men, past work experience, change in work self-efficacy, and

change in teaching quality did not enter the equation. Rather, the second most important predictor of retention for women was socioeconomic status. Although this result needs to be viewed with some caution because of the low number of cells among female dropouts, those women who stayed were on average more likely to be slightly above middle class, whereas those who left were more likely to be slightly below middle class in socioeconomic status.

Table 3

Discriminant Analysis Displaying Significant Change Variables Between Time 1 and Time 3

Dependent Variable: Retention

N = 586*

Wilks' Lambda: .901 Canonical Correlation: .31

Chi-Square Significance: .001

Discriminating Variables	Mean for Retention	Mean for Drop-Out	F-Score	Significance
Number of Co-ops	1.22	.43	20.23	.001
Change in Academic Self-Efficacy	-.03	-.48	10.47	.001
Past Work Experience	4.20	4.79	-6.41	.012
Change in Work Self-Efficacy	.05	-.16	3.18	.075
Change in Teaching Quality	.06	.39	-3.01	.083

*The reason for the lower N compared to Table 2 is due to the nature of multivariate analysis in which the number of missing values is based on the full set of variables entered. Minor discrepancies in scores may also occur due to these differences in handling missing values.

Table 4

Discriminant Analysis Displaying Significant Independent Variables over Three Time Periods

Time Period 1

Dependent Variable: Retention

N = 778

Wilks' Lambda: .915 Canonical Correlation: .29

Chi-Square Significance: .001

Discriminating Variables	Mean for Retention	Mean for Drop-Out	F-Score	Significance
Number of Co-ops	1.28	.61	30.18	.001
GPA	3.32	3.02	19.84	.001
Academic Self-Efficacy	4.03	3.62	14.53	.001
College Matters	3.81	3.33	12.58	.001
Friends Matter	4.34	3.98	11.09	.001
Support Composite	4.33	4.10	7.80	.005

Time Period 2

Dependent Variable: Retention

N = 752

Wilks' Lambda: .875 Canonical Correlation: .35

Chi-Square Significance: .001

Discriminating Variables	Mean for Retention	Mean for Drop-Out	F-Score	Significance
Academic Self-Efficacy	3.97	3.16	42.23	.001
Number of Co-ops	1.18	.40	32.20	.001
Past Work Experience	3.91	4.98	-21.80	.001
GPA	3.23	2.90	21.20	.001
Support Composite	4.39	4.09	12.15	.001
Friends Matter	4.37	4.04	8.30	.004
SAT Score	1281	1243	4.44	.035

Time Period 3

Dependent Variable: Retention

N = 629

Wilks' Lambda: .915 Canonical Correlation: .29

Chi-Square Significance: .001

Discriminating Variables	Mean for Retention	Mean for Drop-Out	F-Score	Significance
Academic Self-Efficacy	4.02	3.29	30.00	.001
Number of Co-ops	1.20	.45	18.47	.001
Past Work Experience	4.18	4.79	-7.37	.007
GPA	3.28	3.07	5.77	.017
Work Self-Efficacy	3.93	3.77	5.39	.021
Support Composite	4.33	4.08	4.88	.028

Moderation of Results by Gender and by Work Self-Efficacy

Since the analysis reported here is part of a multi-year longitudinal study, prior studies were conducted during Years 1 and 2. At Year 1 in an exploration of gender differences, it was found that female undergraduate engineering students in their freshman and sophomore years took significantly more advantage of the support provided to them through friends, professional clubs, and the university, such as through living/learning communities.⁹¹ Therefore in this current study, an attempt was made to determine if the main finding of an insignificant effect of gender on retention was masked by the effect of contextual support. As can be seen in the contingency table displayed in Table 5, reporting only the results for students who persisted in the major and university, there is no particular effect for men on levels of support (which is coded into three categories of low, medium, and high support). However, women who stay in the major or in school are far more likely to report higher levels of contextual support – support being measured in this illustration by an overall composite score at Time 1 (though the pattern reported in this table for support and gender was reflected in all time periods).

Table 5
The Relationship of Gender and Retention Moderated by Contextual Support*

	Low Support		Medium Support		High Support	
	Count	Percentage	Count	Percentage	Count	Percentage
Men	334	30%	407	37%	365	33%
Women	61	21%	97	33%	138	47%

* Pearson chi-square test for stayers significant at .001

A comparable contingency analysis was performed for the moderation of change in work self-efficacy on the relationship between number of co-ops and retention, clearly one of the most powerful relationships uncovered by the DFA. A prior study, using the data at Time 2 of this overall longitudinal study, found that cooperative education programs had a pervasive impact on the development of work self-efficacy among undergraduates.⁹² The results of the current analysis are shown in Table 6. As in Table 5, only data for those who stayed in the major or in the university are included. Change in work self-efficacy has been recoded into three categories: went down, stayed about the same, and went up. As can be seen in the table, a significant inverse pattern has emerged. Some 76% of those who have had at least one co-op saw their work-self efficacy as going up or staying the same whereas the same percentage of those who have not had co-op saw their work self-efficacy going down or staying the same.

Table 6
The Relationship of Co-op and Retention Moderated by Change in Work Self-Efficacy*

	Went Down		Stayed About the Same		Went Up	
	Count	Percentage	Count	Percentage	Count	Percentage
At least one co-op	98	24%	136	33%	180	43%
No co-op	95	43%	71	33%	53	24%

* Pearson chi-square test for stayers significant at .001

Conclusion and Implications

This study has verified the contours of the pathways model linking particular demographic characteristics, cooperative education, contextual support, and self-efficacy to the retention of students in undergraduate engineering education. Since the study was longitudinal, it was able to assess the change in the support and efficacy measures over time. Academic self-efficacy and contextual support in all time periods were found to be critical to retention. Contextual support was found to be particularly important to women and appears to serve as an inducement to stay in school and in the major. Work self-efficacy, developed by students between their second and fourth years in school, is also an important factor in retention, though it is strongly tied to the participation by students in co-op programs. Career self-efficacy did not play a unique role in the analysis.

Besides academic self-efficacy, the overwhelming critical predictor of retention is the number of co-ops. Further, in a finding relatively new to the co-op literature, the more co-op assignments the better the results for retention in both the major and in school. This study was only able to assess the effects of typically two co-op assignments, but at Northeastern University, students take as many as three co-op assignments, and at Rochester Institute of Technology, they may take as many as five (though for a shorter period of time).

Among the demographic variables, there is no substitute for sustaining a relatively high GPA as an inducement to persist in the major and in school. It was also found at Time 2 of the study that a student's prior SAT scores had a measurable effect on retention.

Among the contextual support variables, the two "mattering" variables of feeling support from friends and from one's college at Time 1 were found to sustain retention. In an unexpected though modest finding, those students who persisted in the major and in school were more critical of their instructors than those who left. Finally, those students who were accustomed to work over a relatively longer period of time were more inclined to leave the university compared to those who had less work experience in their lifetimes.

Changes in this study were calculated between the first and second, second and third, and first and third time periods. Most of the changes were in a positive direction except for academic self-efficacy, which decreased in concert with GPA. Engineering students experience a degree of discouragement and lowered confidence as their academic performance declines. There was also a reported decline in college mattering and college involvement. As reported earlier, some students overall found their universities to care less about them by their sophomore year and seemingly responded by decreasing their involvement in campus life, suggesting that the "sophomore slump" is still alive and well.

These results point to some prospective methods to improve the retention of undergraduate engineering students. Although many students in engineering have access to co-op programs or internships, many still do not participate because of personal preferences or because their university hasn't made the sustained financial and human resource commitment to provide for a program of formal targeted placements along with counseling support. Nevertheless, the benefit in terms of retention seems to be worth the investment. Although co-op can be an important resource to enhance work self-efficacy, universities also need to find ways to enhance and develop students' academic self-efficacy. Along these lines, there may be no substitute for continuing to provide a range of support services to students, both of an academic, professional, and social nature. In conjunction with the series of studies conducted in prior years with the original database, support especially for women and for under-represented students can be enhanced through such means as providing academic counselors and mentors to students, giving them the opportunity to have a residence in a living/learning community, affording them exposure to role models in the field, or upgrading instruction to be more experiential than rote.⁹³ Although these support services are thought to be especially important during the first year of college, they should be sustained throughout the collegiate experience. For those students who have had or are currently engaged in extensive work experience, whether or not institutionally

provided, it is especially important that the nature of instruction show a high degree of relevance and connection to the contemporary operating conditions within the working world.

The study's emphasis on and findings for self-efficacy have implications for ongoing research relying on social cognitive constructs. It appears from this study that self-efficacy's power is associated with the distal experience from which it derives.⁹⁴ In this study, given the high association (correlations between .46 and .54) between GPA at each time period with its corresponding academic self-efficacy, it is likely that both conditions sustain each other over time. Meanwhile, this study has also revealed that the reciprocal relationship between work self-efficacy and co-op participation has also played a critical role in retention. Co-op provides the opportunity to develop work self-efficacy, which in turn provides for a deeper co-op experience, and both thus serve to keep students committed to their academic experience.

Acknowledgement

Support for this research was provided by the National Science Foundation under Grant No. 0827490. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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