

Pathways to Work Self-Efficacy and Retention of Women in Undergraduate Engineering

1.0 Introduction

Northeastern University (NU), Rochester Institute of Technology (RIT), Virginia Polytechnic Institute & State University (VT), and the University of Wyoming (UW) will partner in a research study titled: *Pathways to Work Self-Efficacy and Retention of Women in Undergraduate Engineering* (hereinafter referred to as the Pathways Project). The study is designed to investigate the hypothesis that women's participation in formal undergraduate engineering programs that provide work experiences while enrolled (e.g., cooperative education or internships) leads to enhanced self-efficacy and an increased likelihood of retention through graduation. Although all four schools offer cooperative education (co-op) or internship programs, NU and RIT require them. This project will isolate the factors that contribute most to the development of positive self-efficacy beliefs and, ultimately, to the retention of women in undergraduate engineering programs.

Figure 1 displays a path model that represents this study's conceptual design and illustrates the interaction of the principal variable clusters. The variable clusters are: precursory **demographic** variables, such as high school performance; formal **work experience** programs, namely cooperative education (co-op) and internships; **contextual supports**, such as mentorships and advising; **self-efficacy**, featuring three dimensions – work, academic, and career; and the principal dependent variable of **retention**. A path analysis will be conducted to isolate not only the variables that lead to retention, but also to measure their recursiveness and directionality.

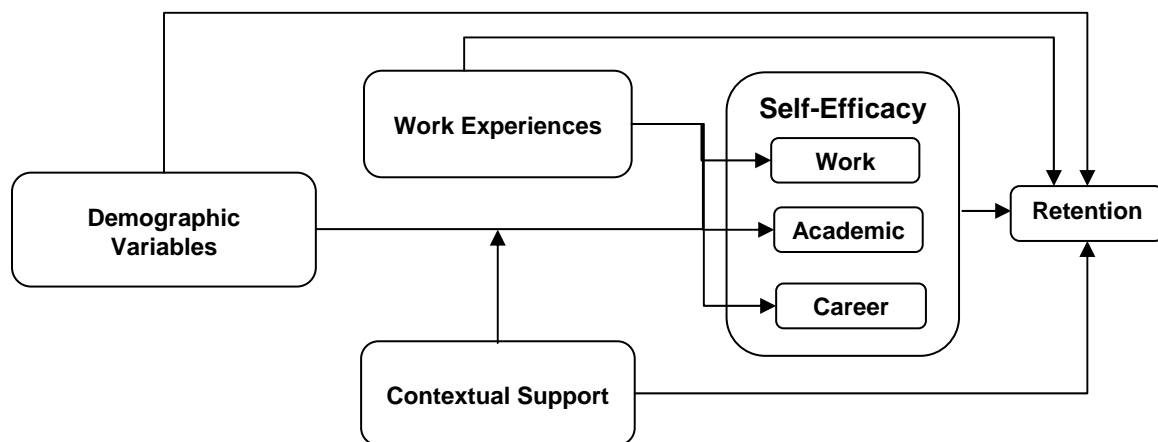


Figure 1: The Conceptual Model: Pathways to Retention

Research Questions: The team's research questions are guided by the principal hypothesis that work experiences related to academic study increase self-efficacy and, in turn, have a positive effect on retention. This project will contribute to the current knowledge about self-efficacy and women's retention in engineering and will build on the already robust research establishing the positive relationship between self-efficacy beliefs and career behaviors. It will expand knowledge about the respective roles of work experiences and work self-efficacy among women in engineering by addressing four hypotheses:

- *Self-efficacy is the principal predictor of the retention of women in undergraduate engineering programs.*
- *Cooperative education and internships, as formal work experience features of undergraduate programs, constitute a critical predictor of women's retention directly and indirectly through their impact on self-efficacy.*

- *Contextual support variables affect work, career, and academic self-efficacy as well as retention both directly and indirectly through self-efficacy.*
- *Demographic variables have an independent effect on retention but also interact with contextual variables and with self-efficacy to indirectly affect retention.*

The research team will thus test whether work, career, and academic self-efficacy alone and in interaction with contextual and demographic variables, contribute to the retention of women in undergraduate engineering programs.

Findings from the Pathways Project will provide research-based clarity regarding the effectiveness of programs offered in academia to promote and advance the participation of women in engineering. Self-efficacy-guided research will reveal the specific factors within formal educational settings that inhibit or encourage women's choice to persist in engineering careers. The research underlying the Pathways Project will be accomplished through the creation of a survey instrument, which has already been piloted. The instrument will be administered to a target population of undergraduate women and men engineering students at three prescribed times during their undergraduate education. Men are included in the study to isolate the unique contribution of gender to the project's outcomes.

Rationale: There are several factors that support the rationale for focusing on women within the Pathways Project. Women have been and continue to be underrepresented in engineering, earning only 19.3% of bachelor's degrees in engineering (Gibbons, 2007) and holding only 11% of engineering positions in 2003 (National Science Board, 2006). Although they are as academically prepared and successful as men (Adelman, 1998; Brainard & Carlin, 1998), they self-report lower levels of academic satisfaction and lack of self-confidence (Felder et al., 1995; Huang & Brainard, 2001; Campbell et al., 2002).

Traditional assumptions about career options for women have been reinforced in our culture and have projected stereotypes that discourage talented women from continuing in engineering careers (American Association of University Women, 2000). A number of studies have revealed a dramatic drop in women's self-efficacy over the course of engineering programs (see, e.g., Brainard & Carlin, 1998; Huang & Brainard, 2001). In an in-depth study of students who switched out of science, engineering, and technology (SET) majors, 77.9% of women cited discouragement and loss of self-esteem as factors in switching (Seymour & Hewitt, 1997). While self-esteem is a global concept and self-efficacy refers to confidence about a particular content area or set of tasks, general self-esteem tends to be related to an individual's feelings of self-efficacy. Research suggests that decreased self-esteem and self-efficacy of women in engineering majors are significant obstacles to persistence (Somers, 1986). Since college is a point in which many women exit the engineering pipeline, it is essential to foster conditions that promote retention. While many engineering programs are characterized by low rates of persistence for both women and men, this is particularly troubling for women because so few enter engineering majors in the first place.

Pilot Study: A study 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 three forms of self-efficacy: academic, career, and work (Raelin, Reisberg, Whitman, & Hamann, 2007). Each of the three self-efficacy scales produced high reliabilities and had a high degree of concurrent validity. Among the findings, cooperative education was found to significantly predict change in work self-efficacy; prior academic achievement predicted subsequent academic self-efficacy; and academic support significantly enhanced all three forms of self-efficacy. Women undergraduates were more confident in obtaining occupational information and learning from their work experiences. While this preliminary

study suggests the strong influence of co-op, additional variables constituting a more comprehensive model within larger populations need to be considered.

2.0 Project Value and Innovation

The research team seeks to develop a theory that relates events that undergraduate engineering students experience to self-efficacy beliefs. It will analyze the relationship between self-efficacy and retention. Unique contributions include theory development and empirical testimony about the relative impact that exogenous demographic variables, program experiences, and work self-efficacy can have on the retention of women compared to men. Therefore, the Pathways Project includes equal representations of women and men in its study population. Additional outcomes from the project will be recommendations for programmatic features that will not only improve retention but also provide for more accurate retention data.

Findings expected from the proposed research include the following contributions:

Provide additional data about how self-efficacy models applied to career theory explain the behavior of an underrepresented population. While similar models have been tested (Lopez, Lent, Brown, & Gore, 1997; Schaefers, Epperson, & Nauta, 1997; Lent et al., 2001; Lent et al., 2003; Nauta & Epperson, 2003), there have been some concerns about how well the models can be generalized to underrepresented groups (Lent et al., 2003).

Contribute to the research base on co-op. A number of studies have provided information on the outcomes associated with participation in co-op. However, there have been virtually no studies that explain what within the co-op model works. While self-efficacy theory has been cited in theoretical pieces (Fletcher, 1990), there is a need to relate it to cooperative education (Eames, 2004).

Identify which aspects of co-op and internship experiences are most valuable to women in engineering. Although there is anecdotal evidence that quality and specific experiences in cooperative education matter, there are no established criteria to determine which aspects are most beneficial. This study will determine which specific qualitative factors, such as the quality of the co-op placements, are most likely to augment self-efficacy in undergraduate engineering majors and will lead to recommendations about enhancing features of co-op and internship programs.

Determine the utility of a new construct, work self-efficacy, in measuring the effect of self-efficacy on retention. This study will include well-established measures of science, engineering, and technology (SET) academic and career self-efficacy. However, work self-efficacy represents a new construct that has potential value in examining the confidence that prospective graduates have in managing themselves in the workplace.

Collect longitudinal data on the pathways to self-efficacy and individual-tracked retention in engineering by following a cohort over three years. Most of the pivotal studies that established the relationship between self-efficacy and persistence were shorter in duration (e.g., Lent et al., 2003 studied persistence over three academic semesters; Lent, Brown, & Larkin, 1984, 1986, and Brown, Lent, & Larkin, 1989 studied persistence over one year). Other studies that measured self-efficacy and persistence over a longer period of time had comparable survey limitations. For example, Schaefers et al. (1997) measured women's persistence in engineering from college entry to their third, fourth, and fifth years, but measured self-efficacy only at the later point by asking students to provide retrospective responses about early college experiences. Farmer, Wardrop, Anderson, and Risinger (1995) tracked students from 1980 to 1990 but only measured self-efficacy at one point, in 1990. Although Nauta et al. (2003) obtained self-efficacy measures both in high school and three to five years later in college, they recommended assessments of additional variables to fully understand the pathways. In short, the proposed research will help address Schaefers' recommendation that more longitudinal studies be conducted that include antecedent measures to persistence in order to better address issues of causality (Schaefers et al., 1997).

3.0 Theoretical Basis for Research Questions

The proposed study draws on research from cooperative education and self-efficacy theory. U.S. colleges and universities are placing growing emphasis on experiential programs that allow students to gain work experience and thereby define success by more than just academic learning. These programs comprise such formal activities as co-op jobs, internships, apprenticeships, service learning, and others that integrate experience in the world with experience in the classroom. These approaches are becoming increasingly relevant in a work culture characterized by the need to continuously reflect and learn from ongoing experience (Raelin, 2008). They help students transition into full-time work more easily, helping them overcome the “reality shock” attributed to first job experiences for uninitiated novices (Raelin, 1980; Wanous, Poland, Premack, & Davis, 1992; Elfering et al., 2007).

A 1998 co-op census found that approximately 250,000 U.S. students were placed in co-op jobs that year (Pettit, 1998). A survey in 2001 of 1,830 college members of the National Association of Colleges and Employers (NACE) found that the vast majority (93%) of the institutions offered internship opportunities (Gold, 2001), and in 2006, the career publisher Vault.com reported in its third Internship Survey that 62% of undergraduate students completed an internship that year (Vault.com, 2006).

Cooperative Education Research: In terms of outcomes studies regarding co-op, the majority of research was conducted in the 1970s and 1980s due to the influx of federal funding to cooperative education. There has been only modest research since that time. Studies can be divided into five outcome categories: career development, academic benefits, initial employment, economic benefits, and personal growth, most of which include student populations from a variety of undergraduate majors.

Career Development: Co-op students (Weinstein, 1980) evinced greater certainty about career choice compared to students who did not participate in a co-op experience. Co-op students were more informed about career opportunities (Brown, 1976), made more informed career decisions (Wilson, 1974), had higher expectations about job outcomes (Sharma, Mannell, & Rowe, 1995), and had a greater recognition of their own abilities, limitations, and interests (Wilson, 1974).

Academic Benefits: Early work showed that co-op has a beneficial influence on academic achievement and persistence to graduation (Smith, 1965; Lindenmeyer, 1967; Davie & Russell, 1974; McNutt, 1974; Somers, 1986). Gardner, Nixon, and Motschenbacher (1992) found that co-op students had higher grade point averages than non-co-op students. Van Gyn, Cutt, Loken, & Ricks (1997) found that co-op students scored higher than non-co-ops on the College Outcomes Measure Program Exam, particularly in the Problem Solving and Functioning in Social Institutions subtests.

Initial Employment: Co-op graduates used more variety in their job-seeking approaches (Brown, 1976), were more likely to have first jobs related to their major and overall career plans (Brown, 1984), and were more likely to hold positions with higher levels of responsibility (Gore, 1972a; Brown, 1976). Later work pointed out that co-ops took less time to find their first job, were less likely to feel underemployed, received more job advancements, had more realistic expectations, and were more satisfied with their potential to further advance in their field (Brown, 1985; Mann & Schlueter, 1985; Pittenger, 1993; Wessels & Pumphrey, 1995). Other studies found that co-op students were more likely to show evidence of early socialization and successful adjustment to a company (Brown, 1984; Gardner & Koslowski, 1998). Specifically, they were more self-reliant in learning about the organization and work groups, and they rated their knowledge of task and role more highly than non-co-ops (Gardner & Koslowski, 1998).

Economic Benefits: Co-op students, compared to non-co-op students, received higher salaries (Gore, 1972b; Brown, 1976; Edison, 1981; Rogers & Weston, 1987; Gardner, et al., 1992), received more frequent raises and promotions, and experienced lower turnover (Jarrell, 1974; Little, 1974; Frankel, Cohen, & Deane, 1977). Subsequent studies confirmed these effects and pointed out that they persisted

over time (Edison, 1981; Gillin, Davie, & Beissel, 1984). Other studies found inconsistent or non-significant salary differences (Jagacinski, Lebold, Linden, & Shell, 1986; Rowe, 1992; Somers, 1995).

Personal Growth: Studies of personal growth and development reported that a co-op experience contributes to increased self-confidence, higher self-concept, and enhanced career identity (Cornelius, 1978; Ducat, 1978; Weston, 1986); an increase in autonomy and independence (Wilson, 1974); the development of social maturity and interpersonal skills, such as tolerance, understanding, and the ability to express thoughts and feelings (Marks & Wohlford, 1971; Wilson, 1974; Morton, Dawson, & Laing, 1993); and the development of practical intelligence and tacit knowledge (Williams, Sternberg, Rashotte, & Wagner, 1997).

Although the aforementioned suggest a substantial body of co-op literature, most research is limited to reporting outcomes (Parks, Onwuegbuzie, and Cash, 2001). Few studies have related outcomes to processes or have examined the characteristics of co-op experiences thought to influence favorable outcomes. For example, it is not known how long it takes for these programs to take effect, although one study found that co-op experiences lasting as little as five months can produce a demonstrable effect (Williams et al., 1997). There is a dearth of literature and theory to explain what happens during the co-op experience that produces beneficial outcomes, leading some researchers to refer to this as the “black box” of co-op (Ricks, Cutt, Branton, Loken, & Van Gyn, 1993).

Self-Efficacy Research: One promising avenue that can be used to tie practice-oriented processes to outcomes is Bandura’s concept of self-efficacy (Eames, 2004). Self-efficacy is an individual’s perceived level of competence or degree to which an individual believes she is capable of completing a task. Self-efficacy is a dynamic 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. Bandura (1986) identified four sources of information that shape self-efficacy: (1) performance accomplishments, (2) vicarious experience, (3) verbal persuasion, and (4) physiological and affective states.

Fletcher (1990) provided a theoretical framework to explain how co-op experiences enhance self-efficacy and help students make the transition from student to practitioner. Fletcher suggested that co-op increases self-efficacy through performance accomplishments, one source of efficacy information. Performance accomplishments could be co-op experiences where individuals use skills, abilities, and coping strategies to perform tasks. Successful experiences can result in a feedback loop where performance accomplishments lead to increased self-efficacy, which, in turn, enhance a person’s subsequent performance, further strengthening self-efficacy beliefs. The possibility that co-op 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 (Bandura, 1986; Lent, Brown, & Hackett, 1994). However, workplace experience also exposes students to successful peer models, mentor figures, and verbal encouragement that can provide self-efficacy information through two of Bandura’s other sources: vicarious experiences and verbal persuasion.

Hackett and Betz (1981) were the first to use self-efficacy to explain the career development of women, especially in male-dominated career domains (Hackett, Lent, & Greenhaus, 1991). They found that societal factors created gender differences in gaining access to primary sources of self-efficacy information. For example, women are thought to have fewer performance opportunities relative to pursuits in male-dominated careers; gain less exposure to role models; receive less encouragement for career pursuits; and experience higher internal physiological responses (e.g., anxiety) that decrease perceptions of self-efficacy (Hackett & Betz 1981). Empirical studies pointed out that college-aged women’s self-efficacy for traditionally female occupations was significantly higher than within nontraditional fields (Betz & Hackett, 1981; Wheeler, 1983; Post-Kammer & Smith, 1985). Nevertheless, when exposed to positive experiences in what is known as Holland’s (1997) career theme of

“realistic” learning experiences, which includes engineering, young women were reported to enhance their self-efficacy (Tokar, Thompson, Plaufcan, & Williams, 2007).

Robert Lent and his associates expanded 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” (Lent et al., 2002, 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 disadvantages from being underrepresented in particular occupations (Blustein, McWhirter, & Perry, 2005).

While this study’s pathways model (Figure 1) bears some resemblance to Lent’s theoretical SCCT model (Lent et al., 2003), they used outcome expectations and interests as additional cognitive-person variables (Lent et al., 1994). The research team will concentrate on self-efficacy since efficacy beliefs are seen as the most central and pervasive mechanism of personal agency (Bandura, 1989).

Focusing on gender, a number of studies confirmed that self-efficacy beliefs predict retention in science and engineering majors for both male and female students (Lent et al., 1984; Lent et al., 1986), with one study suggesting that women may be more strongly influenced than men by self-efficacy (Post-Kammer & Smith, 1985). Longitudinal studies of engineering women’s levels of self-esteem provide related evidence of the importance of self-worth on retention. Women who switch out of science and engineering undergraduate programs tend to lose self-esteem through the course of study (Brainard & Carlin, 1998), citing discouragement and loss of confidence (Seymour & Hewitt, 1997). Preliminary evidence further shows that women experience a loss of self-efficacy as they proceed through engineering curricula (Marra et al., 2005). Taken together, these results suggest that co-op experiences could be considered a support that strengthens self-efficacy beliefs, especially among women, resulting in increased retention in engineering programs.

Other than Lent’s work on contextual factors, there is limited research on interventions that may lead to increased self-efficacy. In theoretical pieces, Betz (1992) and Brown and Lent (1996) 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, a three-day problem-based camp experience was found to increase students’ self-efficacy for specific tasks as well as their general self-efficacy (Speight and Rosenthal, 1995). Hutchison, Follman, Sumpter, & Bodner (2006) recently reported a relationship between academic and advisory support and female students’ academic self-efficacy.

The NSF Program for Gender Equity has funded an array of projects that explore methods to improve the recruitment and retention rates of women in SET. This research has led to a number of best practices in formal and informal settings as well as to curricular reform (NSF, 2003). A number of previously funded NSF- supported research projects use self-efficacy as an outcome variable to evaluate programs. For example, a funded project in the VT Biology Department (HRD0332843) identified cultures that alienate women and correlated measurements of self-efficacy with science, education, and career persistence. Another study (HRD0120786) used mentoring and all-female research teams to increase the self-efficacy of women in science and engineering majors. New York University and University of Oregon Eugene (HRD0332898) are developing a guided web-based simulation game to teach middle school girls programming languages to increase their self-efficacy levels in a software environment.

The Pathways Project will be the first to bridge research in co-op and research in self-efficacy. It uniquely contributes to existing knowledge in both fields by: 1) bringing a theory-based empirical approach to the problem of retaining women in engineering, 2) testing an innovative model that is based

on self-efficacy and includes co-op and internships as well as other contextual supports, 3) supplying longitudinal data on an underrepresented group, and 4) identifying programmatic conditions (including qualities of co-op and internship experiences) that enhance self-efficacy and retention.

4.0 Study Population and School Profiles

The study population will include undergraduate women and a random subset of men at four engineering colleges: Northeastern University (NU), Rochester Institute of Technology (RIT), Virginia Polytechnic Institute & State University (VT), and the University of Wyoming (UW). These four schools are prominent in advancing women in engineering programs nationally. NU is among the first fifteen schools to establish a formal Women in Engineering program. In 2005, VT ranked 5th in engineering enrollment, 15th in the number of BS degrees awarded to women, 18th in BS degrees awarded to African-American students, and 7th in total number of BS degrees awarded in engineering. RIT is home to the first engineering college named after a woman, the Kate Gleason College of Engineering. UW is one of the nine universities participating in the Hewlett Foundation Engineering Schools of the West Initiative, focusing upon recruiting, retention, and quality of undergraduate education, with programs targeted at enhancing the enrollment of underrepresented populations in engineering disciplines. NU and RIT require co-op experiences in engineering, whereas VT and UW do not, allowing the research team to test for differences on the basis of formal work experiences. The schools' study populations and work experience programs are profiled in Table 1. The project co-PIs from each of the partnering schools will be responsible for reaching the target populations and for tracking individual student academic and retention data (See Section 5.0, Tasks 3 and 4).

Table 1. Profile data for partner schools (engineering only)

Data from 2007	# undergrad engineering students	% female	Length of program. Co-op & internship participation
Northeastern University	1957	18%	5 yr. program. All engineering students participate in co-op.
RIT	2010	12%	5 yr. program. All engineering students participate in co-op.
Virginia Tech	5778	15%	4 yr. program. Voluntary co-op and internship programs.
University of Wyoming	1157	15%	4 yr. program. Voluntary co-op and internship programs.

5.0 Research Methods and Tasks

The conceptual framework of this study will be implemented through a full empirical analysis (see detailed model in Figure 2). In order to determine whether formal programs that introduce students to engineering practices while enrolled or other contextual supports can enhance women's self-efficacy beliefs and increase their persistence rates in undergraduate engineering programs, a set of concrete and inter-related tasks detailed below (see timeline Table 2) will be implemented by the cross-institutional research team.

Task 1. Develop a set of measures for the study. The empirical model depicted in Figure 2 will be operationalized primarily by the development of a major student survey using perceptual measures and responses from new or established scales. Demographic data, such as prior high school and current GPA, SAT scores, and race and ethnicity, will be electronically coded from the student records. Through the use of a temporary identification number and a tracking system, pre and post student surveys will be aligned with demographic and retention data for the study participants. Retention data, as discussed below, will be verified using the student record. Each university partner will work with their respective institutional

research offices to remove all evidence of student identity by assigning temporary IDs and maintaining the list that links actual student IDs with temporary numbers to protect confidentiality.

The construction of the measures will proceed as follows:

Retention: Consistent or “clean” data regarding women’s retention rates at the participating colleges will be obtained. Prior studies suggest that women are significantly less likely than men to complete engineering bachelor’s programs, with one finding that 42% of enrolled women completed engineering, engineering technology, and architecture degrees compared to 62% of men (Adelman, 1998). Recent studies show that women may be closing the retention rate gap in engineering (Chubin & Babco, 2003; Campbell et al., 2005). Adleman reported a mere four percent gap in persistence to graduation in 2003 (Adelman, Daniel, & Berkovits, 2003). Institutional rates are often calculated differently, however, depending on whether transfer students are counted and which majors are clustered. This study will establish a uniform policy among the sample schools of using student-by-student tracking rather than aggregating institutional data in order to produce accurate retention figures. Transfer students will not be included in the study and retention data will be determined in the student’s fourth year of study.

Work Self-Efficacy: A recently validated inventory of work self-efficacy will be used (Raelin et al., 2005). The inventory is composed of seven subscales and measures new or prospective workers’ confidence in managing workplace experiences. It is proposed that formal work experiences while enrolled, in particular co-ops and internships, benefit students not so much because of the technical skills they have learned but because of the practical and social skills that enhance their ability and confidence to manage themselves in the work environment. In the pilot study of workplace learning (Raelin, Reisberg, Whitman, & Hamann, 2007), work self-efficacy achieved a reliability of .95 (measured by Cronbach’s Alpha coefficient of internal consistency).

Academic Self-Efficacy: Although a major contribution of this study is the introduction of a work self-efficacy measure to the field, the literature advises consideration of other forms of self-efficacy. In the Pathways Project, it is critical to incorporate academic self-efficacy since as a construct it may vie with work self-efficacy as a basis for women’s retention. The measures to be employed derive from two sources: the Self-Efficacy for Academic Milestones scale (Lent, Brown, & Larkin, 1986), which was derived from the Self-Efficacy for Technical/Scientific Fields (SETSF) survey (Lent, Brown, & Larkin, 1984) and two of the Engineering Self-Efficacy scales validated in the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) developed by the Assessing Women in Engineering program (AWE, 2007). The pilot study of workplace learning resulted in a strong reliability ($\alpha = .92$) of this academic self-efficacy scale.

Career Self-Efficacy: The literature firmly established the relationship between career self-efficacy, particularly as it relates to occupational decision-making, and women’s persistence in their chosen careers. The well-established career decision making self-efficacy scale will be used from the short-form developed by Betz, Klein, & Taylor (1996).

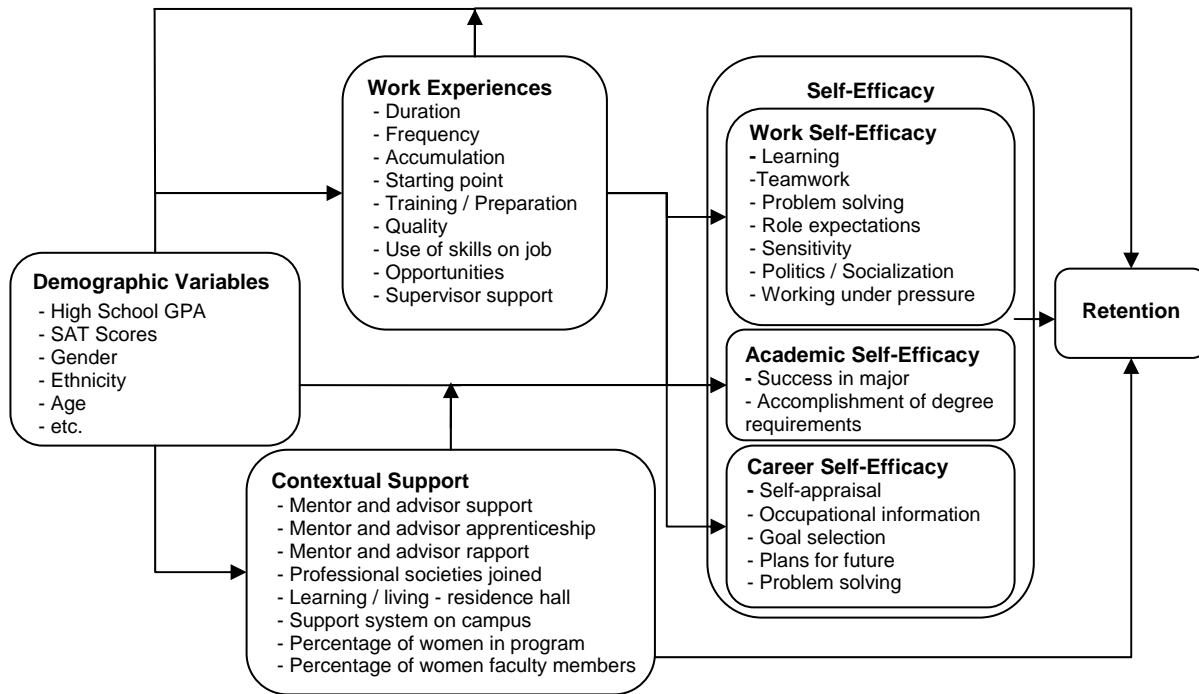


Figure 2: The Full Empirical Model of Pathways

Work Experience: A key discriminator of retention may be the presence of formal undergraduate co-op and internships programs. These experiences are referred to as work experiences in the Pathways Project. Two of the sample schools are co-op schools. In the third and fourth schools, although some students participate in internships and co-op, the majority do not participate in any formal programs. The non-co-op students will be asked about other work experiences, such as summer or part-time employment, both within and outside their major, to determine if such work experiences may compensate for the lack of formal co-ops and internships.

While some students in engineering programs may supplement their coursework by pursuing part-time or summer employment, or even by volunteering, a critical hypothesis of this study is that it is the intentionality and formality of experiential education that distinguishes it from individualistic work experiences. This study asserts that higher levels of self-efficacy and retention are produced because of the formal structure of work experience programs that intentionally link theory with work experiences and asks students, in turn, to use their practice to inform theory.

The research team will differentiate features of co-op programs that may lead to different degrees of outcome effectiveness, as indicated both by the inculcation of self-efficacy beliefs and by retention rates. The study will measure effects not only from administrative differences, such as length (three-month or six-month co-ops), timing (some start in the second year; others in the third year), or accumulation (the incremental benefit of additional co-ops beyond the first one), but also from differences in quality. Quality measures will be based on the work of Fogg and Putnam (2004) and Highsmith, Denes, & Pierre (1998) and will 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 a team of professionals. There has been widespread debate in the co-op literature whether internships, which tend to be shorter and which often have a looser relationship to real-world employment conditions, produce the same level of benefit as co-ops. This study will be able to compare the value of co-ops and internships in terms of their relative contribution to efficacy and to retention.

Contextual Support: Contextual support (Lent et al., 2003) consists of alternative explanations (other than co-ops and internships) that may increase women's self-efficacy and retention. For example, it may be that the sheer percentage of women present in engineering programs, compared to men, predict their acclimation and ultimate retention. Many undergraduate programs offer traditionally underrepresented students a variety of support systems, such as access to mentors and role models, to help them with the transition to college life. In this study, two scales will be included to detect the support, rapport, and apprenticeship from both mentors and advisors. The first will be derived from the support measure in the Lent et al. (2001) model of social cognitive career theory. The second instrument will be constructed from the Advisory Working Alliance Inventory (AWAI) (Schlosser and Gelso, 2001). The existence of support is hypothesized to account for women's retention rates and may moderate the proposed value of formal work experience.

Demographic Variables: Demographic variables are incorporated because contextual conditions may not be sufficient in explaining efficacy attitudes or retention outcomes. Pre-existing demographic conditions may be just as powerful in a prospective explanatory model, though these variables are not always controllable by the student or by the school. The study will examine to what extent factors such as prior school performance (e.g., GPA and SAT scores), socioeconomic status, ethnicity, or gender account for collegiate outcomes, in particular retention, independent of formal work experiences or of other contextual supports. These data will be obtained through self-reports and the student's record.

The universities participating in this study are of different sizes and are split in terms of public vs. private affiliation. The study will ascertain whether these differences account for any changes in the principal study variables of efficacy and retention. The team will systematically determine whether there are demographic differences in the samples (rather than presume that there are) and analyze whether these differences create effects independent of work experience and contextual supports. Measures of self-efficacy will be assessed at an early stage prior to the students' having any formal work experience. The study team believes that the work and career efficacy measures, in particular, may tap any pre-existing conditions that may discriminate the co-op vs. the non-co-op samples.

Task 2. Convert the measures into record searches and survey forms. The team will assemble data from student records and from carefully constructed surveys administered to students from the four university engineering programs, to be conducted at three different points in time (see Task 4). The survey questions will be arrayed in a random and interesting manner onto a single questionnaire.

Task 3. Assemble participants from each of the four schools. The sample will first include all female sophomore engineering majors at the participating universities. Assuming a 75% response rate, it is expected that 303 female sophomore engineering majors will participate in the study. Male sophomore engineering majors will be identified using differential probability weights so that the entire sample will include a roughly equal number of males and females at each university. This sampling plan is expected to produce a samples size of 606. Using the procedures outlined by MacCallum, Browne, and Sugawara (1996), it was determined that a sample size of at least 435 is necessary to obtain the conventional level of statistical power (.80).

All students included from NU and RIT participate in co-op. The VT and UW samples serve as comparison groups on the variable of co-op participation since only small percentages of students participate in co-ops. However, as noted in Task 1, the study will gather information on students from these schools who may have participated in what is referred to as "informal" work experiences not necessarily connected to one's major, such as summer jobs or part-time employment. Once the samples are assembled, a formal tracking system will be established to ensure reliable follow-up of all students in a given cohort.

Task 4. Administer survey and gather data. Each of the participating schools will assemble the data using identical survey forms and record searches. Surveys will be administered through the auspices of the respective co-PI who will ensure that data collection procedures produce both robust and valid

responses. In order to assess change in work, career, and academic self-efficacy and other contextual and descriptive properties, data will be collected from each survey participant at three time points: prior to and immediately after the first co-op experience and one year later. Non-co-op school data collection will proceed at comparable points. In order to achieve desired response rates at each partnering institution, various scenarios are developed including incentives and survey administration during class time in cooperation with faculty who will be fully apprised of the nature of the Pathways Project. The NU Center for Work and Learning will handle and analyze all data and will manage the process in strict confidentiality. The Center is not affiliated with any engineering students. All surveys designed for student administration will be submitted to each school's Institutional Review Board for review and approval.

As noted earlier, a pilot study of self-efficacy, funded by the Hewlett Foundation, NU and UW administered a survey to differentiate and validate the efficacy measures and their respective relationships to students' work experiences while enrolled (Raelin, et al. 2007). The procedures used in this proposal will be similar. In the study, the 80-question survey took the respondents about fifteen minutes to complete. The survey contemplated in the Pathways Project should be 20% longer.

Task 5. Perform statistical analysis. Once the data from all the schools are assembled, they will be submitted to full-scale statistical analysis. Prior to running any linear treatments, all measures will be assessed and "cleaned," in the event that there are any anomalies, such as missing values or incomplete data. A multiple regression analysis will be conducted to test the predictive power of work, career, and academic self-efficacy on the retention of women in undergraduate engineering programs, controlling for work experience, contextual support, and demographic variables.

Hierarchical regression will be used to test the principal hypothesis regarding the main effect of work, career, and academic self-efficacy on retention. Through this regression equation, contextual variables that may not only affect efficacy but may also directly affect retention will be addressed in a step-wise fashion. Finally, demographic control variables will be introduced to see if the predictive power of efficacy is retained as the variance of retention becomes partitioned.

Task 6. Refine the study's model and test it using path analysis. A path analysis, computed through a structural equation modeling program, will be developed to fully understand how retention operates. Using a structural modeling package, the study will determine how the surviving predictor variables from the clusters - work self-efficacy, career self-efficacy, academic self-efficacy, work experiences, contextual support, and demographic variable controls - interact in explaining the optimal pathway to retention. The study will discern whether some variables indirectly affect retention through efficacy or whether they have direct or other interactive effects. The path analysis will also confirm whether covariance paths exist among the contextual support variables and work experiences and whether the demographic variables directly affect efficacy and retention or whether they initially interact with the contextual factors.

Task 7. Disseminate findings. The Pathways Project results will be compared to findings from other studies about retention of women in undergraduate engineering programs, cooperative education, self-efficacy, and social cognitive career theory. The findings, taken together, will be analyzed to compile a comprehensive report as well as secondary reports pertaining to each of the fields represented above.

6.0 Project Personnel

The research team consists of a highly committed and engaged group of individuals from each of the four partnering schools and an influential advisory board to guide the project from its design to completion.

Rachelle Reisberg (NU) is the principal investigator (PI). She is the Director of Northeastern University's Women in Engineering program and Associate Director of Connections, a program to strengthen the pathways for women to pursue careers in engineering and science. She was responsible for the institutionalization phase of Connections, which entails the delivery of middle / high school outreach programs as well as college level programs, such as academic support, residential life programs, work study opportunities, career management classes, and scholarships for women studying engineering. She brings extensive management experience from industry including running a profitable startup company. Reisberg will coordinate project's multiple tasks including data collection, data analysis, and project dissemination.

Margaret Bailey (RIT) led efforts to promote gender diversity within engineering since 1998 when she began her academic career as an Assistant Professor at the U. S. Military Academy at West Point, being the first woman civilian faculty member in her department. In 2003, Bailey accepted the first Kate Gleason Chair position at RIT and has since created and led the development of WE@RIT Women Engineering the Future program. WE@RIT includes a comprehensive series of outreach, recruitment, and retention initiatives with a unifying goal of expanding the pipeline of women pursuing studies and careers within engineering. She maintains a research program in the area of advanced thermodynamic analyses and health monitoring of energy intensive systems and half of her research mentees have been women. Bailey will participate in research data collection and project dissemination activities.

Carol J. Burger (VT) has been interested in gender equity issues in science, engineering, and technology for many years. She is the founder and editor-in-chief of the *Journal of Women and Minorities in Science and Engineering*, which is now in its 13th year of publication. She served as Senior Program Director, Program for Women and Girls, Human Resource Development Division, Education and Human Resources Directorate, National Science Foundation in 1996. She teaches Introduction to Women's Studies, and developed and teaches Biology of Women and Women and Science courses. She has co-authored a number of books and is the co-editor of *Reconfiguring the Firewall: Recruiting Women to Information Technology across Cultures and Continents* (published May, 2007). Burger is co-PI on two recent NSF-funded projects focusing on women in engineering and technology and in this study will coordinate data collection efforts at VT.

Jerry Hamann (UW) is currently the director of the Hewlett Foundation Engineering Schools of the West Initiative at the University of Wyoming. He is tasked with developing and sustaining programs that are focused upon recruitment and retention of undergraduate students in engineering. He has worked extensively with programs that bring K-12 educators together with university and community college faculty to provide applied math and science investigations within the K-12 curriculum base. Jerry maintains research programs in applied signal processing, robotics and control, as well as communication networks and instrumentation. He has authored five book chapters, 20 refereed journal articles, and 45 conference manuscripts. He will coordinate data collection efforts at UW.

Joe Raelin (NU) brings a 35-year career on human resource scholarship to the "Pathways" proposal. Raelin is also the director of the Center for Work and Learning, His background is commensurate with the social science domain of the Pathways Project. A Ph.D. in policy studies from the State University of New York at Buffalo, Raelin received his formal training as an employment researcher. Since then, he has produced some 100 journal publications. His first of seven books was the frame-breaking *Building A Career*, an Upjohn Institute-sponsored analysis of the effect of first job experiences on subsequent employment and one of the first volumes to use path analysis to identify career patterns among young men and women. He will have direct oversight of the design of the survey methodology that will provide the principal data for the study and will supervise the statistical analysis of the data.

Sara Wadia-Fascetti (NU) has been involved with women in engineering programs since her first years as an Assistant Professor in 1994. Wadia-Fascetti created and led the development of the Connections program to strengthen the pathways for women to pursue careers in engineering and science. She

maintains a research program in the area of sensing and diagnostics of civil infrastructure systems and half of her research mentees have been women. Wadia-Fascetti received the 2002 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring for leadership in individual mentoring of women and the development of programs that fosters career development. She will coordinate data collection at NU with Reisberg and participate in project dissemination activities.

David Whitman (UW) has been involved, as both a faculty member and a former Associate Dean, in many activities that are associated with recruitment and retention of engineering undergraduates – especially women. Some of these projects include the formation of Power Groups (a blocked schedule for incoming freshmen to promote the development of study groups), two floors in the residence halls that are specifically for engineering majors (including 25% women), and working with the Middle School Girls Camp in the summer. Whitman will coordinate data collection efforts at UW in conjunction with Hamann.

Nicholas Vasilopoulos is an Associate Professor and Director of the I/O Psychology Doctoral Program in the Departments of Organizational Sciences and Communication and of Psychology at George Washington University. He will work closely with Raelin to perform the statistical analysis of the data.

Advisory Board: An Advisory Board, composed of the Project Team and outstanding engineering educators and administrators who develop and conduct policy initiatives, programs, and research on issues important to women and university faculty with research interests in gender and engineering issues, will assist the Project Team with planning and implementation of the project components. The advisors will review and assist in developing the survey instrument, and they will help identify outlets for the dissemination of the research findings.

Members include:

- Daryl E. Chubin, Director, Center for Advancing Science & Engineering Capacity, American Association for the Advancement of Science (AAAS);
- Emanuel Contomanolis, Associate Vice President & Director of Co-op & Career Services, RIT;
- Lesley K. Pendleton, Director, Undergraduate Student Affairs, The Bradley Department of Electrical and Computer Engineering, VT;
- Kathrin S. Zippel, Assistant Professor, Sociology and Anthropology / Women Studies, NU;

7. Project Plan and Time Line

This project will be implemented over a 3-year period (Table 2).

Table 2. Schedule and tasks.

Task	Year 1			Year 2			Year 3			
	Fall 2008	Spr 2009	Sum 2009	Fall 2009	Spr 2010	Sum 2010	Fall 2010	Spr 2011	Sum 2011	
1. Develop set of measures for the study	[Solid Grey]									
2. Convert measures to record searches	[Solid Grey]									
Convert measures to survey forms	[Solid Grey]									
3. Identify samples from each of four schools	[Vertical Stripes]									
4. Administer survey ¹	[Vertical Stripes]	[Vertical Stripes]		[Vertical Stripes]	[Vertical Stripes]		[Vertical Stripes]	[Vertical Stripes]		
Gather demographic data from student records		[Vertical Stripes]	[Vertical Stripes]	[Vertical Stripes]						
Gather retention data from students records			[Vertical Stripes]	[Vertical Stripes]		[Vertical Stripes]	[Vertical Stripes]	[Vertical Stripes]		
5. Submit data to statistical analysis		[Solid Grey]	[Solid Grey]		[Solid Grey]	[Solid Grey]		[Solid Grey]	[Solid Grey]	
6. Refine study model & fit using path analysis					[Solid Grey]	[Solid Grey]		[Solid Grey]	[Solid Grey]	
7. Prepare reports for dissemination				P				[Diagonal Stripes]	[Diagonal Stripes]	
Participate in conferences, workshops, etc.						P		[Diagonal Stripes]	[Diagonal Stripes]	
Develop & maintain website	[Diagonal Stripes]			[Diagonal Stripes]			[Diagonal Stripes]	[Diagonal Stripes]	[Diagonal Stripes]	
Advisory Board Meetings	T	T	F	T	T	F	T	T	F	
Team Meetings	T	T	T	F	T	T	F	T	T	F

P=preliminary; T=teleconference; F=face-to-face meeting

¹ Survey administration points will vary slightly by school.

Responsibility Key:

[Diagonal Stripes]	Center for Work and Learning and Four Colleges	[Vertical Stripes]	Four Colleges of Engineering	[Solid Grey]	Center for Work and Learning
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8. Dissemination

The results of the Pathways Project will be of interest to scholars in a variety of disciplinary fields, including: engineering education, social cognitive psychology, career development, and women's studies. Project findings will be disseminated to two primary audiences: researcher and practitioner. Research findings will be published in reports from the Center for Work and Learning, presented at conferences – such as those sponsored by the American Association of Colleges and Universities and the American Association of Higher Education, and sent to journals for peer review. Candidate journals include: *Journal of Women and Minorities in Science and Engineering*, *American Behavioral Scientist*, *Journal of Vocational Behavior*, *Social Science Quarterly*, *Career Development Quarterly*, and *Journal of Career Assessment*. The practitioner audience, which includes engineering educators, advisors, and administrators, will be targeted through publications in the peer-reviewed *Journal of Engineering Education* and *Science Education*, as well as through presentation at professional conferences, in particular those sponsored by: American Society of Engineering Education, Women in Engineering Programs Advocate's Network (WEPAN), World Association of Cooperative Education, and the Society of Women Engineers. A website (linked to professional organization web pages) will be established to provide information and updates about the study along with references related to this topic. Workshops will be given at each of the collaborating colleges and at national conferences to present and discuss results of this research. The workshops will be targeted to Women in Engineering program directors as well as to administrators who are considering offering or expanding ongoing programs in experiential education. Finally, workshops will be offered to co-op and internship employers to present them with findings targeted at enriching work experiences for all students, but in particular, to improve the

experiences of female students. Workshops will involve university faculty/staff and professionals from human resource departments, especially recruiting and advising staff, and from senior management.

9. Broader Impacts

The Pathways Project research seeks to answer questions related to the impact of work experiences on the likelihood of women's graduation from undergraduate engineering programs. In addition to the contributions to research in the fields of psychology, social cognitive career theory, and cooperative education, the Pathways Project has a number of broader impacts with national implications: (1) The research results will, for the first time, provide engineering colleges with data-supported measures of the effectiveness of different program supports, including the familiar formal work experience programs (co-ops and internships), women in engineering offices, mentorships, and advising programs. By clinically tracking the effectiveness of these contextual supports over time, the study will make it possible for engineering colleges to emphasize programs that work. (2) The use of cleaned retention data will create a consistent means for comparison across the partnering schools, and since they represent a significant percentage of engineering cooperative education in the U. S., the new retention data may define a new standard. (3) The prominent role of self-efficacy in this study will help to determine if it merits inclusion as one of the most critical explanations of academic outcomes; in this case, the outcome of retention among women engineering undergraduates. (4) This project would be the first to introduce the newly validated measure of work self-efficacy, which once made available through this research, could impact future national studies involving learning outcomes from work experience. (5) Findings from the Pathways Project has the potential to become a standard that can be replicated with other populations (such as multicultural or underrepresented students) or majors (such as the physical sciences).

10. Results from Past NSF-Funded Research

HRD-0120458 - Women in Information Technology: Pivotal Transitions from School to Career.

Carol Burger, PI, Elizabeth Creamer, co-PI, and Peggy Meszaros, co-PI. Since 2001, this research group has developed and administered the Career Decision Making Questionnaire to a diverse sample of male and female high school, college, and community college students (N=1292). Using the theoretical framework of self-authorship, a causal statistical model has been developed that is robust because it predicts a significant percentage of the variance (33%) of women's interest in information technology. Interview data from high school students and parents and college women informed the theoretical grounding of the model, particularly by isolating the factors associated with the decision-making process such as parental support. The diversity of respondents (almost 40% are non-white), the capturing of low-income rural populations, and the inclusion of men has contributed to the robustness of this statistical model. The products of this research include an international conference, an edited book *Reconfiguring the Firewall: Recruiting Women to Information Technology across Cultures and Continents*, published in May 2007, a DVD and Facilitator's Guide titled *The Power of Partners: Helping Females Find Their Way to High Tech Careers*, and numerous peer-reviewed papers, workshops, and presentations at international and domestic conferences.