I THINK I CAN, I THINK I CAN . . . . . I KNOW I CAN'T: SELF-EFFICACY AND ITS RELATIONSHIP TO ATTRITION/PERSISTENCE IN SCIENCE, COMPUTER SCIENCE AND MATHEMATICS PROGRAMS

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This proposal examines the relationships between self-efficacy and persistence of students enrolled in science, computer science (as a technology-based program of study), and mathematics programs (STM) in a Midwestern university. It also examines gender differences between persisters and non-persisters as to self-efficacy levels, academic performance, attrition/persistence, and contributing factors related to self-efficacy.

A review of related research was found to be somewhat contradictory and inadequate in examining the relationship between academic self-efficacy and student persistence in college STM programs.

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I dedicate this dissertation to my mother and father, Marilyn and Major Drake, who unfortunately passed away without knowing of my efforts involved with this research. I am hopeful that they would be immensely proud of me.

J.K.D.G.

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CHAPTER I

INTRODUCTION

"I think I can, I think I can, I think I can" – the theme from the children's book, *The Little Engine That Could* by W. Piper (1930), provides an excellent metaphor for examining the reason why some students persist in their college careers, especially in science, technology, engineering, and mathematics (STEM) programs while others drop out or switch majors. Similar themes have emerged throughout history including writings from the ancient Roman poet Virgil "they are able who think they are able" (Pajares, 2002). One of the factors at work in determining students' persistence throughout college careers is this "I can" attitude, hereafter referred to as student self-efficacy. This proposed study seeks to: a) examine differences between students' general and academic self-efficacy; and b) discover how having high levels of self-efficacy in the science-related academic areas influences students' selection of and persistence in science, technology, and mathematics program (STM) majors. (*Note*: this proposed study will not include any engineering students as the institution where this study is being conducted has no engineering programs. However, research quoted in this proposal does include engineering.) Thus, this research will reveal the role that students' academic self-efficacy beliefs have on performance and persistence in science-related areas.

Problem Statement

Despite decades of research to identify factors influencing a "pipeline leakage" in collegiate mathematics and sciences programs, there remains a shortage of students, especially women, who persist in pursuing math and science careers. In the last 20 years, research in this area has included efforts to link self-efficacy with academic achievement and persistence/attrition, especially attrition rates in these programs. Examining why gender differences occur in mathematics and science interest, aptitude, self-efficacy, and persistence has focused on obstacles both within students themselves and the external factors of the social-cultural ethos limiting women's opportunities in mathematics and sciences.

Self-efficacy beliefs, the "I think I can" attitude which enables students to perform tasks that they believe they can successfully accomplish, is a factor that does exert an influence on choices of majors and careers for many students, and in many cases to a greater degree than any other factor, including interest (Pajares, 2002). Brown, Lent & Larkin (1986, 1989) as well as Betz and Hackett (1983) found that self-efficacy has a predictive power over career options as well as academic grades and persistence (Lent, Brown & Larkin (1984, 1986, 1987).

Women and men have differing levels of self-efficacy, their "I think I can" attitudes. This difference, especially prominent in mathematics and science, begins in the middle school years (Wilson, 2003). Thus, the problem of lack of persistence in college STM programs traces its roots to middle and high school science and mathematics experiences and the lowering of female self-efficacy beliefs, aptitude, and interest in these grades (Schunk and Pajares, 1997).

As self-efficacy plays a role in influencing student career choices as early as the pre-collegiate level (Pajares, 2002), research findings have been included to document such influence. Few studies exist at the collegiate level linking self-efficacy with academic performance and persistence in college, particularly in STEM programs.

According to Schunk and Pajares (1997) there is a need for more research to focus on the relationship of self-efficacy with student's activities, effort, and persistence as the interaction between these factors is quite complex. The level of complexity enters into Schunk's earlier study (1987) where no consistent links were found between self-efficacy and its relationship with persistence.

On the other hand Lent, Brown and Larkin (1984) found that for STEM college students, high levels of self-efficacy were found to be an influence on the academic persistence necessary to maintain high academic achievement. As the author is one of those statistics, a woman who changed majors from a science major to a secondary education major, and who has first-hand experience advising, tutoring, and mentoring science students, there is a first-person interest in this subject.

The problem of this study is: can self-efficacy be related to students' persistence in STM programs? This research will provide data and analysis to provide evidence, if such a link exists.

Purpose of the Study

The purpose of this study is to provide an examination of factors correlating with STM students' levels of academic self-efficacy and the relationship between these levels and persistence in STM programs including:

1. Student demographic factors related to self-efficacy.
2. Gender differences between levels of males' and females' levels of self-efficacy for persisters and non-persisters in STM programs.
3. Gender differences in self-efficacy beliefs/levels between males and females enrolled in specific STM programs.
4. Factors correlating with students' decisions to persist or drop/switch out of STM programs and differences, if any, between males and females.

Research Questions

As a result of the review of the literature, the overarching question addressed in this proposed study is: Is there a significant relationship between student academic self-efficacy and persistence in STM majors? Embedded in this over-arching question are sub-questions:

1. Is there a significant difference between male and female levels of self-efficacy in STM programs?
2. Is there a significant difference in self-efficacy across STM programs?
3. Is there a significant difference in self-efficacy levels for persisters and non-persisters?

4. Is there a significant difference in self-efficacy levels between males and females who persist in STM programs vs. non-persisters?

5. Is there a significant difference in the self-efficacy levels between males and females across the STM programs?

6. a) Do certain demographic factors correlate with self-efficacy levels and persistence in STM programs? b) Are there additional factors which research indicates should be considered in examining the relationship between self-efficacy and persistence?

Significance of Study

What is it that correlates with students' "I think I can" attitude changing to one of "I think I can't" or "I know I can't," leading to lowered levels of persistence in STEM majors? This loss of students has been a major concern to post-secondary institutions, scientific organizations and societies, and STEM related businesses and agencies for many years. Fewer professionals entering these areas combined with more demand for computer and science-related jobs have increased the demand for students graduating in these areas. With no end in sight to the exponential increase in demand for skilled professionals in these areas, concern about persistence/attrition in these majors remains high. This study has merit to colleges and universities seeking to uncover and explain this dilemma and the factors which compound it.

Definition of Terms

The following terms apply throughout this proposal:

- *Academic self–efficacy* refers to the belief that students have in their ability to successfully perform academic tasks such as writing papers, taking exams, etc. This is also referred to as subject-specific self-efficacy when used with specific content areas. (Bandura, 1997).
- *Pipeline leakage* refers to the loss of students in STEM programs beginning with the transition from high school to college by undergraduates switching into non STEM majors and by declining enrollments throughout graduate school. These losses are referred to as the "leakage" from the STEM pipeline (Seymour and Hewitt, 1997).
- *Self-efficacy (general)* refers to the belief that persons have in their ability to successfully perform certain tasks (Bandura, 1997).
- *STEM* and *SMET* refers to science, technology, engineering, and mathematics programs. SMET is used exclusively by Seymour and Hewitt. STEM is the more current use-age.
- *STM* refers to the science, technology, and mathematics programs that are the focus of this study, specifically science (biology, chemistry, and physics), mathematics, and computer sciences.
- *Persistence (or persisters)* refers to students remaining in the same STM program until completion of an undergraduate degree in such major.

- *Non-persisters* are students who either drop or switch out of a STM program before completion of an undergraduate degree in such a major.

Assumptions and Limitations

Limitations to this study include: 1) the lack of an engineering college or programs at the collection site, hence no data from engineering students will be obtained; 2) the single technology area to be assessed is computer science; and 3) the "point-in-time" nature of this study lacks longitudinal data.

Assumptions subsumed within this study include:

- Students have accurate perceptions of their self-efficacy levels as well as all demographic information and would honestly report this information.
- Students will have accurate perceptions regarding the causes for dropping/switching or persisting in STM programs.
- Measures of self-efficacy used in the *Motivated Learning Strategies Questionnaire* (MLSQ) are reliable and valid.
- Students who self-select entering STM programs at the college level may have higher self-efficacy levels than students who avoid STM programs.

Overview of Research Methods

This study used a combination of both qualitative and quantitative research methods. A representative sampling of junior and senior STM majors were emailed a questionnaire containing qualitative sections consisting of demographic items and factors correlating with self-efficacy levels. The questionnaire also consists of a quantitative section, a Likert Scale, which will ascertain students' levels of academic self-efficacy in

STM programs. These questions are from the *Motivated Learning Strategies Questionnaire* (MLSQ) developed by Pintrich et al. (1991) in which its original sub-scale of eight self-efficacy questions have been modified to specifically address STM programs. This questionnaire was selected because it is derived from the theoretical framework of all self-efficacy research, that of Social Cognitive Theory (Bandura, 1997). Further use of qualitative methods consists of a focus group who will be using a web-board to respond to questions. These questions will elicit in-depth responses related to academic experiences and factors contributing to students' decisions to persist in STM programs.

The representative sampling of junior and senior STM majors was obtained from lists provided by the Office of the Registrar consisting of the names, majors, and email addresses for: 1) junior and senior STM majors; 2) junior and senior non-STM majors who once were STM majors; and 3) one-time STM majors who have dropped from Illinois State University. The names/addresses provided from the lists were sorted as to persisters and non-persisters, by both genders, and program area.

Statistical analyses used in this study include:

- T-test for comparing gender differences for each STM program.
- ANOVA comparing self-efficacy across the three STM programs.
- T-tests for group comparisons of self-efficacy for gender and persistence.
- Pearson Product Moment Correlation to determine if self-efficacy significantly correlates with persistence in STM programs and if yes, does

it have the same significance for both males and females across STM programs.

- ANOVA (2x2) for group comparison of self-efficacy levels between males and females who are persisters vs. non-persisters in STM programs.
- ANOVA (2x3) for comparison by gender across STM programs for differences in self-efficacy levels.
- Partial Correlation for certain demographic variable correlations to self-efficacy and persistence in STM programs.
- Content analysis to determine if there are additional contributing factors which should be considered as associated with self-efficacy and persistence.
- Chronback Alpha and factor analysis to determine reliability and validity of the self-efficacy instrument.

CHAPTER II

REVIEW OF SIGNIFICANT RESEARCH

Organizational Overview

The literature review is organized to offer the reader a gestalt concerning the issue of persistence in STEM programs, how self-efficacy plays a role, as well as gender differences beginning with pre-collegiate through graduate school. This review of the literature provides an analysis as to: a) factors which correlate to differing levels of academic achievement in STEM courses as well as persistence in these programs; b) contributing factors which influence students' academic self-efficacy levels; c) evidence of the relationship between academic self-efficacy and persistence in STEM students; and d) evidence that supports gender differences, beginning in middle schools and continues through the collegiate years, affecting STEM program persistence.

This literature review examines research which focuses on the relationship between gender, academic success, and students' levels of academic self-efficacy in different STEM programs, including computer sciences in the field of technology. Students' academic and life experiences mediate their decision to persist or drop out of STEM programs. This review of the literature examines major factors including demographic variables which influence students' academic self-efficacy levels and their decisions to persist or drop out of STEM programs. A way to visualize these relationships is diagramed in figure 1.

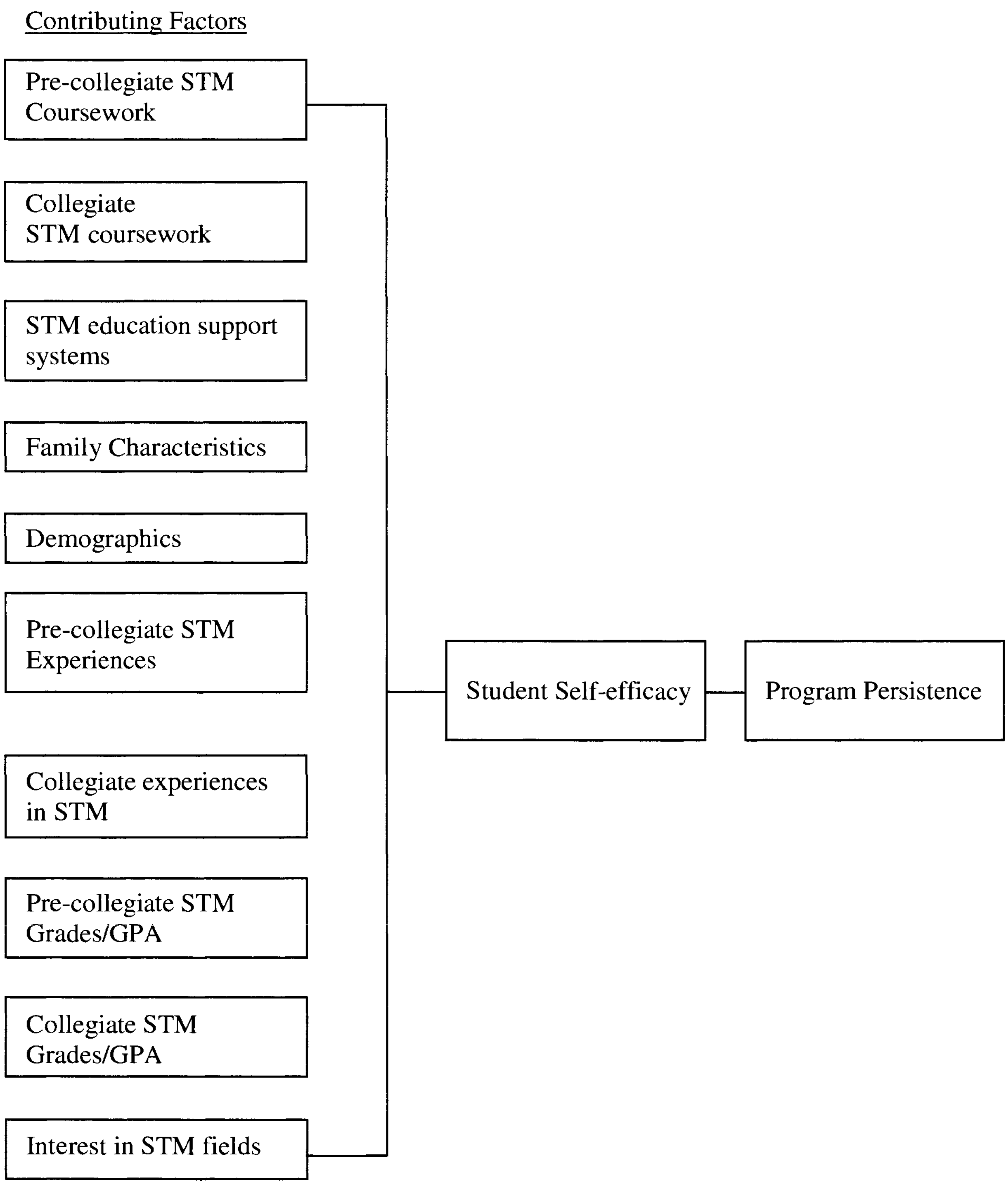

Figure 1. Model for contributing factors and their relationship to student self-efficacy and persistence in STM programs.

History of Attrition Rates in STEM Programs

The science, technology, engineering, and mathematics (STEM) pipeline has for many years been undergoing a dramatic attrition rate. The numbers fall off beginning with the year after high school and continue throughout undergraduate and graduate programs.

Early studies by Green (1989) found that from the mid-1960's to mid-1980's the numbers of freshmen STEM majors declined by approximately one-half with mathematics and physical sciences having the most decline: mathematics having an almost 80% decline and the physical sciences about a 50% decline. Engineering and computer sciences also saw a decline although not as great as that in mathematics and physical sciences.

In other studies during the 1980's, a similar pattern of attrition in STEM programs was illustrated with the exception of the physical sciences. Seymour (2001) found, by examining research conducted by UCLA's Higher Education Research Institute that less than half of the students who began their college careers in a SMET program actually graduated in SMET programs. (Note: Seymour is the sole author in this study to use the acronym SMET in place of STEM when referring to science, technology, engineering, and mathematics programs. Any other authors cited in this study use STEM.) This loss occurs mainly before the junior year with attrition rates of 50% in biology, less than one-half (40%) in engineering, and only 20% in the physical sciences. The highest losses occur before students enter college with over one-third of high school graduates switching to non-SMET majors and with another approximately one-third of SMET students switching out before their sophomore year.

Additionally, in Seymour and Hewitt's 1997 work, *Talking about Leaving*, the authors reported that in tracking over 800,000 SMET majors from 1987 to 1991, engineering had the most stable population (as well as the most selective screening procedures) of 51.4% of students completing a degree; biology was next with 42%; math/statistics was next with 34.1% retention; physical sciences with 29.9%; and taken solely, math had the lowest retention to graduation with 29.2%. Overall, the SMET majors retained 46.05 of its majors. This is in comparison to 48.1% for all humanities/social science majors, 67.7% for education majors, 59.5% for business majors, and 29.4% for health professions (Seymour and Hewitt, 1997, p. 1). These physical science and mathematics findings also are in line with the earlier findings of Green (1989).

The engineering data from Seymour and Hewitt (1997) is supported by a study at the University of Pittsburg by Shuman, Wolfe, Scalise and Besterfield-Sacre (1999) where it was found that approximately 50% of engineering students graduated with engineering degrees, with half of the attrition occurring before the sophomore year. These statistics on engineering attrition rates are also supported by a broader, national study undertaken by Astin and Astin (1993) in which it was found that engineering programs lose at minimum, a little over half of their students to attrition, most of it occurring before the sophomore year.

The engineering students involved in Astin and Astin's (1993) study responded that some of the reasons for dropping the program included dissatisfaction with the way faculty taught courses, their GPAs, as well as overall dissatisfaction with collegiate life. These factors lead to students disliking or losing interest in the engineering field. In addition to these reasons why students opt out of STEM majors, Seymour and Hewitt (1997) analyzed data from two national surveys conducted through the US Department of Education. Two main reasons were given to explain the attrition: a) students preferred non-STEM majors, and b) students found the work too demanding. This study also found that faculty believe that undergraduate students lacked the preparation needed for the science content and of knowing how to study – that a certain portion of students need to be weeded out of the major.

Gender Differences in Attrition Rates in STEM Programs

Seymour and Hewitt (1997) discovered differences between male and female attrition rates in SMET programs in 1987 where approximately three-fourths of those who dropped were women. Women in these majors ranged from about 14% in engineering to 25% in physical sciences, to slightly over 45% in biology, and almost 48% in math and statistics. When taking into account the skewed proportion of males to females, the national attrition rate in these fields increases the under-representation of females in SMET programs: from slightly over 60% for males to slightly under 50% for females. These statistics are reinforced by their findings that the greatest numbers of females choosing to switch are in the areas of mathematics/statistics and biology – those areas with the greatest numbers of women but also with the lowest numbers of women who persist to graduation.

In a related technical field, the computer sciences, the gender gap is growing due to the shrinkage of women in the field starting immediately after high school and continuing through graduate programs. In 2000-01 only 17.5% of those receiving B.S. in computer science were women as compared to 37% in 1983-84 (Wilson, 2003). This computer science gender gap is further highlighted by his findings that from 1980-1994, computer science was the only STEM program where the percentage of B.S. degrees decreased. The computer sciences are included in STEM due to their math-related nature, the emphasis on the study of computation, what can be computed, and how to compute it, thus requiring thinking at multiple levels of abstraction. In addition, there is a reliance on engineering-type thinking as computer scientists construct machines that interact in today's world in increasingly essential capacities (Wing, 2006).

This gender gap is further supported by findings from Seymour and Hewitt (1997) who found women were more often switchers than men – from almost 59% for males who persist to only 48% of women who persist in their SMET majors. Women move more often to other non-SMET majors than do men. The SMET fields in which there are more women switchers are mathematics/statistics and biology, areas which happen to have the lowest number of female graduates.

While these findings paint a bleak picture as to the gender gap in STEM programs, more recent studies conducted by The National Science Foundation (2006) state that from 1995 to 2004 there has been a 4% increase in the number of women who earn undergraduate STEM degrees. These statistics still mean women have much ground to gain, especially in the fields of computer sciences and engineering where in 2004, only one-fourth and one-fifth (respectively) of B.S. degrees in those fields were earned by women. Thus, women still have significant challenge equity in attaining undergraduate degrees in these two STEM fields. This study will shed more light on understanding why females remain so far in the minority of B.S. degree completers in these fields as well as in other STEM programs.

To what majors do the females, originally in STEM programs, transfer to? According to Seymour and Hewitt (1997), while males tend to transfer to computer sciences from mathematics, engineering, and biology, few females do so. Women by far tend to switch to education from those fields, with engineering being the exception — where almost equal numbers of males and females chose to transfer to business majors.

Santiago and Einarson (1998) found that during the graduate school years there is a great degree of difference in completion rates between white males and other students with women and minority graduate students having lower degree completion rates. Thus, the gender gap exists in STEM fields throughout the collegiate years.

Reasons for STEM Pipeline Attrition, Particularly for Women

The most common reasons identified through research by Seymour and Hewitt (1997) for switching out of SMET majors by all switchers include:

1. Lack or loss of interest in science.
2. A non-SMET major holds more interest or offers a better education.
3. Poor teaching on the part of SMET faculty.

4. Feelings of being overwhelmed by pace and demands of the curriculum.
5. Choosing a SMET major for inappropriate reasons.
6. Inadequate departmental advising or counseling concerning career options.
7. Academic or personal concerns.
8. Inadequate preparation for the content depth, conceptual grasps, or study skills.

(Seymour and Hewitt, 1997, p. 32)

In addition, Seymour and Hewitt (1997) found that one-third of students lost their confidence and were discouraged by low grades in their first years in SMET majors. Similar findings for engineering majors were found on the National Academy of Engineering's On-Line Ethics Center, (2007) where, in addition to the above, students' decisions to switch were influenced mainly by unexpected length of time to graduation, lack of peer study groups, and lowered morale.

On the other hand, Seymour and Hewitt (1997) found that women who choose humanities, education, fine arts, English are much more likely to stay in it. Reasons are often cultural – SMET majors are seen as being more traditionally male-oriented and thus women are supported and even encouraged by the cultural norms and traditional pressures to select non-SMET majors and to leave SMET majors for more traditionally "female" majors.

To further this encouragement out of STEM programs, Pajares (2002) states that the media also plays a factor as it continues to send messages which reinforce stereotypical gender roles – males as leaders and authority figures and women as subordinates. In addition, biases are found to affect the hiring of more women faculty in the STEM fields and in leadership capacities at universities. In one study conducted by the nation's largest public university system, the University of California, women make up 36% of faculty in 2003-4, down from 37% in 1993-94, before Proposition 209, making it illegal for public universities to consider sex or race in hiring (Lewin, 2005). Lewin (2005) states that Sheila O'Rourke, director of the University of California's academic placement office, finds that hiring patterns are field specific and that in math and science as in universities everywhere, there are disparities that begin in high school and undergraduate years. Additionally, Lewin (2005) states that even though women are earning increasingly more PhD's, particularly in biology, the increase in the hiring of female faculty is not increasing proportionately.

In another article Weise (2005) stated that even though National Science Foundation statistics put the number of doctorates earned by women at 27% in the physical sciences, and 17% in engineering, they make up only 10% of university faculty. Powell (2007) finds that the percentage of female, tenure-track faculty in the "Top 50" science departments as reported by the *Commission of Professionals in Science and Technology Professional Women and Minorities* (2006) at: 6% for Chemistry; 6% for Physics; 13% for Astronomy; 8% for Mathematics; 11% for Computer Science; and 20% for Biology. In addition, according to an article in the *Arizona Daily Star* (2007) "In 2006, the University of Arizona listed only 17% of the tenure-track faculty in the College of Science and 12% in the College of Engineering and Mines as women." (p. A5)

Historically, barriers have prevented women from entering STEM fields including: a) prior to 1972's passage of Title IX of the Education Amendments, engineering schools could ban women; and b) some medical schools had percentage caps on numbers of women who could be admitted (*Arizona Daily Star*, 2007).Women find implicit biases all along the pipeline. In hiring doctoral students, one finds white males, hiring those who think and look like themselves (i.e., more white males). To help science departments get past these biases, workshops hosted by The National Science Foundation, Department of Energy, and National Institutes of Health for chairs of top-ranked departments were begun in 2006. These workshops highlighted research on these implicit biases and on issues affecting women's ability to succeed in academia. Before training, participants blamed factors outside of their control as to why women were not being recruited, hired, and retained. Once the training was over, they were more likely to admit a lack of communication or out-right opposition to hiring more women as faculty members. In order to begin the turn-around, more women are needed as both graduate and undergraduate students with more female professors serving as mentors and role models. However, in major research institutions this is not currently the case (Powell, 2007).

In other studies focusing on problems with retaining females in STEM majors, Seymour and Hewitt (1997) found a psychological factor at work – one that alienates women by lowering their self-esteem and career ambitions. Thus, women leave STEM programs, most by their sophomore year due, in part, to discriminatory actions by undergraduate faculty, who by direct or indirect actions reinforce the message of lowered expectations. Reinforcing this idea of self-defeating experiences in STEM majors, Seymour and Hewitt (1997) found "almost three-fourths of women in a study by Manis et al. (1990) had experienced many negative experiences in their freshmen STEM classes with almost two-thirds of the women indicating classes in mathematics and chemistry lowering their interest in STEM fields". (p. 11)

What is it about STEM classes that turn female students off? Is it often the context in which science and mathematics activities and tasks are taught?

These majors often find classrooms containing poor teaching, difficult material (*combined with loss of confidence in their ability to do science*), and cut-throat competition geared to weeding out students rather than cultivating student interest in the subject, dull subject matter, and grading systems which do not reflect what students felt that they had accomplished. Additionally, it was found that a lack of applicability of the subject matter as well as the narrowness of the field were also factors. (Seymour and Hewitt, 1997, p. 11)

The trend seems to continue as reported recently by the National Science Foundation (NSF) in its study, *Research on Gender in Science and Engineering* (2006). It was found that the continued portrayal of the stereotypical scientist – one of a white male in a lab coat – begins to turn girls off to science by eighth grade. This attrition continues into college and career fields, with women who have STEM higher education degrees twice as likely to leave a STEM career as males with comparable degrees. (NSF, Research on Gender in Science and Engineering, 2006, p. 1) Thus, women switching and dropping out of STEM programs at a disproportionate level continues.

Self-Efficacy Defined

In Bandura's 1977 work, *Self-Efficacy: Toward a Unifying Theory of Behavioral Change,* self-efficacy was defined as the perceptions persons (e.g., students) have of their abilities to do well in certain tasks (i.e., getting good grades) including putting forth the effort needed to accomplish these tasks, and to persist when things are not going as well as anticipated. Included in this concept are many personality traits including motivation, persistence, and self-control. Beliefs students hold about their abilities have a direct influence on the ways in which they behave. A student who has high levels of self-efficacy should be successful in carrying out tasks. However, just by having the belief that a student can perform beyond his/her abilities will not allow completion of the task simply by believing the "I think I can" mantra. Conversely, having the skills and knowledge to complete a task will not necessarily mean that the student will be successful if they do not believe that they can carryout a task successfully. There must exist a harmony between the "I think I can" attitude and the skills and knowledge necessary to perform a task successfully. What students actually do accomplish academically comes from their beliefs in what they have and can accomplish (Pajares, 1997).

According to Bandura (1986, 1997) levels of self-efficacy are based around four sources of information: a) personal mastery of tasks; b) observation of others; c) verbal persuasion; and d) physiological/emotional reactions. Students' most important source of information is in personal performance accomplishments in which students' successes and failures become internalized. Schunk and Pajares (1997) reinforce Bandura's perspective by stating that it is the perceptions students have about a job well done, increasing their skill level, and becoming more successful in their accomplishments which increases their level of self-efficacy.

Bandura (1986, 1997) found that students also gain information from watching others succeed and fail, against which they compare their own performance. While watching others succeed raises students' levels of self-efficacy, watching failures lowers it. The more students observe successful models, the more their self-efficacy increases.

Students are verbally persuaded by suggestions and encouragement from others, often teachers and counselors, who try to convince students that they have the abilities to perform certain tasks. If not given in an honest, sincere manner, such suggestions may negatively affect student self-efficacy levels (Bandura, 1986, 1997).

Students react physiologically and emotionally to experiences which indicate their level of competence/preparedness/confidence. Such physical reactions include those typically experienced during "fight or flight" responses: rapid heart and respiration rates, sweating, etc. (Bandura, 1986, 1997).

However, achieving a level of self-efficacy also involves meta-cognitive abilities- the ability to think about one's thinking (Goldman, 1995). Thus, self-efficacy is not static; it changes depending on the specific tasks that one undertakes and past experiences that lead one to re-evaluate and re-assess performance and ability levels (Bandura, 1986, 1997).

Academic and General Self-Efficacy Influences on Academic Achievement

The role of general self-efficacy in improving students' academic standing has been researched and studies show that self-efficacy does have a direct relationship in explaining students' academic performance. Bandura (1997) states that student's self-efficacy beliefs can be affected by students' attitudes and gender influencing their academic performance. Bandura's Social Cognitive Theory (1997) provides the theoretical framework for self-efficacy, "the internal factor in the interplay between cognition and environment" (Bandura's Social Cognitive Theory, 1997, p. 5).

Thus, Bandura's construct is re-affirmed by The Center for Positive Practices (n.d.) which states: "students' academic performances (behavioral factors) are influenced by how learners themselves are affected (cognitive factors) and by instructional strategies (environmental factors)." (The Center for Positive Practices, n.d. p. 5). The Center for Positive Practices, (n.d.) researched studies conducted on the relationships that exist between the confidence adolescents have about doing well in subjects and the belief that they are capable in successfully performing well in certain tasks. This belief, termed academic self-efficacy, is the basis for this study.

However, to perform successfully and thus reach a desired outcome, Zajacova et. al. (2005), Bandura, (1986) as well as Pajares (1996), re-affirm that self-efficacy varies according to the domain of the task and as such must be evaluated with specificity within the context of the domain. Pajares (1996) goes so far as to criticize those self-efficacy studies that do not link specific self-efficacy measures to specific tasks. One cannot measure a general sense of confidence in doing things without directly assessing what it is that is being carried out.

Taken a bit further, Zajacova et al. (2005) and Multon, Brown, and Lent (1991) offer that 'one must operationalize the domain of academic self-efficacy rather than rely on general self-efficacy as academic self-efficacy more closely aligns with students' beliefs in their abilities to do academic tasks: take tests, write papers, etc.' and that 'general self-efficacy does not have a strong effect on academic outcomes.' These measures are domain and situation specific, thus supporting Bandura's original (1986) hypothesis as well as other researchers who have built on his work and whom are previously cited.

Additionally, these authors, along with Brown, Lent, and Larkin, (1989) found that domain-specific, academic self-efficacy positively correlated with both grades and persistence. In their meta-analysis, Multon, Brown, and Lent (1991) state that for all 39 of their studies, "self-efficacy beliefs accounted for approximately 14% of the difference in student performance and 12% of the variance in their academic persistence." (Multon, Brown, and Lent, 1991, p. 34). Additionally, a more recent meta-analysis conducted by Robbins et al. (2004) found that academic self-efficacy may account for as much as 14% of the variance in GPA for college students. These authors also found academic self-efficacy beliefs significantly correlating to both persistence in college and in accounting for variance in college GPA and retention, going beyond that accounted for by high school performance and standardized test scores. Thus, the focus of this study will center on academic self-efficacy levels so as to be congruent with the research noted above and to provide valid results.

Self-efficacy is perpetuating, students having high degrees of self-efficacy are more likely to persist in many specific behaviors long enough to achieve positive outcomes, which in turn serve to bolster their levels of self-efficacy. Changing a behavior (e.g., task or performance) necessitates a different context for assessing levels of self-efficacy (Schunk, 1987). Some students may try new activities or performances or tasks which are well beyond their capabilities, thus leading to stress, failure, and withdrawal from programs. Other students may underestimate their level of self-efficacy, shying away from or avoiding activities/performances/tasks which they could carry out. The ideal is for students to attain levels of self-efficacy that slightly exceed what they think they can do at any point in time. This will enable students to more easily form appropriate decisions about beginning a task/performance/activity (Bandura, 1986).

Also congruent with Bandura's social cognitive theory (1986) is the finding that college upperclassmen's self-efficacy beliefs are more strongly related to performance and persistence than that of collegiate underclassmen. It is the experience gained by performing academic tasks that leads these more experienced college students to greater self-efficacy and to improved college performance and persistence (Gore, 2006).

The Role of Stress

The link between self-efficacy and stress is demonstrated when self–efficacy is used to evaluate demands put on students by their environment, where each demand is evaluated as either a threat or a challenge. For instance, studies reported by Zajacova et al. (2005) have shown that students who have high levels of self-efficacy are more likely to see these demands more as challenges to be faced and thus feel confident about their ability to handle a given situation, rather than viewing them as stressful or threatening (Chemers et al. 2001). When viewed as a challenge, students approach demands with effective solutions in which they persist until the demand is eliminated or accomplished. Thus, self-efficacy is found to regulate the relationship between such demands put on students by their environment and students' levels of psychological stress. Additionally, studies undertaken by Hacket et al. (1992) also found that stress and anxiety lowered the levels of students' self-efficacy. There is a two-way impact here: stress reduces levels of self-efficacy while self-efficacy mediates stressors' impacts.

Social cognitive theory helps provide the needed framework for examining the relationship between self-efficacy and perceived stress. One study in this area by Hacket et al. (1992) offered a link between stress and anxiety, and the lowering of students' self-efficacy levels, establishing a mild-to-moderate negative correlation between self-efficacy and stress. According to Zajacova et al. (2005) when comparing the joint effect of stress and self-efficacy on persistence by undergraduate majors, self-efficacy has been found to be a better predictor of persistence than stress.

In a study by Zajacova et al. (2005) on stress and self-efficacy's relationships to academic success of 107 first semester freshmen at one City University of New York campus, an instrument was developed to test both levels of stress and self-efficacy on the same college-related tasks. While 30% of the students in the original sample did not enroll for the third semester, the researchers found no difference in attrition rates for men and women, but did find a negative correlation between grades and attrition rates. Students who were enrolled at the start of their second year had GPA's, on average, 0.4 points higher than those who dropped out. Results of Zajacova's et al. (2005) *Stress and Self-Efficacy Scales* equated the tasks students rank most stressful with those in which they have the least confidence as well as equating those tasks they found least stressful with those that were near the top of their confidence rankings. In addition, they found a negative relationship between academic self-efficacy and stress; that domain-specific self-efficacy has a consistent relationship with performance both in and out of the classroom, in school interactions, and in managing work. The stress-self-efficacy relationship is strong in these areas. They also found academic self-efficacy to be a predictor of freshmen grades and persistence as consistent with Brown et al. (1989) and Lent et al. (1984, 1986, and 1987) but not on persistence in the sophomore year.

Computer/Mathematics Self-Efficacy

Computer self-efficacy (CSE) refers to the self-judgment of one's capacity to use or interact with a computer. "It is positively correlated with a person's willingness to choose and participate in computer-related activities, expectations of success in such activities, and persistence or effective coping behaviors when faced with computer-related difficult tasks" (Karsten and Roth, 1998, p. 62).

It has been demonstrated in research studies that many people believe they will never be able to control or interact successfully with computers, especially when initial experiences are frustrating – leaving them with little sense of self–efficacy regarding computers and related tasks (Hill, Mann & Smith, 1987). These researchers investigated the role of people's CSE and their decision to use computers. In one study, the researchers used an instrument designed to assess students' CSE, their beliefs about the instrumental value of learning about computers, and future intentions to purchase or use computers. The researchers gathered data from 157 female and 147 male introductory psychology students. The results from Hill et al. (1987) showed "CSE made a significant contribution to prediction of future behavioral intentions, independent of belief about the instrumental value of learning to use computers." (Hill et al. 1987, p. 309)

A second study done by Hill et al. (1987) investigated the role of previous experience with computers in the decision to adopt computer technology. This study provides a means of testing the role of direct experience as aligned with the most important of the four sources of information noted previously: personal experience. "Experience with computers is likely to increase CSE, however it is not likely to directly influence decisions to learn about or use computers unless CSE beliefs have themselves been affected." (Hill et al. 1987, p. 310). In addition, CSE is related to decisions to use technological innovations in general. The results again showed that those students who feel least likely to successfully perform computer related tasks were less likely to learn about or use them. The study also found that with previous computer experience, students exhibit higher levels of self-efficacy than those without this experience and that intent to enroll in future computer courses is significantly related to CSE. Thus, Bandura's concept that direct experience or control over a previously avoided task or object is likely to reduce anxieties and lead to the person adopting a new behavior. This conception of personal efficacy is supported by this study.

Gender and Self-Efficacy in Sciences

Investigations into the role of gender on academic achievement in college science courses conducted by DeBaker and Nelson (1999) and Smist, Archambault, and Owen, (1997) found that differences begin to emerge during middle school when girls' mathematics and science self-efficacy levels are lower than boys. In addition, their findings revealed middle school girls tend to have lowered confidence in their ability to do well in mathematics and science. Kennedy (1996) found that girls with lowered levels in these areas do not go on to further study in these areas nor do they pursue STEM careers. Schunk and Pajares (1997) found similar patterns in their research, with gender differences in self-efficacy beginning at middle or junior high school. They also found that girls at that age having lower self-efficacy beliefs than boys. More evidence from Smist, Archambault and Owen (1997) reveals the same pattern – males in high school physical science classes outscoring the female students on self-efficacy assessments, including laboratory skills.

To the contrary, Santiago and Einarson's (1998) study found entering graduate students in a Midwestern university's engineering and physical sciences programs with similar academic self-efficacy scores had a significantly different mean GRE Math score. However, most research findings support that in secondary school science and mathematics classes, females have lower levels of self-efficacy. Lower self-efficacy is linked to lower academic performance. Lowered levels of self-efficacy in secondary sciences have been shown to contribute to lowered academic achievement and increased attrition rates out of the STEM pipeline as early as the secondary school level. Thus, research suggests that gender differences are already established when students enter college. This is an important aspect of this study.

In addition, evidence shows there are some differences in self-efficacy across gender and ethnicity demographics in regards to self-efficacy's relationship to achievement and persistence among undergraduate STEM majors. Brown et al (1989) and Hackett et al (1992) found no significant gender differences in students' academic self-efficacy levels, yet Hackett et al. (1992) did discover that women had lower expectations and that they would complete their degrees at a lowered rate than males. They also found students' levels of expectation toward degree completion were predictive of their academic self-efficacy: higher self-efficacy reveals higher expectation for degree completion.

At the collegiate level, studies indicate that gender differences in computer science programs are not due to ability differences. Wilson (2003) found that the gender differences in attrition levels in computer science programs were determined by four sources of information: previous computer experience; the hostile (as perceived by females) nature of the computer science environment and culture; attribution theory; and self-efficacy.

Reinforcing his finding that previous computer experience leads to gender differences, Wilson (2003) found that entering freshmen males have more specific experiences and skills with computers, especially in programming and computer games. Females who have any type of computer experience before taking introductory computer science in college have higher levels of success. According to Wilson (2003):

> In a study in New Zealand by Brown, Andreae, Biddle, and Tempero (1997) of freshmen females in introductory computer courses it was found that females who found the course difficult were intimidated by seeing others who had prior experience do the work quickly. (Wilson, 2003, p. 6)

Thus, the second source of information for determining levels of self-efficacy – seeing others perform - is relevant.

Betz and Hackett (1983) focused on determining: a) if there is a gender difference in mathematics self-efficacy beliefs; and b) if mathematics self-efficacy is related to career decisions, especially in choosing science-related majors. Results using a Mathematics Self-Efficacy Scale consisting of items on Math Tasks, College Courses, and Math Problems found consistently higher self-efficacy beliefs for males than females across all areas.

More evidence from Betz and Hackett's (1983) study supports gender differences in mathematics self-efficacy where males were found to have higher self-efficacy with regard to mathematics attitudes. They also scored higher on the scale's items regarding their confidence in their ability to do math. In addition, this study's findings revealed that those students "who have higher levels of mathematics self-efficacy beliefs, more years of high school math, and lower levels of math anxiety were more likely to have selected science-based college majors, as were male students in contrast with female students." (Betz and Hackett, 1983, p. 341) This study's discussion section summarized the research by stating that females' self-efficacy levels, especially in mathematics, may be a factor in the decision by many women to opt out of STEM programs. Thus, when females do not pursue taking mathematics and science courses, their self-efficacy levels are lowered.

Emotional/physiological responses to mathematics and science are the fourth source of information impinging on self-efficacy. Wilson (2003) demonstrated the emergence of math anxiety and lack of confidence in mathematics by females as early as the middle school or junior high years and continuing throughout the college years in the math-related field of computer sciences. In a related study, Betz and Hackett (1983) found students who have higher levels of mathematics self-efficacy have lower levels of math anxiety and greater math confidence. Pajares and Kranzler (1995) and Pintrich and De Groot, (1990) found pre-collegiate students' mathematics self-efficacy to be a strong predictor of students' ability to do math. An interesting finding is that mathematics self-efficacy beliefs are better predictors of success in math – better than math self-concept, math anxiety, perceived usefulness of mathematics, or prior experience (Pajares and Miller, 1994).

Zajocova et al. (2005) also found that for students lacking in confidence and self-efficacy in certain skills, engagement in tasks and activities which require these skills will be unlikely to occur. When encountering difficulty with such tasks and activities, students with low self-efficacy and confidence will likely give up. Following Zajocova's thinking, since women in STEM programs have lowered confidence and self-efficacy as compared to males, female students are especially vulnerable to dropping out or switching out of these majors. This is compounded by females' tendency to underestimate their abilities and thus avoid taking math-related courses and programs.

More recently the National Science Foundation's Gender Research Program (2006) has found mentoring as one of the most effective means to helping women choose and persist in STEM programs. Thus, the female mentor or role model's personal, supportive relationship with female STEM students is an important factor in encouraging the students' pursuit of math-related careers.

Gender Differences Related to Enrollment and Persistence in the Continuum Towards Graduate Level STEM Programs

Issues surrounding persistence in upperclassmen were discussed by Polson Enterprises Research Services in their report, *Engineering Student Retention: Reducing Attrition and Improving Graduation Rates of Upperclassmen Engineering Students* (2003). One main thread centered on the similarities and differences in issues regarding retention of freshmen and upperclassmen. In this report the authors acknowledged there is less research with regards to upperclassmen, who are further along in age and thus, may deal more with major adult challenges and issues such as marriage, child-raising, jobs, and work experiences in the field. These situations do not always lead to positive outcomes. Santiago and Einarson (1998) found, at the graduate level, a difference in the levels of self-efficacy between entering women and minority students compared to their white, male counterparts. In addition, they also found that females have lowered levels of academic self-confidence and self-efficacy as well as lowered expectations regarding employment, earnings, and career advancement than their male counterparts.

Santiago and Einarson (1998) also found the most significant predictors of graduate students' self-efficacy included their undergraduate preparation, how they felt about interactions with faculty, minority students and marital status, as well as if they have a M.S. degree. Those students who felt academically well-prepared had almost twice the self-efficacy ratings as other students who felt academically less prepared.

Santiago and Einarson (1998) found the graduate school years to be a time in which there is a great difference in degree completion between women and minority graduate students and white male students. They also found a study by Jackson et al. (1993) in which it was found that women students have more concerns about the challenges faced when marriage and careers are merged. Both women and minorities were found to have lower degree completion rates than their white, male peers. Gender differences were also found by Brown et al. (1989) and Lent et al. (1986) who reported finding males had higher self-efficacy levels in graduate STEM majors. Thus, this gender-oriented research is important for understanding that the pipeline leakage exists in STEM fields beyond the B.S. degree, remaining a concern in graduate education as well.

Students' Demographic Characteristics and Their Impact on Self-Efficacy

What is it about students' backgrounds that impact their levels of self-efficacy? Initially, the family is the biggest influence on how children interact with their environment and develop their sense of self-efficacy. In families where the home has many resources to stimulate children's' curiosity and thinking, where parents play major roles in their children's cognitive development by encouraging them in a variety of experiences, children develop high levels of self-efficacy (Bandura, 1997).

Santiago and Einarson (1998) found that parental socioeconomic status including income, student academic achievements and GPA, student perceptions as to their preparedness for their current major, and previous work experience in their major as strong influences on academic persistence and performance at both undergraduate and graduate levels. Going further, Seymour and Hewitt (1994) found parental socioeconomic status a strong influence on undergraduates' levels of academic self-confidence and self-efficacy. In addition, Pajares (2002) noted that in pre-collegiate education, teaching methods are especially influential in determining students' levels of self-efficacy. Giving students the skills on how to set goals that are specific and short-term and how to strategize and apply their learning strategies also raises students' self-efficacy. Offering models for how to apply these skills as well as feedback are essential as evidenced by Bandura's four sources of information detailed previously. In this study, parental SES information will be restricted to the level of education and in what content areas, while student academic achievement will be restricted to GPAs, and student preparedness will be restricted to high school STM courses as well as study skill preparation.

Pajares (2002) found parental beliefs and expectations were often lower for daughters, seeing math and science as typically male fields. This holds true also for teachers and counselors who discourage their female students from scientific and technological careers. Thus, it is the perception and belief that persons close to students, as well as the students themselves, influence females' career choices and academic performance, particularly in STEM programs. By making students more aware of the range of STEM careers and their importance in today's technical world (NSF, 2006), teachers and counselors can lead more females into STEM careers. In addition, they can lead them to these careers (NSF, 2006) with knowledge of the content and skills needed to succeed in STEM careers.

Conclusion

It has been many years since research on the topic of attrition rates in college STEM programs began revealing the presence of attrition in the pipeline and where its leakages occur. The research base on male and female differences in STEM attrition rates does reveal more serious leakages for women, especially in the mathematics, physical, and computer sciences. Reasons why the leakages occur is traced back through research on male and female differences in interest, aptitude, and self-efficacy in science and mathematics, initially observed as significant in middle and high schools. Research on college student self-efficacy is a newer phenomenon with the preponderance occurring since the publication of Bandura's Social Cognitive Theory framework in the late 1980's. Even so, after more than 20 years, the research focusing on college students' academic self-efficacy and academic achievement in STEM programs is limited. Many variables are at work to influence students' academic achievement other than self-efficacy (attitude, motivation, and interest to name a few) as well as differing levels of self-efficacy: general and more specifically, academic.

Of the studies conducted on self-efficacy some deal with general self-efficacy findings and the relationship to academic achievement. These studies have been criticized for not being aligned to specific academic tasks or performances when assessing students' self-efficacy beliefs. Some self-efficacy studies have linked self-efficacy to academic performance in the sciences but few have connected self-efficacy to levels of persistence in STEM programs. Adequate research on the topic of the relationships between academic self-efficacy and attrition rates in college STEM programs has not been conducted to document a firm link. Yet, the current research results do suggest a possible direct or indirect relationship between academic self-efficacy, academic performance, and attrition rates in college STEM programs. However, much more research on this topic is needed to determine if there is a significant correlation between academic self-efficacy, academic performance, and attrition rates by STEM programs for both genders as well as and to suggest contributing factors to this phenomenon. In addition, the research suggests general gender differences in these areas, but not the specific differences that this study will explore: to reveal significant differences between the STM persisters and the non-persisters and to what degree demographic and related factors contribute to any significant differences in the academic self-efficacy/ performance-attrition relationship for these groups of college seniors. In addition, using college juniors and seniors will serve to enhance the data showing changes in students' perceptions related to the variables being examined as they reflect on their academic decisions and progress.

CHAPTER III

METHODOLOGY

Overview

This study consists of two activities: a) administering a questionnaire comprised of quantitative and qualitative items to a sample of STM juniors and seniors at Illinois State University containing both male and female STM persisters and non-persisters; and b) formulation of a focus group of both male and female persisters and non-persisters drawn from questionnaire respondents. The programs within STM which are a focus of this study include: biology, chemistry, and physics (science); math; and the computer sciences (technology). The questionnaire assesses: demographic information, self-efficacy levels in STM courses, and factors which correlate with persistence. A sample consisting of approximately 700 students representing each of the STM areas, persisters and non-persisters, as well as both males and females was drawn using purposive sampling. The electronic focus group addressed the questions as they offered a look back at their STM careers and the factors influencing their decisions to either persist or drop out of STM programs.

The objective of this study is to determine to what extent levels of student self-efficacy are correlated with persistence in STM programs by assessing: students' levels of self-efficacy, demographic factors, and identifying those factors which correlate with students' decisions to persist or drop out of STM programs. This study utilizes: a) questionnaire consisting of demographic information, self-efficacy scale, ranking of potential factors for either persisting or dropping/switching out of STM majors, and open-ended questions allow students to further elaborate on their ranking; and b) an electronic focus group discussion via Web-board which focused on questions related to students' experiences in pre-college and collegiate STM courses leading to decisions to persist or drop out of STM programs. The focus group consists of both male and female persisters and non-persisters. All the items in the questionnaire come from research cited in this proposal which correlates to self-efficacy levels and college persistence.

Questionnaire's Theoretical Framework

Self-efficacy as a theoretical construct is used to explain changes in people's behavior and was first set forth by Albert Bandura in his 1977 seminal work, *Self-Efficacy: Toward a Unifying Theory of Behavioral Change.* In his later work *Social Foundations of Thought and Action,* Bandura (1986) wrote that self-efficacy is the means by which people can guide their decisions on how to act, as well as their thoughts and feelings that influence such decisions. As such, self-efficacy plays a major role in the formation of Bandura's social cognitive theory.

Pajares' *Self-Efficacy Beliefs in Academic Settings* (1996) reinforces the foundational tenants of Bandura's Social Cognitive Theory by stating that it is the beliefs students have about their abilities and how successful they will be in performing tasks which lead students to undertake tasks in which they feel competent and confident and to avoid those tasks in which they do not feel competent and confident. Such efficacy beliefs also determine how much effort students will expend on any task and how long they will persist when confronted with barriers. The greater their perceived self-efficacy the greater the effort and persistence.

Bandura's Social Cognitive Theory offers that the experiences in which people have a direct influence over vary and that many factors serve to direct peoples' motivation, thoughts, feelings, and behaviors. As self-efficacy is a judgment of a person's capabilities to perform certain tasks and achieve certain goals, it is very sensitive to these factors. Self-efficacy beliefs are much more task and situation specific with a specific goal used as a frame of reference for judging one's capabilities (Pajares, 1996). Thus, in assessing student self-efficacy levels in STM programs, questions are situation-specific and focused on one goal – that of academic persistence in STM programs.

The data on student self-efficacy levels is obtained by using only the self-efficacy items from the *Motivated Learning Strategies Questionnaire* (Pintich, 1991) and adapted to specifically focus on STM courses. The students offer information regarding certain demographic factors which may influence their self-efficacy levels and hence affect persistence in STM programs. These demographic factors are: gender, collegiate major, high school and collegiate GPA in STM courses, number of STM courses in high school and college, and parents' (or parental figures') educational levels and collegiate majors, careers/jobs and descriptive household factors.

Additionally, students complete a section in which they rank order a list of factors according to their relative importance in their decision to persist or drop out of STM programs. Additional open-ended questions offer students a chance to expand on what they perceive as significant events in their choice to persist or not. The factors which are found to be influential in this decision include: interest in STM fields, collegiate STM courses' pedagogy, demanding nature of STM coursework, advising, mentor influence, family responsibilities, self-defeating experiences in STM classes, parental, and home characteristics.

The University Registrar provided three lists of names, majors, and email addresses for emailing and mailing out the *Student Inventory* and all related information including: the letter of consent, link to the Survey Monkey site, and request for focus group volunteers.

The *Student Inventory* (Appendix A) includes the eight self-efficacy questions within the *Motivated Strategies for Learning Questionnaire* (MSLQ) revising the focus of the questions to aim at more specific STM courses in which students are enrolled or will be enrolled. The MSLQ was selected based on the following:

- It was developed using the social-cognitive construct which forms the theoretical basis for this proposed study;
- It includes a self-efficacy component comprising an eight question scale that is appropriate for use in this proposed study. The scale is based on the self-efficacy related construct, expectancy. Expectancy is similar to self-efficacy in that its focus is on student beliefs that they can accomplish tasks. Pintich et al. (1991) combined this construct with students' judgments about and confidence in their abilities to perform tasks to define self-efficacy. Thus, there is a seamless match between self-efficacy definitions in the MSLQ and this study;

- It has been used in numerous research studies and has formal assessments of its validity and reliability applicable to many areas of educational research and assessment; and
- Additionally, the Chronbach Alpha for the self-efficacy section of this instrument is 0.93 indicating a strong level of reliability (Duncan and McKeachie, 2005). The researcher will determine the reliability of the instrument as it is applied to this research through another Chronbach Alpha score. Factor analysis will be conducted to determine its validity.

Questionnaire's Level of Specificity

The specificity of academic self-efficacy beliefs was addressed by focusing the MLSQ self-efficacy assessment questions on the STM domains which closely align with the more general goal of persistence in the STM major. This strikes a balance between using questions which are too task-specific within each STM domain and that of too general levels of questions which does not directly relate to STM performance. General academic self-efficacy questions are not appropriate in regards to the research earlier presented (Pajares, 1996, p.2) in which he states that "to achieve predictive power self-efficacy judgments should be consistent with the domain and/or task under investigation". Thus, in order for this study to be predictive concerning student persistence, a reasonably precise set of question related to students' judgment (as asked on this study's questionnaire) is aligned to a reasonably precise outcome: attrition/persistence rates in STM programs.

Appropriateness of Research Methods/Design

As a result of the review of the literature, the overarching question addressed in this proposed study is: Is there a significant relationship between students' academic self-efficacy and persistence in STM majors?

The specific research questions investigated under this framework include (with the appropriate statistical analysis):

1. Is there a difference between male and female levels of self-efficacy in STM programs? [The analysis consists of a t-test for comparing gender differences for each STM program.]
2. Is there a significant difference in self-efficacy across STM programs? [The analysis consists of an ANOVA comparing self-efficacy across the three STM programs.]
3. Does self-efficacy significantly correlate with persistence in STM programs? If so does it have the same significance for both males and females across STM programs? [The analysis consists of Pearson Product Moment Correlation.]
4. Is there a significant difference in self-efficacy levels between males and females who persist in STM programs vs. non-persisters? [The analysis consists of a 2x2 ANOVA for comparing these groups.]
5. Is there a significant difference in the self-efficacy levels between males and females across the STM programs? [The analysis consists of a 2x3 ANOVA for comparing these groups.]

6. a) Do certain demographic factors correlate with self-efficacy levels and persistence in STM programs? b) Are there additional factors which research indicates should be considered in examining the relationship between self-efficacy and persistence? [The analysis for part "a" consists of a Partial Correlation controlling for specific demographic factors. The analysis for part "b" consists of content analysis of the open-ended responses.]
7. In addition, due to the preliminary nature of this study $p \leq .10$

The use of both qualitative and quantitative methods, including a questionnaire with both quantitative and qualitative sections combined with use of an electronic focus group, are important steps in obtaining a rich, triangulated source of data. Qualitative data describe students' thoughts, beliefs, and perceptions going back to pre-collegiate years related to their self-efficacy and decisions to persist or drop out of STM programs. Content analysis of the dialogue from the electronic focus group discussion and open-ended *Student Inventory* responses was conducted in order to analyze the presence and frequency of various contributing factors correlated with persistence in STM programs. The use of the questionnaire and the focus group triangulates the data and thus increases the validity of the results. Validity is an essential component of qualitative research, dealing with the appropriate use of the inferences which researchers draw from their data. In essence, triangulation is a way to double check the biases and perceptions of the researcher helping to ensure that validity is maintained (Fraenkel and Wallen, 1996).

Timeline for Research Activities

Upon IRB approval in May, 2008, a request was sent to the Illinois State University Registrar asking for: a) current junior and senior STM majors' names, major, and email addresses; and b) a list with the same information for current ISU juniors and seniors who have switched out of a STM program at some point in their college careers; and c) a list of names and mailing addresses for former STM majors of the last three years.

Once the lists were obtained in June, 2008, a sample of names from lists of current students was drawn from the over 700 names reflecting as much as possible an equitable distribution from all male and female persisters and non-persisters in each STM program. This purposive sampling is done to ensure there is an appropriate quantity of data from each of the program areas, for both sexes, and for both persisters and non-persisters.

Current students who were in the sample were emailed by the University's Office of Computer Services the statement of confidentiality along with the link to Survey Monkey, the mechanism for responding anonymously to the inventory. Included in this email was the initial information seeking volunteers for the follow-up focus group. All students who were drops from the University (about 300) were mailed the same information. The initial email and mailing consisting of about 700 names were sent in early August, 2008.

When two weeks passed another emailing and mailing was conducted in early September. When few responses were collected (about 50) it was decided by the committee to send all current students an email. Thus in mid-Sept another email of almost 600 names was sent. At the end of ten days, all completed inventories (79) were collected, copied and Survey Monkey link was terminated.

The focus group web-board was open for a week in late September, 2008 for asynchronous on-line discussion. The focus group was composed of ten volunteers who received by email information as to the nature of the focus group questions, its procedures, use of alias log-ons as assigned by this researcher, the link to the web-board, and a time-line for completion several days before the opening of the web-board. When completed, only five of the ten volunteers responded to the questions and in mid-October the responses were collected and the board closed.

The analysis of the web-board responses and how they support the statistical data occurred in November and December of 2008. The writing and revisions of chapters four and five took place beginning in December of 2008, with defense in early spring, 2009.

CHAPTER IV

RESULTS AND ANALYSIS

Demographics Overview

Of the seventy-nine students who responded to the *Student Inventory* (Appendix A) there was an almost even split between males and females, 39 males and 40 females, ranging in age from 19 to 34 years. The most frequent (20 each) ages were 21 and 22 years (as would be expected of collegiate junior and seniors), each representing 25.3% of the population with the median age of 26 years. The mean age was 23 years.

The most often reported response to the current major of these students was "other" which included (with frequency): accounting (3); biochemistry/molecular biology/BMB (6); biology education (1); biomedical science (1); chemistry and public relations (1); civil engineering (1); clinical lab sciences (1); cultural studies (1); engineering, M.E. (1); geology (1); journalism (1); marketing (1); nursing (1); and veterinary medicine (1). The overall current majors are found in Table 1.

In order to determine the persisters from the non-persisters, student prior majors were assessed. Prior majors are those majors in which students were enrolled previous to their current enrollment (as of spring, 2008). Persisters are defined as those students who have stayed in a STM program since freshmen year, even though they may have switched from one STM program to another. Non-persisters are those students who have dropped/switched out of a STM program at some point in their collegiate years. (Note: although biochemistry, molecular biology, Bachelors of Molecular Biology, and ecology are housed in either the biology or chemistry departments at Illinois State University for this research they are considered "other".) This is due to the fact that the students did not declare themselves as biology or chemistry majors. Prior majors (Table 2) are listed in alphabetical order.

Table 1

Current Majors

Major	Frequency	Percent
Other	22	27.8
Mathematics	16	20.3
Biology	15	19.0
Physics	2	2.5
Technology	4	5.1
Computer Science	8	10.1
Chemistry	11	13.9
Currently not enrolled	1	1.3

In order to determine the persisters from the non-persisters, student prior majors were assessed. Prior majors are those majors in which students were enrolled previous to their current enrollment (as of spring, 2008). Persisters are defined as those students who have stayed in a STM program since freshmen year, even though they may have switched from one STM program to another. Non-persisters are those students who have dropped/switched out of a STM program at some point in their collegiate years. (Note: although biochemistry, molecular biology, Bachelors of Molecular Biology, and ecology are housed in either the biology or chemistry departments at Illinois State University for this research they are considered "other".) This is due to the fact that the students did not declare themselves as biology or chemistry majors. Prior majors (Table 2) are listed in alphabetical order.

Table 2

Prior Majors

Major	Frequency	Percent
Accounting	4	5.1
Actuarial Science	1	1.3
Aeronautics	1	1.3
Agriculture	1	1.3
Arabic	1	1.3
Biochemistry	1	1.3
Biology	9	11.4
Business	1	1.3
Chemistry	3	3.8
Civil engineering, mechanical eng, engineering physics, business	2	2.6
Computer science	5	6.3
English	3	3.8
Fire	1	1.3
MA cultural studies, BS computer science, BA cultural studies	1	1.3
Mass communications, biology	1	1.3
Mathematics	2	2.6
Music	1	1.3
None, never switched	26	34.3
Physics	5	6.4
Physics engineering, accounting, M.E.	1	1.3
Spanish	2	2.6
Speech	1	1.3
Veterinary medicine	1	1.3
Non-categorical response	2	2.6
Total	79	100

This overview shows an equitable representation including almost 50-50% gender; a 70-30% split between persisters and non-persisters (56 persisters and 23 non-persisters) and a 50-29-21% split between persisters in the STM programs: 28 science, 16 math, and 12 technology/computer science. In science there were 16 male and 12 female persisters; for math there were 11 female and 5 male persisters; for computer science/technology there were 3 females and 9 males.

The researcher did not expect to have such an even split of responses between genders and especially to have more than twice as many female math majors respond as males. As outlined in the research presented in chapter two, STM fields are overwhelmingly male populated and mathematics is one STM field where few females (as compared to males) persist to graduation. The researcher expected fewer non-persisters due to the difficulty with contacting those who dropped from the University and their perceived lack of motivation to respond.

Pre-Collegiate Factors Correlated with Persistence

Of the factors noted previously in research regarding correlations with persistence, some factors begin to surface at the pre-collegiate level and include: number of semesters in high school science, math, technology, and computer science; high school GPA; and ACT score. The range in the number of semesters taken in high school in STM fields, the most frequent number of semesters taken and the percentage of those students who took them as well as the median number of semesters of STM courses taken in high school is found below.

Table 3

Semesters of High School STM Courses

STM Field	Range in number of semesters	Most frequent number of semesters (% who took)	Median number of semesters
Science	2-11	8 (43.0%)	6.5
Mathematics	2-10	8 (58.2%)	6.5
Technology	0-5	0 (38.0%)	2.5
Computer Science	0-6	0 (45.6%)	2.5

High school GPA ranged from 2.0-4.0 with the most frequent being 3.7 (13%) and the median as 3.78. (Note: GPA's above 4.0 were reported on either 5 or 6 point scales and so were translated to 4 point scales.) ACT scores ranged from 14-34 with the most frequent being 26 (15.2%) and the median score, 27.

In summary, the respondents reflect well rounded backgrounds as far as the number of courses taken in high school in mathematics (especially) and science but few took any technology (62%) or computer science courses (54.4%). GPA data reveal that students earned As-Bs in all their subjects, not just STM courses in high school.

Collegiate Factors Correlated with Persistence

College GPAs (overall) were reported as ranging from 2.02- 4.0 with the most frequent scores being 3.5, 3.6 and 4.0 with five students receiving each of these GPAs for a total accounting for almost 19% of all student GPAs. Refer to table 4 for data by program as well as comparison to the total junior-senior STM population at Illinois State University.

Table 4

Number of Courses Taken and GPAs by STM Program and GPAs Across Entire ISU STM Population

Program	Range, number of courses	Most frequent number of courses and % of students	Median number of courses	Avg. GPA range	Most frequent GPA and % of students	Median GPA	Mean GPA by courses[a]	Overall GPA by major (n)[b]	ISU Overall GPA by major (n)[b]
Biology	0-30	1 (27.8)	7	2.0-4.0	4.0 (36.7)	3.0	3.5	3.3 (15)	3.0 (308)
Chemistry	0-13	1 (25.3)	5	1.0-4.0	3.0 (24.1)	2.75	3.0	3.2 (10)	3.1 (75)
Physics	0-13	1 (39.2)	4	0.0-4.0	4.0 (24.1)	2.75	3.1	2.3 (2)	3.0 (61)
Mathematics	0-20	1,3 (15.2 each)	6.5	1.0-4.0	3.0 (32.9)	3.25	3.1	3.4 (16)	3.1 (229)
Computer Science/tech	0-11	0 (50.6)	4.5	0.0-4.0	4.0 (13.9)	3.0	3.1	3.3 (12)	3.0 (70)

[a] In biology 49 of 79 students responded to this section while in chemistry 58 of 79 students responded, in physics 76 of 79 students responded, in mathematics 66 of 79 students responded, and in computer science 26 of 79 students responded.
[b] The overall GPA was reported by program major.

In summary, while the respondents' overall GPAs mostly reflect A-/A grades in all college courses, their STM mean GPAs reflect B/C+ grades. Thus as a whole, participants are earning lower grades in their STM courses than their overall college courses. They have also, to this point in their college careers, taken significantly less technology/computer science courses than math and science. In comparison to all Illinois State University junior-senior STM majors, respondents' overall GPAs are very similar with the one exception being for physics majors. As there were only a very limited number of physics respondents no real comparison can be established for this major.

Parental and Home Environment Factors

Parental education level is another important factor correlated with persistence in college STM programs. In assessing father's (or father-figure's) and mother's (or mother-figure's) education levels the following was reported:

Table 5

Fathers' Education Levels

Education level	Frequency	Percent
High school only	25	31.6
Some college	19	24.1
Bachelor's degree	21	26.6
Advanced degree	13	16.5
Missing	1	1.3

Table 6

Mothers' Education Levels

Education level	Frequency	Percent
High school only	14	17.7
Some college	31	39.2
Bachelor's degree	30	38.0
Advanced degree	4	5.1
Missing	0	0

The area of study for those parents who had more than a high school education included both STEM (here expanded to STEM to reflect the engineering major) and non-STM majors. For the fathers, 13/79 (16%) responses indicated a STEM area of study, for the mothers it was 4/79 (5%). Tied to this finding was the question asking for parental career field. This resulted in: fathers 6/79 (8%) employed in a STEM career while for mothers 4/79 (5%) are employed in a STEM field. It was an unexpected finding that the mothers had higher education levels than the fathers, except for advanced degrees.

Additionally, exposure to informal STM related activities or resources in the home while growing up was assessed. Of the responses for each question, the following data were reported:

a.) parents who read to you: 74/79 or 94% indicated 'yes'

b.) had books at home: 77/79 or 98% indicated 'yes'

c.) had educational toys/games other than computer: 61/79 or 77% indicated 'yes'

d.) participated in STM-related clubs: 36/79 or 46% indicated 'yes'

e.) participated in non-academic clubs/organizations (4-H, scouting, etc): 61/79 or 77% indicated 'yes'

f.) took vacations/trips with family: 73/79 or 92% indicated 'yes'

g.) had a computer at home: 70/79 or 89% indicated 'yes'

Information in this section indicates that for all students, growing up with parents who were not STM graduates did not seem to affect students' decisions to persist in a STM program, as the percentage of STM persisters is not significantly higher having a parent who is employed in STM career or who pursued STM program in college. Not having parents in STM careers did not influence students' exposure to STM-related activities and resources as youth.

Reliability of Instruments

Reliability of the eight elf-efficacy scale items taken from the *Motivated Learning Strategies Questionnaire*, Pintrich et al. (1991) were found to have the following Chronbach's Alpha: 0.95 for math items, 0.93 for science items, and 0.97 for computer science items. This indicates strong level of reliability within the self-efficacy scale.

Research Questions

In order to provide answers to each research question, the data from the Survey Monkey excel spreadsheet was exported to SPSS where each relevant application was run to provide the necessary data analysis. Information in this section presents each research question and the data that either supports or refutes each question.

Question 1: '*Is there a difference between male and female levels of self-efficacy in STM programs?*' This question was analyzed using a t-test which found there was a statistically significant difference between males and females in math self-efficacy and science self-efficacy with females having higher self efficacy than males. There were no differences between males and females in computer science self-efficacy. The data are presented in Table 7.

Table 7

Differences Between Males' and Females' Self-Efficacy

Measure	Mean	SD	t	df	p
Math self-efficacy					
Males	3.924	1.042	-2.120	65.32*	0.038**
Females	4.356	0.719			
Science self-efficacy					
Males	4.185	0.825	-1.809	76	0.074**
Females	4.505	0.731			
Computer Science/technology					
self-efficacy	4.195	1.004	.615	40	0.542
Males	3.992	1.094			
Females					

* Equal variances not assumed

** Significant at $p \leq .10$

Question 2: *'Is there a significant difference in self-efficacy across STM programs?'* Using ANOVA, there was a statistically significant difference in computer science self-efficacy across the STM programs with science and technology/computer science significantly higher than math. There was a significant difference in science self-efficacy across the STM programs with science and technology higher than math. The mean, SD, F ratio, df and significance level for self efficacy in each of the programs is presented in Table 8.

Table 8

Differences Across STM Programs

Measure	Mean	SD	F	df	p
Math self-efficacy			1.274	54	.288
Math	4.359	0.730			
Science	3.954	1.048			
Technology	4.335	0.815			
Science self-efficacy			2.391	54	0.102*
Math	3.934	0.931			
Science	4.491	0.628			
Technology	4.220	0.987			
Computer			6.689	34	0.004*
Science/Technology self-					
efficacy	3.490	1.210			
Math	4.713	0.457			
Science	4.506	0.685			
Technology					

* Significant at $p \leq .10$

Question 3: *'Does self-efficacy significantly correlate with persistence in STM programs?'* If so does it have the same significance for both males and females across STM programs?

Using a Pearson Product Moment Correlation there was no correlation found between self-efficacy and persistence in the STM programs. However, when looking at genders across STM programs, there was a significant negative correlation between science self-efficacy and persistence for females (p=.026) with female non-persisters having higher self-efficacy in science. Data are presented in Table 9.

Table 9

Correlation Between Self-Efficacy and Persistence

	Math self-efficacy	Science self-efficacy	Computer Science / Technology self-efficacy
Persistence			
r value	.015	-.128	.154
p value	.893	.266	.331
N	78	78	42
Persistence (Males)			
r value	.261	.153	.271
p value	.114	.353	.181
N	38	39	26
Persistence (Females)			
r value	-.213	-.357*	-.032
p value	.186	.026	.905
N	40	39	16

* Significant at $p \leq .10$

Question 4: *'Is there a significant difference in the self-efficacy levels between males and females who persist in STM programs as compared to non-persisters?'*

No interaction was found between gender and persistence on self-efficacy through use of a 2x2 ANOVA. There was no main effect of either gender or persistence. The data are presented in Table 10.

Table 10

Persisters, Non-Persisters, Gender Differences in Self-Efficacy

Source	Dependent variable	df	F	p
Gender (main effect)	Math self-efficacy	1,37	.343	.562
	Science self-efficacy	1,37	.445	.509
	Technology/computer science self-efficacy	1,37	.002	.962
Persistence or non-persistence (main effect)	Math self-efficacy	1,37	.491	.488
	Science self-efficacy	1,37	.643	.428
	Technology/computer science self-efficacy	1,37	.167	.685
Gender and persistence or non-persistence (interaction)	Math self-efficacy	1,37	.067	.798
	Science self-efficacy	1,37	.924	.343
	Technology/computer science self-efficacy	1,37	.418	.522

Question 5: *'Is there a significant difference in the self-efficacy levels between males and females across the STM programs?'*

Using a 2x3 ANOVA there was no interaction between gender and the STM programs on self-efficacy. There was a statistically significant difference in computer science self-efficacy among those in STM programs (p= .009) but there was no difference between males and females. From pair-wise comparisons, computer science self-efficacy was significantly higher for those in science than for those in math. No other comparisons were significant. Refer to table 11.

Table 11

Self-Efficacy Levels Across Programs

Source	Dependent variable	df	F	Sig (p)
Gender (main effect)	Math self-efficacy	1,28	.385	.540
	Science self-efficacy	1,28	.092	.764
	Technology/computer science self-efficacy	1,28	.057	.813
STM program (main effect)	Math self-efficacy	2,28	.218	.805
	Science self-efficacy	2,28	2.122	.139
	Technology/computer science self-efficacy	2,28	5.649	.009*
Gender and STM program (interaction)	Math self-efficacy	2,28	1.179	.322
	Science self-efficacy	2,28	.572	.571
	Technology/computer science self-efficacy	2,28	.226	.799

* Significant at $p \leq .10$

Question 6: a) *'Do certain demographic factors correlate with self-efficacy levels and persistence in STM programs?'* b) *'Are there additional factors which research indicates should be considered in examining the relationship between self-efficacy and persistence?'*

Question "6a" examined the relationship between self-efficacy levels and persistence while controlling for several sets of demographic factors through use of partial correlation:

1. *High school GPA and overall college GPA*: There is a significant positive correlation between math self-efficacy and persistence (p=.023) when controlling for high school GPA and overall college GPA.
2. *Mothers' and Fathers' education*: Even when controlling for parents education, there was no correlation between the variables.

3. *High school STM courses taken*: There was no correlation found between the variables when controlling for STM courses taken in high school.
4. *Number of college STM courses taken*: There was a statistically significant positive correlation between computer science self-efficacy and persistence (p= .094) when controlling for the number of STM courses taken in college.

To further explore question "6a" the same sets of factors as noted above were controlled for both males and females. The following results were found:

1. *High school GPA and overall college GPA:* When these are controlled for, there is a statistically significant positive correlation between math self-efficacy and persistence for males (r=.489, df=20, p=.021) and also a statistically significant positive correlation between computer science self-efficacy and persistence for males (r=.457, df=20, p=.033).
2. *Mothers' and fathers' education*: Even when controlling for parents education, there was still no correlation between the variables.
3. *High school STM courses taken:* When the number of STM courses taken in high school are controlled for there is a statistically significant negative correlation between science self-efficacy and persistence for females (r=-.642, df = 9, p=.033). Those who were non-persisters had higher science self-efficacy scores than did the persisters.
4. *Number of college STM courses taken:* No correlation was found between these variables for males and females who persist.

These findings, in summary, show that GPAs (both in high school and overall in college) are important positive factors in the relationship between self-efficacy and persistence for males in math and computer science ($r=.489$, $df=20$, $p=.021$; $r=.457$, $df=20$, $p=.033$). The number of high school STM courses taken is an important positive factor for females in the relationship between science self-efficacy and persistence.

For insight into question "6b" the Focus Group (Appendix B) responses as well as the open-ended responses and the rank ordering of factors influencing persistence contained in the *Student Inventory* (Appendix A) were analyzed for their alignment with the major contributing factors including: both high school and collegiate STM instructors; pre-collegiate and collegiate STM extra-curricular activities; pre-collegiate and collegiate STM course grades; advisors; mentors/role models; parents; interest in the field; course and/or work load in college; pre-collegiate and collegiate STM classroom experiences; external influences such as media, cultural mores and traditions; and other. The analysis of these open-ended responses (104 total) further explored these factors with the results noted in the following paragraphs.

For "Instructors" there were 14 responses, 13 of which were positive, relating to either pre-college and/or collegiate instructors' influence, seven from females and eleven from males. Five responses refer to the support offered by teachers in helping students with difficult classes, in leading to math/science path in college, in believing in and challenging students, and excellent teaching in high schools. One of these comments was a negative comment. Examples of these comments: "I had an 8^{th} grade math teacher who was very understanding;", "Teachers in my schools were the biggest sources of support, helping me with the content and with projects;", "High school teachers helped me with difficult classes, believed in me and challenged me;", "Some were close to retiring who were the worst or who were teaching out of their area", and "Some normally weren't willing to be flexible." Three refer to teachers at both levels providing excellent instruction who were very supportive and kept students on-task, and continued interest in biology. Examples of these include: "I had excellent teachers who were encouraging and great role models;", "I had great teachers in both high school and college who helped me stay on task and to continue on in biology." Eight responses dealt solely with collegiate instructors/professors, with five of those reflecting positive influences including professors' willingness to meet students outside class to explain course materials, and encouraging students to enroll in or persist in STM courses. Examples of the positive comments include: "I had professors who were willing to explain course material outside of class;", and "I picked up a chemistry major due to college professor." An example of the negative comments include: "Computer science classes are so poorly taught that students don't learn from instructors and have to rely on books which is infinitely harder."

For "Pre-collegiate and collegiate STM extra-curricular experiences," no responses were offered in this area.

In the areas of "Pre-collegiate and collegiate STM grades" there were ten responses, three related to excellent pre-collegiate STM grades while seven responses related to collegiate STM grades. Five responses were from females and five from males. Four of the seven responses related to collegiate grades indicated that excellent grades lead to higher levels of confidence in math and science courses, while one response indicated poor grades caused a switch in STM majors. Examples of the comments in this area include: "Getting As definitely has increased my confidence level;", "A B in Organic lab has increased my confidence in doing science;", "College grades caused me to drop physics and pick up biochemistry:", "I excelled in high school math and science."

For "Advisors" there were only two responses, one response from each gender. Of the two, one was entirely negative concerning advisor's lack of support. The other student's comments were mostly negative regarding advising, but they also related a positive experience with advisors in a local community college. The negative statements were: "My advisor did not think I could do Biology, no support from (name withheld) as she flat out thought I could not do it;", "I considered dropping due to one particular advisor who has been horrible and caused me to waste tens of thousands of dollars on classes I did not need and not qualified for. Junior college advisors were really good but I did not see them often and I am mislead by ISU advisor who is incompetent."

For "Mentor/role model" there was only one response from a female who commented that high school teachers were "excellent teachers, encouraging, and good role models. I want to provide the same for my students when I teach."

For "Parents" there were ten responses related to parental influence including their support and encouragement. Three responses were from females and the rest from males. Examples include: "My family fully supports educational decisions as they are strong believers in education;", "My parents – one main factor – as they are very supportive;" and "If my parents were not supportive I would have given up at some time." One student mentioned that his parents, "now ten years after military, are not as supportive as they had been earlier in my college career."

For "Interest in the field" there were eight responses related to interest as a motivating factor, with two from females and the rest from males. All indicated their interest in the field directly influenced their decision to persist. Two responses showed that when students lost interest, they switched to different programs with one staying in a STM field and one not. Examples of these comments include: "I like to study problems and find new solutions, how everything in science fits together like a big puzzle;", "Definitely must be interested in the field, if not interested then what is the point;", "I have persisted despite the workload due to interest in the subject matter;", "Interest in certain science field caused me to drop physics and pick up biochemistry."

For "Course and/or workload in college" there were four responses (all from males) indicating workload was a factor, not just from the coursework but also from jobs and marriage. A comment in this area was: "Workload is big factor as I get frustrated easily with big workload due to marriage and work taking time from school."

For "Pre-collegiate and collegiate classroom experiences" there were eleven responses, seven from females and four from males. Five responses indicated that positive pre-collegiate experiences helped students choose STM majors in college. Six responses indicated that they had positive experiences in college STM classes. Comments here include: "ISU actuarial classes prepares me to take professional exams;", "College classroom experiences have helped me stick with my program;", "I did well in high school classes which lead me to chemical engineering career choice;", and "Science research has helped me gain confidence in the material."

For "External (external refers to activities beyond typical classroom instruction) influences" there were fifteen mostly positive and widely varied responses (eight from females, seven from males) including: "Going to recycling plants and waste water plants lead me to wanting to make a difference to help the Earth;", "By not doing well on the PCAT I did not realize my dream of becoming a pharmacist but still wanted to do science so enrolled in the ISU Molecular Biology program;", "Great staff at ISU provides connections to me for entering graduate school;", "I want to go into bioinformatics to help sick people;", "to make more money;", "to get into vet school;", and "church, friends, school clubs, sisters who call offering support."

For "Other" there were 28 responses that discussed mostly positive factors influencing persistence in STM programs. There were 22 comments from females and six from males. These included: "Success in difficult science or really challenging courses;" (2), "Support from peers in the actuarial program;", "Grandma is the one who kept telling me to go back to school. She didn't want me to waste my talents as I did well in high school;", "I always loved science/biology/STM field;" (13), "I get much enjoyment when helping other students;",; "Math is the closest field to finishing my degree;", "job market;", "I have personal experience in nursing field which led me to switch out of biology;", "I want to be a pharmacist so I switched to chemistry;", and "I lacked maturity and discipline needed for the demanding field of biology when thrust into a new environment at an early age. This lead to me falling behind although I was confident of my math and science skills but lacked the discipline to display them."

In the rank ordering section of the *Student Inventory* (Appendix A) students ranked 15 factors according to their importance in their decisions to persist from 1-15 with 1 being the most important factor. The researcher categorized the responses according to the usage of each contributing factor contained herein. Thus some students' responses containing references to more than one contributing factor (also known as domains) were broken down into separate responses and categorized accordingly. The researcher anticipated an inverse relationship between the rankings and the number of responses devoted to them – with those items having lowest means scores (meaning they were of the most importance to students) generating the most number of responses devoted to them. Of these 15 factors, the factor students most selected as the number one factor was "interest in the field." This factor had the lowest mean = 2.79. This was to be expected by the researcher as the rank of 1 in importance equates with having the most responses devoted to it. There were eight responses which dealt directly with this factor as well as another 13 responses in the "other" domain which closely associated with developing this interest – love or enjoyment of the subject – for a total of 21 responses. Thus this factor generated the most responses. "Instructors" was second and third in importance (collegiate mean = 4.71, pre-collegiate mean = 4.97) with 14 responses in this domain. "Class experiences" were the fourth and fifth most important factors selected (collegiate mean= 5.14, pre-collegiate mean = 5.15) with 11 responses. "Collegiate grades" were sixth in importance; however with only seven responses related to this domain (mean = 5.59) a lower ranking would have been expected (or in reverse, a high number of responses were expected with this ranking). In addition when controlling for GPAs for both males and females, there is a significant correlation between math self-efficacy and persistence for males (p=.021) and also a significant correlation between computer science self-efficacy and persistence for males (p=.033). These correlations help to further support this ranking but would have anticipated more responses dealing with college grades. "Other" was the seventh most important domain selected (mean = 5.67) with a total of 15 responses in this category. This number of responses shows/illustrates where this factor lies in the ranking scheme. The next most important factor, ranking eighth, was "mentors/role models"; however, the importance of this ranking is not supported as there was only one response in this domain. "Pre-collegiate grades" was ninth in importance (mean = 6.02); however, with only three responses in this domain this ranking does not seem supported. "Parental influence" was the tenth most important factor (mean = 6.23) but with 10 responses a higher ranking would have been expected due to this number of responses. "Course or workload" was ranked eleventh in importance and with four responses this ranking is supported. "External influences" was twelfth in importance and with 15 entirely different responses in this domain this ranking is supported as there were no overlaps in what students viewed as external – beyond the typical classroom instruction- influences. "Advisor" was thirteenth in importance (mean = 8.63) with two responses which is expected as something of this lack of importance would not have much discussion. Last was "extra curricular experiences" (collegiate mean =9.38, pre-collegiate mean = 9.68) and neither had responses. The corresponding numbers of responses in this domain were expected as this domain was of least importance to students, thus they would not have written much about factors of little importance to them.

Analysis

Demographics of Study Participants

Of the 79 students who responded to the *Student Inventory* (Appendix A) there was an almost even split between males and females, 39 males and 40 females, ranging in age from 19 to 34 years. Of the respondents there is an equitable representation including almost 50-50% gender; a 70-30% split between persisters and non-persisters (56 persisters and 23 non-persisters) and a 50-29-21% split between STM programs: 28 science, 16 math, and 12 technology/computer science. In science there were 16 male and 12 female persisters; for math there were 11 female and 5 male persisters; for computer science/technology there were 3 females and 9 male persisters.

The findings of this research indicate that the respondents had overall well-rounded backgrounds in high school math and science, but few had taken courses in high school technology or specifically, computer science. The high school GPAs indicated students were in the A-B grade range: however in college, the STM fields' GPAs dropped to reflect B-C range. Few students had parents employed or who had majored in a STM field so that was not a factor in determining student persistence. Not having parents in STM fields did not affect students' exposure to or experiences with STM-related activities and resources in the home environment.

Research Questions

A summary of the contributing factors and their relationship to student self-efficacy and persistence in STM programs reveals the following insights into the research questions that were posed in this study. The contributing factors are grouped by factors related to all STM programs, factors related to gender and factors related to specific STM programs.

Question 2. *Is there a significant difference in self-efficacy across STM programs?* There was a significant difference in computer science self-efficacy across the STM programs with science and technology/computer science significantly higher than math. There was a significant difference in science self-efficacy across the STM programs with science and technology higher than math.

This finding was unexpected as there is no significant difference in the mean GPAs in the STM fields: (3.2 in the sciences, 3.1 in computer science, and 3.1 in math), something that research noted earlier by Schunk and Pajares (1997) along with Brown, Lent, and Larkin, (1989) found: that domain-specific, academic self-efficacy positively correlated with both grades and persistence. Additionally, students have taken significantly more math and science courses than technology/computer science so this finding is in further contradiction to Bandura's (1986, 1987) four foundations of his self-efficacy theory, later reinforced by research by Schunk and Pajares, (1997) in which it was found that the more experiences students have in taking courses the greater their skill level, the greater their perceptions about doing a job well, the more success they have in their accomplishments and thus their self-efficacy levels are increased. It is also contradictory to the finding by Gore, (2006) that college upperclassmen's self-efficacy beliefs are strongly related to persistence through the experiences gained by performing academic tasks. For example, how math is applied in science and computer science/technology may be one contributing factor – by not having math applications to reinforce math concepts, students will not have the experiences in the classroom to further increase their math self-efficacy.

Question 3. a) *Does self-efficacy significantly correlate with persistence in STM programs*? There was no correlation found between self-efficacy and persistence in the STM programs.

This finding was not altogether unexpected as not all of the research noted earlier in chapter two supported a consistently strong relationship between these two factors, with only 12% of variance in persistence accounted for by self-efficacy (Multon, Brown, and Lent, 1991)

Question 6. a) *Do certain demographic factors correlate with self-efficacy levels and persistence in STM programs*? b) *Are there additional factors which research indicates should be considered in examining the relationship between self-efficacy and persistence*?

a) A significant positive correlation between math self-efficacy and persistence was found when controlling for high school GPA and overall college GPA. In addition, there was a significant positive correlation between computer science self-efficacy and persistence when controlling for the number of STM courses taken in college. These findings were not entirely expected in that in a meta-analysis conducted by Robbins et al.

(2004) it was found that academic self-efficacy may account for as much as 14% of the variance in GPA for college students. Additionally it was found by Brown, Lent, and Larkin, (1989) that domain-specific, academic self-efficacy positively correlated with both grades and persistence. In their meta-analysis, Multon, Brown, and Lent (1991) state that for all thirty-nine of their studies, "self-efficacy beliefs accounted for approximately 14% of the difference in student performance and 12% of the variance in their academic persistence." What was unexpected was that only math and computer science self-efficacy were found to correlate to persistence.

b) The content analysis of the open-ended questions and rankings revealed that the factor students most often selected as number one in influencing their decision to persist was "interest in the field." This reinforces the ranking of this item as number one in the data captured by Seymour and Hewitt (1997) for reasons why students drop out of STEM programs (stated as "loss of interest" therein). With the least important factors being "extra-curricular experiences" the rankings and corresponding number of responses are very closely aligned, with the only outliers being: 1) the "mentor/role" domain which had a much more important ranking than the supporting number of responses related to it and 2) the "parental influence" domain which had a lower ranking than the corresponding number of responses it garnered and 3) 'collegiate grades" were sixth in importance; however, with only seven responses related to this domain (mean = 5.59) a lower ranking would have been expected (or in reverse, a high number of responses expected with that ranking).In addition when controlling for GPAs for both males and females there is a significant correlation between math self-efficacy and persistence for males and also a significant correlation between computer science self-efficacy and persistence for males . This would have supported the ranking but with only seven responses, it was out of line.

A ranking of the domain "workload" as 11th in importance does not reinforce Seymour and Hewitt's (1997) analysis of a ranking of 4. In addition, the ranking of "advising" as 13^{th} in importance does not reinforce Seymour and Hewitt (1997) whose analysis ranked this as 6^{th} in importance.

Figures 2 and 3 outline the significant differences between males and females in the relationship between contributing factors, self-efficacy, and program persistence. Figure 2 shows the relationships for females, in which the domains found from the qualitative methodology to be most important to females in their decision to persist are listed as "Contributing Factors" at the top of the figure. The bottom of the figure illustrates the significant finding from the quantitative methodology: that persistence is correlated with science self-efficacy when controlling for the number of high school STM courses.

Figure 3 illustrates the relationships for males, in which the domains found from the qualitative methodology to be most important to males in their decision to persist are listed as "Contributing Factors" at the top of the figure. The bottom of the figure illustrates the significant findings from the quantitative methodology: that persistence is correlated with computer science and math self-efficacy when controlling for high school GPA and overall college GPA. The analysis is devoted to these relationships. Differences between the genders can be seen by the nature of the importance in the contributing factors with females giving more importance to "other" responses as well as "collegiate

STM experiences" and males more importance to "course/workload." In addition statistical significance differed as females only significant correlation with persistence and self-efficacy was in science controlling for the number of high school courses taken ; while males significance lies in controlling for GPAs with math and computer science self-efficacy (see pages 89 and 90).

Question 1. *Is there a difference between male and female levels of self-efficacy in STM programs*? There was a significant difference between males and females in math self-efficacy and science self-efficacy with females having higher self-efficacy than males. There were no differences between males and females in computer science self-efficacy.

The finding that females had higher self-efficacy than males in math and science was unexpected due to the fact that, as persisters, they all have roughly the same amount of courses and academic successes in their programs. The fact that only a few students were computer science/technology majors may have led to the "no difference" finding in that field.

Question 3. a) *Does self-efficacy significantly correlate with persistence in STM programs*? b) *If so, does it have the same significance for both males and females across STM programs*? When looking at genders across STM programs, there was a significant correlation between science self-efficacy and persistence for females with female non-persisters having higher self-efficacy in science.

The finding that female non-persisters have higher self-efficacy in science was unexpected, as reported by Pajares (1997) and Bandura (1986, 1997) students who actually accomplish positive academic results do so from their beliefs in what they have and can accomplish. Thus, one would think that those students who persist would have more experiences leading to increased beliefs in their academic accomplishments in science. This phenomenon was not revealed in this study.

Question 4. *Is there a significant difference in the self-efficacy levels between males and females who persist in STM programs as compared to non-persisters*? No interaction was found between gender and persistence on self-efficacy. There was no main effect of either gender or persistence. This outcome is expected in light of the finding that overall there was no relationship between self-efficacy and persistence in STM programs.

Question 5. *Is there a significant difference in the self-efficacy levels between males and females across the STM programs*? There was no interaction between gender and the STM programs on self-efficacy. There was a significant difference in computer science self-efficacy among those in STM programs but there was no difference between males and females. From pair-wise comparisons, computer science self-efficacy was significantly higher for those in science than for those in math. No other comparisons were significant.

Question 6. a) *Do certain demographic factors correlate with self-efficacy levels and persistence in STM programs*? b) *Are there additional factors which research indicates should be considered in examining the relationship between self-efficacy and persistence*? To further explore question "6a,"the same sets of factors as noted above were controlled for both for males and for females. When high school GPA and overall college GPA are controlled for males and for females, there is a significant positive correlation between math self-efficacy and persistence for males and also a significant positive correlation between computer science self-efficacy and persistence for males.

This finding was expected since research has shown that starting even before high school, males tend to out-perform females in both grades and self-efficacy levels in STM fields. (DeBaker and Nelson (1999); Smist, Archambault and Owen, (1997); Schunk and Pajares (1997); and Wilson (2003).

Differences between the number of male and female responses for any domain were few, with outliers being "pre-collegiate and collegiate experiences" where almost twice as many responses came from females; "other" where there were almost four times as many responses from females, including: succeeding in difficult or challenging courses (2); support from peers; support from grandmother; having always enjoyed or loved science/processes of science (5); biology, and math; thinking math is beautiful; enjoy working and helping students; natural ability in math and science; passing on love of math to future students by teaching. "Parental influence" was responded to by over twice as many males than females and the four "course/workload" responses were solely from males. Societal mores may have an influence on these two domains as males traditionally see their roles as heads-of-households or being the major wage earners. In addition to being students, these males are under great pressure from their roles as heads-of-households so one would expect responses in this domain from married males. Additionally, as heads of families, their fathers may exert/have exerted pressure on their sons to get a good education so as to get good jobs and to continue on as future heads-of-the-household. In addition, these factors were identified in chapter 2 by Polson Research Services (2003) as experiences that upperclassmen may find come into play in their decisions to persist or not. However, having only males respond to the workload factor was surprising to the researcher as it was noted earlier by Santiago and Emerson (199) that female students were more concerned with issues regarding combining careers with marriage.

Figure 4 illustrates the relationship between persistence, the rankings and corresponding number of responses in the domains from the qualitative methodology by STM program. "Contributing Factors" are the responses garnered from this methodology. From the content analysis the following factors were viewed as important influences (with more than one response) by STM program:

1. *Science*: instructors, college grades, interest in the field, course/work load, college STM classroom experiences, parents, people other than parents, instructors, wanting to teach others, going on to professional schools, monetary gain, loved/enjoyed science/process of science
2. *Mathematics*: pre-collegiate grades, high school STM experiences, college STM classroom experiences, passing professional exams, love/enjoy math, support from people other than parents, instructors
3. *Computer Science/Technology*: negative experience at Illinois State with departmental advisor and instructors, interest in the field (negative and positive responses), work/workload.

The same high rankings from the overall 79 respondents were reflected in science and mathematics majors. Since these majors were represented by the most numbers of students these rankings would be expected. It was unexpected to have such negative experiences offered by the computer science majors (2). That these majors were few in number is reflected by the fewer responses in just a few domains. It may have also been the fact that negative experiences eclipsed any positive comments that might have been made had not the negative so outweighed them.

Data from the quantitative methodology utilizing pair-wise comparisons found that computer science self-efficacy was significantly higher for those in science than for those in math. This finding was surprising in that math and computer science share many of the same underlying thought processes which Wing, 2006 summarized in saying that "computer science formal foundations rest on mathematics" (Wing 2006, p. 35).

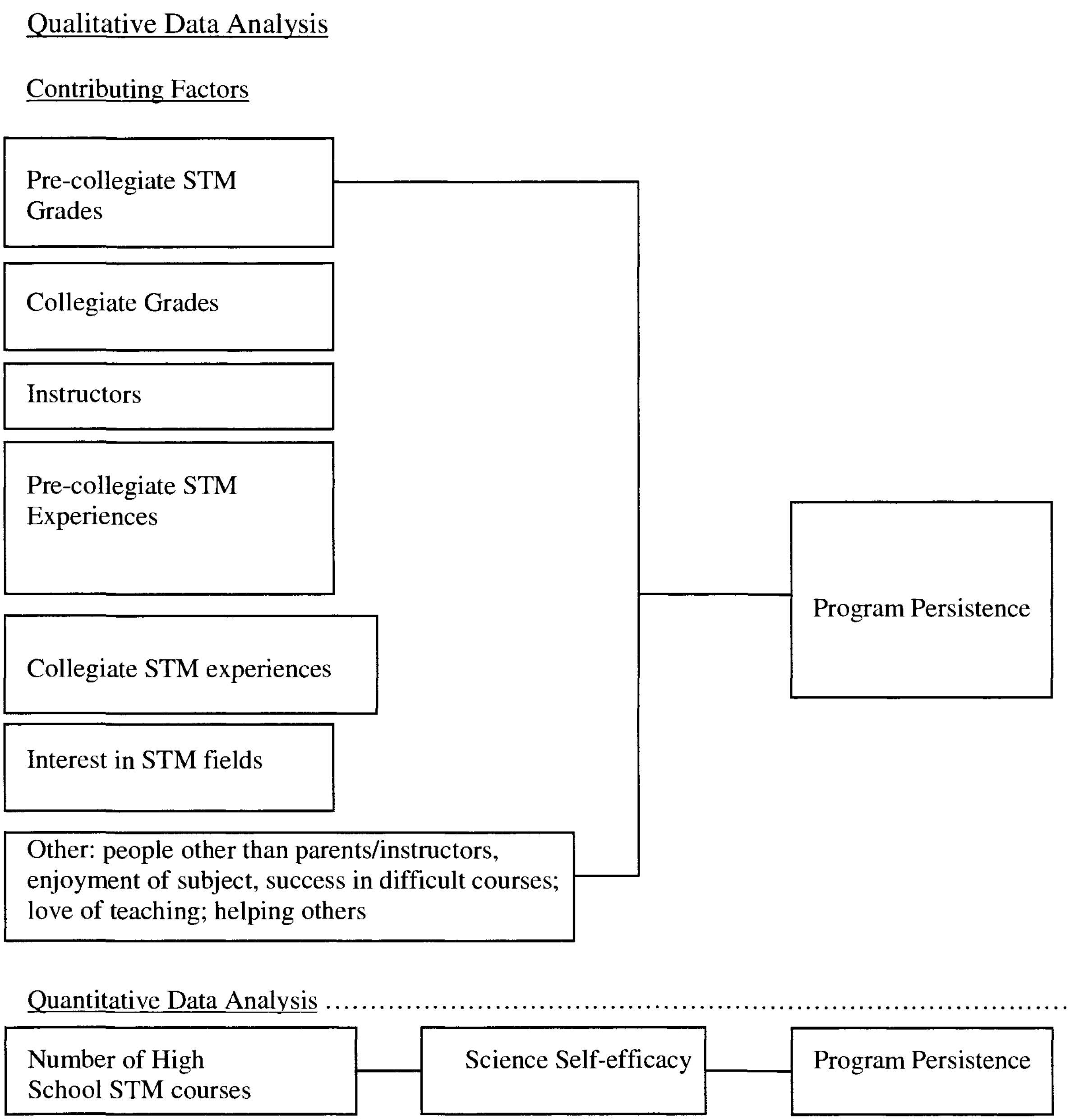

Figure 2. Model for contributing factors and their relationship to student self-efficacy and persistence in STM programs for females.

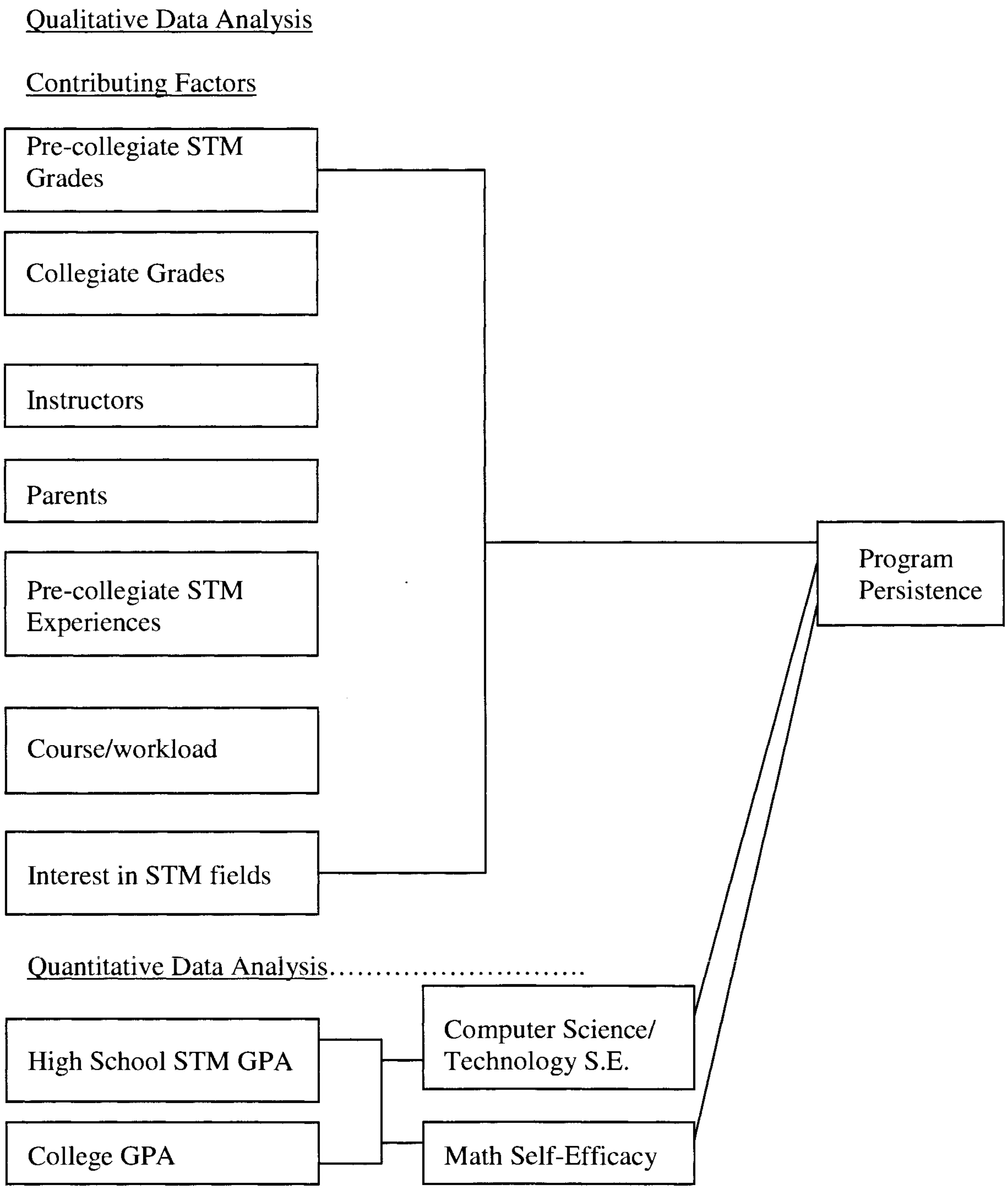

Figure 3. Model for contributing factors and their relationship to student self-efficacy and persistence in STM programs for males.

Contributing Factors

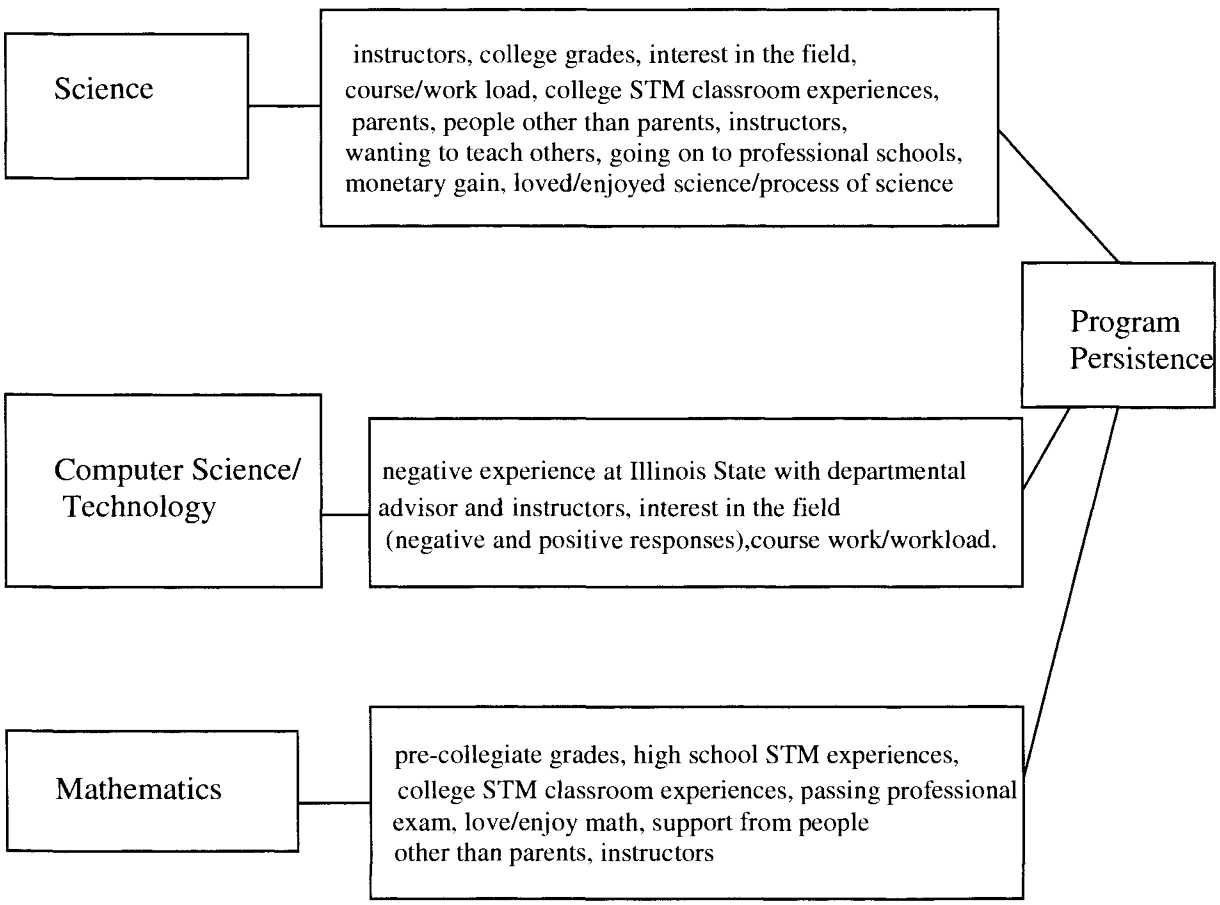

Figure 4. Model for contributing factors and their relationship to persistence in STM programs by STM program.

CHAPTER V

MAJOR FINDINGS, IMPLICATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The purpose of this study is to provide an examination of factors correlating with STM students' levels of academic self-efficacy and the relationship between these levels and persistence in STM programs. Variables examined included gender, persistence and non-persistence, as well as a variety of descriptive factors related to self-efficacy and persistence.

Few studies exist at the collegiate level linking self-efficacy with academic performance and persistence in college, particularly with upperclassmen in STEM programs. Although the number of factors influencing the academic self-efficacy and persistence of STM students examined in this research is considerable, it is not an exhaustible list. The data does reveal findings that both support the research in these areas but which also brings into question prior research findings. Additionally, it adds to the limited body of evidence linking self-efficacy with academic performance in STM programs by upperclassmen and persistence at the college level. Several findings that emerge from this study related to factors influencing self-efficacy and persistence will be summarized in this chapter. Additionally, how this study's results lend to future research as well as implications for future directions in STM program policies and programs will be examined.

Findings and Implications Regarding Self-Efficacy and Persistence Across STM Programs

Overall, across STM programs: a) there was a significant difference in computer science self-efficacy with science and technology/computer science significantly higher than math; and b) there was a significant difference in science self-efficacy across the STM programs with science and technology/computer science higher than math. In that this finding contradicted research noted earlier by Pajares and Schunk along with Brown, Lent, and Larkin, (1989) who found that domain-specific, academic self-efficacy positively correlated with both grades and persistence, but in this study there was no difference in the GPAs across the fields. Additionally, students have taken significantly more math and science courses than they have in technology/computer science so this finding is in further contradiction to Bandura's (1986, 1987) four foundations of his self-efficacy theory, later reinforced by research by Schunk and Pajares, (1997). That study found that the more experiences students have in taking courses, the greater their skill level, the greater their perceptions about doing a job well, the more success they have in their accomplishments and thus self-efficacy levels are increased.

Although this researcher does not have complete information regarding why these findings occurred, some possible reasons include the following: Could it be that there are more computer technology applications in science than in math? Or could it be due to the increased use of computer science/technology by students outside of the classroom lends to more applicability in this area, whereas in real life, there are limited, practical applications of mathematics?

Other possible reasons involve the instrumentation and methodology used in this study. In the self-efficacy section of the "Student Inventory" questions were devoted solely to the classroom and not to real life uses and applications. On this scale the non-applicable response was recorded as missing data and that could affect correlations as only the students answering all items were counted in the analysis. In addition, computer science had fewer participants so this could have also affected the data.

Findings and Implications Regarding Gender Differences

Several important findings of this study relate to gender differences in levels of self-efficacy and persistence: a) there was a significant difference found between males and females in math and science self-efficacy with females having higher self-efficacy than males. In focusing further on females and science self-efficacy, there was a significant negative correlation found between science self-efficacy and persistence with female non-persisters having higher self-efficacy in science than female persisters; b) no interaction was found between gender and persistence on self-efficacy. There was no main effect of either gender or persistence and there was no interaction between gender and the STM programs on self-efficacy; c) there was a significant difference in technology/computer science self-efficacy among those in STM programs but there was no difference between males and females; d) when high school GPA and overall college GPA are controlled for males and for females, a significant correlation between math self-efficacy and persistence for males and also a significant correlation between computer science self-efficacy and persistence for males were found; and e) when the number of STM courses taken in high school are controlled for a significant positive correlation between science self-efficacy and persistence for females was found.

These findings suggest that more research into the area of self-efficacy and persistence in STM programs be conducted as several of these findings refuted or draw into question data accumulated in prior research in this area. The following explains this in some detail.

These gender findings, including higher self-efficacy for females in math and science as well as the correlation between science self-efficacy and persistence for females were unexpected in that research quoted in chapter two of this study (DeBaker and Nelson, 1999; Kennedy, 1996; Schunk and Pajares, 1997; Smist, Archambault, and Owen, 1997; and Wilson, 2003) found that women and men have differing levels of self-efficacy especially in mathematics and science. Beginning in the middle school years, the lowering of female self-efficacy beliefs, aptitude, and interest continues on with a lack of persistence in college STM programs.

In addition the finding that the female, non-persisters in science had higher science self-efficacy than did female persisters refutes the foundation for Bandura's (1986, 1997) self-efficacy theory. This theory, later reinforced by Schunk and Pajares (1997), found that experiences gained by performing academic tasks, getting feedback, and seeing others' performances leads students to greater self-efficacy and to persistence. In no longer being science majors and thus no longer engaged in any science-related academic tasks, one would have thought that the female non-persisters would have lowered self-efficacy.

Possible reasons for these unexpected findings include the nature of the learning environment as to the types of pedagogy experienced by the female math and science participants as well as the gender of the instructors –if instructors are female do they contribute to persistence as role models or mentors and to what degree? In addition and not to be overlooked is the small number of participants involved in this study. Larger numbers may provide entirely different results to any of this study's research questions.

The implication one is left with from this study's results is that self-efficacy may be a 'minor' contributor to persistence - that there are other 'major' contributors to non-persistence such as poor STM academic achievement, loss of interest/love for the chosen STM field, or familial constraints.

Recommendations for Future Research

Further research is suggested to find why: 1) math self-efficacy was consistently lower than the two other programs when students across programs have the least experience with computer science/technology, and 2) there are significant differences in females' levels of science and math self-efficacy when persisters and non-persisters are compared as well as by gender. This could be accomplished by further examining the nature of other 'major' contributors to non-persistence (i.e., poor academic achievement, loss of interest/love for the chosen field or familial constraints). Additionally, recommendations for the design of future research would include: 1) using causal modeling to find out any significant linkages; 2) using a longitudinal study to identify factors that influence persistence, aimed at gathering data immediately following or, in the best scenario, preceding students' decisions to not persist in a STM program.

Especially important would be keeping students in college who have dropped completely by re-focusing their interests either in a different STM field or in other majors; and 3) the incorporation of a broad sampling of STM students across several teacher education institutions in various locations across Illinois and the country. Coordination between STM teacher education faculty as well as science and technology-based businesses would be prudent as business' input is needed on these issues to maintain the highly educated and skilled workforce needed for the future. Research on this topic conducted through these types of longitudinal studies would find out if persistence issues are specific to this institution or are shared by institutions across the state and nation.

To replicate this research in future studies, this researcher would recommend applying the following methodologies:

1. Utilize a similar questionnaire including the self-efficacy sub-scale of the *Motivated Strategies for Learning Questionnaire* as it remains consistently valid and reliable and is easily accessed because it is a public domain instrument;
2. Use a mixture of both quantitative and qualitative methods, expanding the qualitative methods to include interviews with faculty regarding their knowledge and perceptions concerning the problems and issues of this study;
3. Capture focus group data more effectively so there is more and higher quality dialogue or discussion; possibly use face-to-face or a synchronous web-board to provide a richer, more dynamic process; and
4. Use *Survey Monkey* as it is very user-friendly and relatively inexpensive.

The researcher would recommend another way to recruit participants – ideally seeking the assistance of STM faculty to distribute the questionnaire in select classrooms or by personally distributing the instruments in classrooms where faculty have granted permission. In addition, gathering a cadre of female STM professors together to discuss their perceptions of issues related to gender differences uncovered in this study (and in related research studies) would be another way to get more input on factors which correlate with student persistence.

Implications for STM Program Policies and Procedures

Beginning in the middle schools and through high schools, counselors, STM teachers, and administrators should find the information garnered quite relevant concerning females and the number of science courses taken, as well as high school STM grades. Thus, many counselors and teachers at these levels should find ways to encourage their female students to take more STM courses in high school and to assist them in maintaining good grades. Examples of some of the ways to meet this goal would be by incorporating pedagogy which females excel in, such as activities that focus more cooperation and less on competition, and exposing high school students to what scientists and mathematicians actually do in their fields. The faculty from the college STM and STM education programs should take an active role in assisting with these activities.

Collegiate STM departments should find these results interesting, particularly when reviewing admission criteria, especially in regards to high school grades and the number of courses taken in STM fields. Increased lines of communication between pre-collegiate and collegiate advisors/counselors, teachers and instructors could help to increase the recruitment, enrollment, and persistence by students in collegiate STM programs. STM departmental advisors would also find it useful to be cognizant of the relationship between the contributing factors found in the college environment. Some of the more important of these include: instructors, college grades/GPA, students' interest/love of /enjoyment of these fields, as well as classroom experiences. Knowledge of these factors and their relationship to persistence should be integral in the student advisement process as this study has indicated that there exists a relationship between these factors and levels of self-efficacy and persistence among male and female students. Thus systematic conversations between advisors and advisees – either on a one-on-one or in small groups should occur to elicit students' concerns and suggestions in regard to issues detailed in this study. Advisors can then share this information with STM instructors and also facilitate discussions with STM departments and educational faculty on these issues and ways to address them. Such discussions that reveal influences to the positive or negative in these areas can lead to suggestions, changes, or advice about ways faculty and advisors can help students persist in their choice of study. Additionally, this information would be useful in guiding students to different STM (or other) majors.

In addition, all STM departments with the help of STM educators should examine the pedagogical approaches as well as curriculum design used in their programs. As identified earlier, the cadre of female professors is a needed extension to the qualitative methodology. These faculty members should be involved in this discussion. In this way, departments can explore the application of current pedagogical approaches and curriculum alignment which maintain or increase students' interest/love of the subject and which foster a high level of academic performance and persistence, especially for females. Assisting instructors and faculty in the use of such applications should be a part of new (and continuing) faculty professional development as an ongoing process, not just a one-time introduction. This professional development should be facilitated by STM and STM education faculty who teach using proven methods for increasing/maintaining student interest, academic achievement, and persistence.

STM departments can also use this study's findings as part of overall STM departmental evaluation programs through which departments maintain systematic, ongoing evaluations. Evaluation data could be collected through systematic, anonymous instruments as well as "end-of-the-term" instructor evaluations and post-graduation (or near graduation) program evaluations. Thus, on-going monitoring of programs can assess early-on, factors which may influence students' decisions on whether or not to persist in their chosen STM field. STM department advisors should use this information to advise students in a proactive manner when dealing with issues related to students' academic performance and persistence. Often advisors are not aware of issues until students have already committed to dropping out of their programs. Thus, regular monitoring of the program combined with discussions in and amongst departments, on-going assistance to faculty on appropriate pedagogical approaches, and proactive attention to advisees' issues in regards to persistence would aid in limiting attrition from STM programs.

Post Study Limitations

In hindsight there were a few changes that would be employed in any future research on this topic. The following discusses what limitations were encountered once the study was begun, identification of contributing factors to these limitations, as well as suggestions for alternate methods in future research.

The most important limitation to this study was the low response rate; 56 persisters and 23 non-persisters. This amounted to an approximate 10% return rate, thus limiting the applicability of this study's results. This low response rate was due, in part, to the researcher not being on campus to directly recruit students enrolled in STM courses or by not working with faculty to distribute questionnaires. Another factor which may have contributed to this limitation was that the researcher did not offer an incentive for student participation.

An additional factor was the issue of recruitment of the non-persisters. Using mailed questionnaires to last known addresses resulted in many non-deliverable, unopened returns. One way of increasing this population might have involved "googling" or "fingering" through the internet to identify current email addresses of these students.

In addition, by not being on campus to conduct the face-to-face focus group, a limited amount of responses were garnered through this methodology. If the researcher had been present or had chosen to use web-based synchronous discussion (as opposed to asynchronous) further dialogue amongst participants might have occurred. In addition, recruitment here could have also involved some sort of monetary (or other) incentive for participation in the focus group above that offered for completion of the *Student Inventory*.

Another limitation was the use of a correlational study. In a future study, using casual modeling measures to expand upon this research by allowing other variables to emerge that effect persistence other than solely self-efficacy would be prudent.

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APPENDIX A

STUDENT APPRAISAL INVENTORY

Student Appraisal Inventory
By

Jennifer K. Grogg, Candidate for the EdD
Dept of Curriculum and Instruction
Illinois State University
Normal, IL

I am a doctoral student at Illinois State University who is concerned about how students persist in their study of science, mathematics or computer science. I am studying the effects of student judgments about their capabilities to do well in math, science, and computer science programs and their persistence in these programs at ISU.

You have been identified as either a current or past major in a math, science, or computer science program at Illinois State University. I am asking for your participation in this research study by completing the following inventory. In addition I am seeking volunteers to participate in an asynchronous, on-line discussion group as a follow-up to this inventory. Your involvement in the completion of the inventory and the focus group follow-up is a one-time effort, your participation is voluntary, and unfortunately there is no financial stipend for your participation. Your reward is knowing you helped expand the base of knowledge related to this study.

There is no way of identifying you from the inventory, your email addresses will not be shared with anyone and your responses are kept confidential. The results will be analyzed solely for research pertaining to my dissertation or follow-up paper(s). None of your responses will be shared by anyone outside of the professors who are assisting with this research.

The attached inventory asks about your background, your skills at judging your capabilities to do well **ONLY** in math, science, and computer science classes, and factors influencing your decision to either persist or drop or switch out of these majors. **There are no right or wrong answers to this questionnaire.**

There is no penalty what-so-ever if you do not decide to participate. I want you to be as honest as possible in your answers. I would estimate this should take you no more than 15 minutes to complete.

Should you have any questions, you can reach me at my ISU email address, my major professor, Dr. Tom Haynes, at tshayne@ilstu.edu or the Office of Research Ethics and Compliance at: (309) 438-2520.

By adhering your electronic signature (or name) to this form and submitting it with your completed questionnaire, you have granted your consent to be a part of this study.

Your name: ______________________________ Date: ________________

Thank-you in advance for your anticipated participation in my study.

Yours in quality education,

Jennifer K. Grogg, Candidate for the EdD
Illinois State University
Dept of Curriculum and Instruction
Email: jgrogg@ilstu.edu

Student Appraisal Inventory

Part I: Background Information

This section seeks information about your background and influences on your selection of a science, math, and computer science major. Please answer honestly all questions.

1. **My sex is:** **male ______** **female ____**

2. **My age is: _______**

3. **My major program of study is:** **mathematics ____** **science ____**

   technology _____ computer science ____ other: (name) ___________________

   I am currently not enrolled: _____

4. **I once did major in: mathematics _____ science ____ technology ____**

   computer science _____

5. **Number of courses taken in high school in:**

A. science:	**# of courses:**	**______**
B. math	**# of courses:**	**______**
C. technology (not computer science)	**# of courses:**	**______**
D. computer science	**# of courses:**	**______**

6. **My high school GPA was:** **_____**

7. **My ACT score was:** **_____**

8. **Number of courses and average GPA (on a 4 pt scale) taken thus far in college in:**

A. science:	**# of courses:**	**______**	**average science GPA:**	**_____**
B. math:	**# of courses:**	**______**	**average math GPA:**	**_____**
C. computer science:	**# of courses:**	**______**	**average C. S. GPA:**	**_____**
D. technology:	**# of courses:**	**______**	**average tech. GPA:**	**_____**

E. overall GPA: _____

9. Parental level of education and major. Please indicate for each parent (or whomever you consider as raising you through high school) the following:

a). Father (or other male father-figure in your household):
education level: high school only _____ some college _____ a BS degree _____
advanced degree ____

If you checked anything other than "high school only", what was his major/area of study? ________________________________

b) Father's career field ____.

c). mother (or other female mother-figure in your household):
education level: high school only _____ some college _____ a BS degree _____
advanced degree ____

If you checked anything other than "high school only", what was her major/area of study? ________________________________

d). Mother's career field____.

10. Growing up, did you have (or do) any of the following (check all that apply):

____ parents (or parental figures) who read to you
____ books at home
____ educational toys/games at home which you played with besides a computer
____ participation in science, math, technology, computer clubs
____ participation in non-academic clubs/organizations (i.e. scouting, 4-H, etc)
____ trips/vacations with family
____ a home computer

Part II.

This section asks about your ability to self-reflect on whether you can/did accomplish a task and your confidence in your skills to perform that task. Use the same scale for all questions in this section. If you are currently NOT taking or will NOT be taking any science, math and computer science classes in the future, think back to your last classes. If you think the statement is/was very true of you, circle 5. If not at all true, circle 1. If you think the statement is/was sometimes true of you, circle the number (2, 3, or 4) that best describes/described you. Please respond to all of the questions/statements which pertain to you. If a question/statement does not pertain to you circle n/a.

1	2	3	4	5	6
not at all true of me			**somewhat true of me**	**very true of me**	**n/a**

1. I believe I will or did receive an excellent grade in my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
2. I believe I will or did receive an excellent grade in my current/upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
3. I believe I will or did receive an excellent grade in my current/ upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
4. I am certain I can or did understand the most difficult material presented in the readings for my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
5. I am certain I can or did understand the most difficult material presented in the readings for my current/upcoming (or past)science class.	**1**	**2**	**3**	**4**	**5**	**6**
6. I am certain I can or did understand the most difficult material presented in the readings for my current/upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
7. I'm confident I can or did understand the basic concepts taught in my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
8. I'm confident I can or did understand the basic concepts taught in my current/upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
9. I'm confident I can or did understand the basic concepts taught in my current/upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
10. I'm confident I can or did understand the most complex material presented by the instructor in my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**

11. I'm confident I can or did understand the most complex material presented by the instructor in my current/ upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
12. I'm confident I can or did understand the most complex material presented by the instructor in my current/upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
13. I'm confident I can do or did an excellent job on the assignments and tests in my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
14. I'm confident I can do or did an excellent job on the assignments and tests in my current/upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
15. I'm confident I can do or did an excellent job on the assignments and tests in my current/ upcoming (or past)) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
16. I'm certain I can or did master the skills being taught in my current/upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
17. I'm certain I can or did master the skills being taught in my current/upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
18. I'm certain I can or did master the skills being taught in my current/upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
19. I expect(ed) to do well in my current/ upcoming (or past) math class.	**1**	**2**	**3**	**4**	**5**	**6**
20. I expect(ed) to do well in my current/ upcoming (or past) science class.	**1**	**2**	**3**	**4**	**5**	**6**
21. I expect(ed) to do well in my current/ upcoming (or past) computer science class.	**1**	**2**	**3**	**4**	**5**	**6**
22. Considering the difficulty of my current/upcoming (or past) math class, the teacher, and my skills, I think/thought I will do or did well in my class.	**1**	**2**	**3**	**4**	**5**	**6**

23. Considering the difficulty of my current/upcoming (or past) science class, the teacher, and my skills, I think/though I will do or did well in my class.	**1**	**2**	**3**	**4**	**5**	**6**
24. Considering the difficulty of my current/upcoming (or past) computer science class, the teacher, and my skills, I think/thought I will do well or did well in my class.	**1**	**2**	**3**	**4**	**5**	**6**

From *The Motivated Strategies for Learning Questionnaire* by P. Pintrich, 1991. The authors have "located the Motivated Strategies for Learning Questionnaire in the public domain- readily used by researchers in whatever ways to meet the needs of potential users…we encourage users to use the questionnaire in its entirety or to select whatever subscales are most relevant for their purposes, in whatever form is most practical". (The Making of the Motivated Strategies for Learning Questionnaire. *Ducan & McKeachie. Educational Psychologist, 40(2),* p.120*)*

Part III. Factors influencing your decision to persist or drop/switch out of science, mathematics, or computer science program.

Please indicate by rank ordering (with 1 being the most important, and 13 the least important)the factors which have influenced your decision to persist or drop/switch out of a science, mathematics, or computer science major. If can rank more than one factor with the same number if you feel they are of equal importance. Any which you feel were NOT AT ALL AN INFLUENCE YOUCAN MARK "N/A".

____ pre-collegiate science, mathematics, or computer science course instructors

____ pre-collegiate STM extra-curricular experiences (i.e. clubs, organizations)

____ pre-collegiate science, math, or computer science grades

____ advisors

____ collegiate science, mathematics, and computer science instructors

____ collegiate math, science, or computer science grades

____ collegiate extracurricular experiences (i.e. clubs, organizations)

____ mentors /role models

____ parental (or others who raised me) influence on my college career

____ interest in the field

____ course and/or work load during college

____ high school classroom experiences in science, mathematics, or computer science

____ collegiate classroom experiences in science, mathematics, or computer sciences

____ external influences other than parents, teachers, advisors, or mentors (i.e. media portrayal, cultural mores and traditions, etc.

____ other: please explain: ____

____

Part IV. Explanatory question.

Please elaborate on any of the factors indicated above (or any others) which you feel play an especially important role in forming your decision to persist or drop/switch out of a science, mathematics, or computer science major.

PLEASE CHECK BELOW IF YOU WOULD BE ABLE TO PARTICIPATE IN THE INTERNET FOCUS GROUP WHICH WILL BE SET UP FROM _____ TO _____.

____ YES, I WOULD LIKE TO BE A PART OF THE FOCUS GROUP

PLEASE PROVIDE YOUR EMAIL ADDRESS FOR FURTHER CONTACT/INFORMATION FROM ME:

YOU ARE NOW FINISHED WITH THE INVENTORY. THANK-YOU SO MUCH FOR YOUR INVOLVEMENT IN MY RESEARCH.

APPENDIX B

FOCUS GROUP INFORMATION

Focus Group Instructions

During the week of September 21-28th, 2008 a web-board will be opened for you, the focus group participants, to discuss the inventory follow-up questions which offer you a chance to give more detailed information about your college careers.

Please note that you are to log on using the assigned code which is provided here. Your code is: ____. On June 14th the web-board will be open, the link to the web-board is: ________________.

This is an asynchronous discussion so whenever you are free to respond you can do so. Please take the time over the course of the week to answer not only the questions I have posted but to respond to AT LEAST ONE OTHER STUDENT RESPONSE. I will periodically check on the progress of the discussion and may interject more questions mid-week. I would suggest entering the discussion if at all possible before and after the mid-point to check on any additional questions that may have arisen from the discussions.

In the early morning of September 29th, I will review and download the discussion responses and close the site. No-one will know of your responses other than me.

I thank-you in advance for participating in this research, and should there be any questions you can email me at: jgrogg@ilstu.edu.

Focus Group Questions:

1. **Looking back over your college career what were some of the milestone events that stand out in your decision to persist or drop/switch out of a STM major?**
2. **Do you feel more confident in your abilities to do well academically now as opposed to your freshmen year? A) If yes, what do you feel are the milestone events in gaining more confidence in your abilities to do well in science, math, and technology/computer science courses? B) If no, what have been the most important obstacles to increasing your confidence?**
3. **What supports were there to help you persist or would have helped you persist in a STM major?**

APPENDIX C

INSTITUTIONAL REVIEW BOARD (IRB) DOCUMENTS

June 6, 2008

Thomas Haynes
C&I 5330
tshayne@ilstu.edu

Thank you for submitting the research protocol titled I Think I Can, I Think I Can…I Know I Can't; Academic Self-Efficacy and its Relationship to Attrition/Persistence in Science, Mathematics, and Computer Science Programs for review by the Illinois State University Institutional Review Board (IRB). The IRB has reviewed this research protocol and effective 6/6/2008, has classified this protocol as Exempt from Further Review.

This protocol has been given the IRB number 2008-0176. This number should be used in all correspondence with the IRB.

This classification of this protocol as Exempt from Further Review is valid only for the research activities, timeline, and subjects described in the above named protocol. IRB policy requires that any changes to this protocol be reported to, and approved by, the IRB before being implemented. You are also required to inform the IRB immediately of any problems encountered that could adversely affect the health or welfare of the subjects in this study. Please contact Joseph Casto, PhD, Assistant Director of Research, at 438-2520 or myself in the event of an emergency. All correspondence should be sent to:

Institutional Review Board
Campus Box 3330
Professional Development Building
Telephone: 438-2529

It is your responsibility to notify all co-investigators (Jennifer Grogg), including students, of the classification of this protocol as soon as possible.

Thank you for your assistance, and the best of success with your research.

Gary Creasey, Chairperson
Institutional Review Board
Telephone: 438-8139

cc: Alan Bates, Department Rep, 5330

IRB Number ____________ (Number to be completed by RSP)

Illinois State University Institutional Review Board Research with Human Subjects Protocol Submission Form

Federal regulations and Illinois State University policy require that all research involving humans as subjects be reviewed and approved by the University Institutional Review Board (IRB). Any person (ISU faculty member, staff member, student, or other person) wanting to engage in human subject research at or through Illinois State University must receive written approval from the IRB before conducting research. For more information, templates, and forms please go to www.rsp.ilstu.edu

Please complete and forward this form and all supporting documents to your Department/Unit IRB representative. If you have any questions, please contact your Departmental/Unit IRB representative or the Research and Sponsored Programs Office (RSP), 438-8451, Campus Box 3040

I. General Information

A. Protocol Information
Protocol Title: I Think I Can, I Think I Can.... I Know I Can't: Academic Self-Efficacy and its Relationship to Attrition/Persistence in Science Mathematics and Computer Science Programs
Is this research part of a thesis or dissertation proposal? ☐ No ■ Yes If yes, has the thesis or dissertation proposal been approved? ☐ No ■ Yes

B. Principal Investigator Information (PI must be an ISU faculty or staff member)			
Principal Investigator	**Dr. Tom Haynes**	Department	**Curriculum and Instruction**
Telephone Number	**309-438-2137**	Email Address	**tshayne@ilstu.edu**
Fax Number		Mailing Address	**Campus Box 5330**
Co-Principal Investigator Information			
Co- Principal Investigator	Ms. Jennifer Grogg	Department	Curriculum and Instruction
Telephone Number		Email Address	
☐ Faculty ☐ Staff ■ Graduate Student		Mailing Address	
Co-Principal Investigator Information			
Co- Principal Investigator		Department	
Telephone Number		Email Address	
☐ Faculty ☐ Staff ☐ Graduate Student		Mailing Address	

II. Principal Investigator Assurance

As Principal Investigator I certify that:

1. The information provided for this project is correct
2. No other procedures will be used in this protocol
3. I agree to conduct this research as described in the attached supporting documents
4. I will request and receive approval from the IRB for changes prior to implementing these changes. (including but not limited to changes in cooperating investigators, as well as any changes in procedures)
5. I will comply with the IRB and ISU policy for the conduct of ethical research.
6. I will be responsible for ensuring that the work of my co-investigator(s)/student researcher(s) complies with this protocol.
7. Any unexpected or otherwise significant adverse events in the course of this study will be promptly reported to the RSP
8. In the case of student research, I assume responsibility for ensuring that the student complies with University and Federal regulations regarding the use of human subjects in research.

9.	In the case of externally funded research, I will request a modification to my approved protocol if any relative changes to the project's scope of work are requested by the agency.

_________________________ Principal Investigator Signature   _____________ Date

III. Protocol Description

A. Provide a BRIEF description, in LAYMAN'S TERMS, of the proposed research.

The proposed research project is designed to gain a deeper understanding of the relationship between students' academic self-efficacy and persistence in science, mathematics, and computer science programs. A sampling of students, representative of these programs, will be asked via a questionnaire (Student Appraisal Inventory) to judge their abilities to do well these programs. In addition this instrument will ask students to indicate the relative importance of various contributing factors to their decisions to persist (or not) in these programs. Volunteer students consisting of a focus group will be also asked via web-board to reflect back on their academic careers, pointing out milestone events which contributed to their decisions. The students' judgments and reflections will be analyzed to determine the level of correlation between self-efficacy and persistence in these programs.

B. Methodology

1. Participants (all protocols must have a completed appendix A)
    a. How many participants will be included in the study?
    Number: Male _____ Female _____ Total: 300 is the goal, reflecting a representative sample of both males and females across science, mathematics, and computer science programs. Age range: 21 To 30
    b. Where will participants be recruited from?
    Participants will be recruited from biology, chemistry, physics, mathematics, and computer science programs across Illinois State University.
    c. How will they be recruited? (attach all recruitment documentation. i.e. letters, flyers etc)
    Participants will be recruited through use of email. (see attached document: "Student Recruitment/Informed Consent Letter")
    d. How will you secure informed consent?
    Informed consent will be secured through the "Student Recruitment/Informed Consent" letter outlining participants' involvement and confidentiality and offering a disclaimer which states that submission of the completed inventory constitutes consent to participate.

If consent (and assent) forms are being used, attach a copy. If presented verbally, a copy of presentation text must be submitted. Templates for informed consent, parent consent and assent can be found at **www.rsp.ilstu.edu**

2. Procedure
   a. What are you asking the participants to do?
      Before emailing the "Student Appraisal Inventory" to the sample population a small group of 5-10 students will be approached to act as consultants, offering their suggestions for any changes to the instrument which would help clarify any needed portions. The sampling of students will complete a one-time only electronic "Student Appraisal Inventory" consisting of sections of questions devoted to: demographics; student levels of self-efficacy in science, mathematics, and computer science; rank ordering of the importance of various contributing factors correlated with decisions to persist (or not) in these programs; as well as open-ended explanations concerning their rankings. A small (no more than 12) volunteer focus group will respond to questions via web-board using alias's log-ons for anonymity. Questions posed by the researcher will ask participants to reflect back over their academic careers and the milestone events which influenced their decisions to persist in these programs.
   b. Will you involve them in a psychological intervention, deception, or biomedical procedure?
      There will be no psychological intervention, deception, or biomedical procedures employed.
   c. Will you audio or videotape them? No
3. Instruments/Apparatus
   The "Student Appraisal Inventory" and "Focus Group Questions" will be used.
4. Data
   a. How will the data be stored and kept secure?
      As a distance student, the information gathered will be kept in my current office where only I will control access via password protected computer. If I leave my current situation of employment at the University of Arizona, the data will be kept a locked place in my, Jennifer Grogg's, home.
   b. Who will have access? How will the data be used (during and after the research)?
      Only the researchers will have access to the data collected. The data will be analyzed, allowing insights, themes, facets, and/or patterns to emerge. The outcome will be a dissertation and articles or papers which may follow.
   c. How will the data be disposed?
      The data will be shredded and deleted off my, Jennifer Grogg's, computer at home and work.

C. Risks

1. What are the physical, psychological, or social (loss of reputation, privacy, or employability) risks?
   There are no risks.
2. Will the data be anonymous or confidential?
   The data will be anonymous by: 1) use of Survey Monkey, an anonymous survey instrument and 2) ensuring that in the electronic focus group, participants are issued an alias as a log-on. All data will be kept confidential.

D. Benefits

1. What do you hope to learn?
   I hope to learn of the correlation between student academic self-efficacy and persistence in science, mathematics, and computer science programs and if there is a significant difference across programs and gender.
2. Who might find these results useful?
   The results of this research might be useful for individuals involved in teaching and/or research in collegiate programs as well as college administrators, advisors, and counselors.
3. For what purpose?
   For the purpose of improving teaching, advising, and counseling practices as well as assessing science, mathematics, and computer science programs.

IV. Checklist

This checklist must be completed and attached to all protocols or Department Representatives will return them to the PI. Please note that for any items checked "yes" you must attach the designated, completed appendices.

__X__ Yes	_____ No	Informed consent procedures/ documentation have been clearly explained. (All protocols must have a completed Appendix A)
_____ Yes	__X__ No	Is your research being funded? (if yes, complete Appendix B)
_____ Yes	__X__ No	Are you recruiting and enrolling subjects 0-7 years old? (if yes, complete and attach Appendix C)
_____ Yes	__X__ No	Are you recruiting and enrolling subjects 8-18 years old? (if yes, complete and attach Appendix C)
_____ Yes	__X__ No	Are you recruiting and enrolling prisoners as subjects? (if yes, complete and attach Appendix D)
_____ Yes	__X__ No	Are you recruiting and enrolling pregnant women as subjects? (if yes, complete and attach Appendix E)
_____ Yes	__X__ No	Are you recruiting and enrolling mentally incapacitated individuals as subjects? (if yes, complete and attach Appendix F)
_____ Yes	__X__ No	Will the subjects of this study be exposed to the possibility of harm, including physiological, psychological, or social (e.g., loss of reputation, privacy, or employability), (if yes, complete and attach Appendix G)
_____ Yes	__X__ No	Will the subjects of this study be exposed to any psychological interventions such as contrived social situations, manipulation of the subject's attitudes, opinions or self-esteem, psychotherapeutic procedures, or other psychological influences. (if yes, complete and attach Appendix H)
_____ Yes	__X__ No	Will this study involve any elements of deception? (if yes, complete and attach Appendix I)
_____ Yes	__X__ No	Will the proposed research involve any biomedical procedures (e.g., the taking or withholding of medication, ingestion of any food or other substances, injections, blood drawing, or any other procedure which would normally be done under medical supervision). (if yes, complete and attach Appendix J)
___ Yes	_____ No	Will all or some of the subject(s) of the proposed research will be audio or videotaped? (if yes, complete and attach Appendix K)
___X__ Yes	____ No	Will this proposed research involve any elements of technology? (i.e. web-based subject recruitment, email recruitment, web survey).