AIR 2005 Dissertation Fellowship Proposal Cover Page

Higher Education's Impact on Women's Educational Attainment and Outcomes Across Science and Engineering Disciplines

Grant Amount Requested: $15,000

Beginning Postsecondary Students Longitudinal Study 1996-2001

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2. PROJECT SUMMARY

The objective of the proposed study is to investigate why women are disproportionately represented in the social, psychological, and life sciences (soft science) in comparison to other science and engineering (SE) fields such as mathematics, computer science, engineering, and physical science (hard science). The investigation will look through the lens of higher education's influence on SE women in hard and soft sciences. To achieve this task, Weidman's (1989) conceptual model of undergraduate socialization will be used as a guide to understand higher education's impact on these two groups of women. Weidman's model was selected because it includes non-collegiate factors, which potentially influence women's choice of a SE degree, and socialization outcomes such as career choices in addition to incorporating the impact of postsecondary education. The expectations are that new insights into (1) why women disproportionately select soft SE majors over hard SE majors will be revealed, (2) how higher education influences persistence and degree attainment in these groups, (3) and how higher education and choice of major effects outcomes such as employment or graduate school.

The Beginning Postsecondary Students Longitudinal Study: 1996-2001 (BPS) national dataset (restricted version) from the U.S. Department of Education will be used for this study. The BPS Longitudinal Study is designed specifically to collect data related to persistence in and completion of postsecondary education programs; relationships between work and education efforts; and the effect of postsecondary education on the lives of individuals. This study proposes to investigate women's persistence, attainment, and outcomes covering the six year period of the BPS longitudinal dataset. Because of low sample sizes in some categories, SE disciplines will be grouped into hard science major or soft science major. The approximate sample sizes for women choosing a SE major in 1996, 1998, and 2001 are 245, 303, and 397, respectively.

Previous research identifying factors that influence women's selection of a SE degree and Weidman's model will be used to guide the selection of variables from the dataset. In addition, logistic regression will be implemented in order to determine predictor variables for membership in each of the hard/soft SE category. Based on Weidman's model, results from logistic regression, and previous research on women in science, a causal model will be proposed to explain women's selection of hard and soft SE fields. To evaluate the adequacy of the causal model, path analysis will be used. Factorial MANOVA will be used to examine educational outcome differences.

The proposed study is relevant to President Bush's *No Child Left Behind* (NCLB) policy. One portion of the NCLB is the development of Math and Science Partnerships (MSP) to strengthen K-12 science and mathematics

education. The MSP authorizes funds to develop programs to encourage young women (and other underrepresented groups) to pursue careers in math, science, engineering, and technology. However, women are not underrepresented in all areas of SE. America's interest will not be served well by increasing women's participation in SE areas where they now represent a majority. This proposed study addresses that issue by seeking to understand the influences on women's path to hard versus soft SE fields. If factors which influence women's decision to pursue soft sciences rather than hard sciences can be identified, then more effective MSP can be developed to promote increased female participation rates in the hard sciences.

There are several innovative aspects to this proposal. One, it focuses on higher education's influence on women's participation in SE. Most previous studies have examined non-collegiate factors such as K-12 experiences, parental influences, and societal influences. These forces are important in promoting interest and preparation for SE, but the postsecondary environment affects one's persistence and attainment in SE. Two, educational outcomes are included as an extension of higher education's influence. Of the few studies that have examined higher education's impact on women in SE, even fewer have included career/employment outcomes as part of their study. Lastly, the most innovative aspect of this proposal is that it attempts to study the issue of underrepresentation of women in SE by segmenting the disciplines into hard versus soft sciences. Previous studies group SE disciplines together, but not all SE fields have problems recruiting and retaining women. Therefore, it is important and necessary that a more focused examination occur so that policy and practice efforts to increase the participation rates in SE are effective.

The results of this proposed study will be of interest to a variety of audiences and will contribute to the existing knowledge base of women in SE. For example, those involved in MSP such as SE faculty, agents of state K-12 and higher education systems, and professionals from business and industry will benefit from the knowledge gained from this study. The identification of factors influencing women's participation in the hard/soft fields of SE should help guide the development of federal, state and institutional policies and practices, as well as innovative MSP. Administrators and faculty interested in bring about systemic change in their SE departments will also benefit. If institutional and departmental characteristics which affect women's participation can be determined, then changes can be made to alter the culture and climate of SE disciplines. Additionally, researchers interested in equity issues will gain insights from this study due to the examination of women's participation in SE disciplines which are still struggling to achieve increased participation by women.

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4. PROJECT DESCRIPTION

a. Statement of the problem and variables

National Discussion of the Condition of the Science and Engineering Workforce

The U.S. is considered to be the leader in research and technology (Hanson, 1996). That statement used to go unquestioned, but recently the National Science Board's (NSB) *Science and Engineering Indicators 2004* report brings into question the future scientific leadership of the U.S. Science and technology plays a critical role in the nation's economic well being. Technological and scientific advancements have improved productivity and created new jobs and industries (Committee on Equal Opportunities in Science and Engineering (CEOSE), 2000), and the result is one of the strongest economies in the world (Congressional Commission on the Advancement of Women, & Minorities in Science, Engineering and Technology Development, 2000). However, to maintain or further scientific and technological advancements, the U.S. must have a sizable reservoir of quality scientists (Xie & Shauman, 2003). It is this group of people who will ensure the nation's ability to provide for its citizens, compete in the global economy, and improve quality of life (Chubin & Pearson, 2001).

The Bureau of Labor Statistics projects the science and technology labor market to grow at three times the rate of other occupations between 1998 and 2008 (Chubin & Pearson, 2001). Additionally, areas such as computer and information technology are predicted to have a shortfall of U.S. workers (CEOSE, 2000). This projected growth spurt is expected to produce 5.3 million new jobs, and five of the top ten fastest growing occupations are computer related (Congressional Commission, 2000). The federal government and academe are stakeholders in the preparation of scientists for the future. Both of them are involved in essential programs such as defense, environmental protection, and space exploration, among other things (Congressional Commission, 2000). All of these jobs will require expertise, skills, and knowledge in science, engineering and technology (CEOSE, 2000), and the science and engineering (SE) workforce must be ready to meet the challenges and demands of the future.

By 2010, it is predicted that 68% of new workforce participants will be women and minorities (Congressional Commission, 2000). Presently, the SE workforce is comprised mostly of white males (Congressional Commission, 2000). The percentage of white males in the SE workforce is much higher (68%) than their representation in the general population (37%) and workforce (42%). In comparison, women comprise about 51% of the population, 46% of the nation's workforce but only 19% of the SE workforce (Huang, Taddese, & Walter, 2000; Congressional Commission, 2000).

Moreover, the NSB (2004a) report noted a continual decline in the number of U.S. citizens who are becoming scientist and engineers, and over the next 20 years, retirement among degreed SE workers is expected to increase. The predicted increase among women and minorities in the workforce, the decline in the number of SE degrees, and the retirement loss of SE workers makes it more important than ever to increase the participation of women (and other underrepresented groups) if the U.S. is to meet the demands of the future (CEOSE, 2000; Congressional Commission, 2000; Chubin & Pearson, 2001).

Condition of Science and Engineering in Higher Education

The overall enrollment trend in higher education has increased from about 7 million in 1967 to 15.6 million in 2000 (NSB, 2004a). Future projections indicate that enrollment of college age students will increase to 21.7 million by 2015 in addition to an increasing number of older (>24 years) students (NSB, 2004a). Part of the increase in higher education enrollment can be attributed to the increasing number of women entering postsecondary education (PSE) institutions. Based on data from the 2002 *Digest of Education Statistics* (Snyder & Hoffman, 2003), the percentage of females obtaining college and graduate degrees has increased at every level from the past three decades. Women now earn a higher percentage of degrees than men do at all levels except the doctoral level, but even at that level the disparity is not as great as it once was.

The UCLA Higher Education Research Institute's Annual Freshman Norms survey provides information about students' degree intentions. Historically, more men than women have been interested in SE majors, but the gap in interest has narrowed. In 1975, 66% of freshmen males were interested in SE and only 34% of females. By 2002, that gap narrowed to 56% for males and 44% for females (NSB, 2004a). The survey results revealed that women are overwhelmingly interested in biological and social/behavioral sciences, especially since 1990s. Women's interest in math and physical science has not changed much since 1975. For engineering and computer science fields, women's interest peaked in the early 1980s and has since continued to decline (NSB, 2004a).

Interest in SE does not necessarily translate into degree attainment. As students enter PSE, institutions have the potential to influence students' decision to leave or persist in SE programs. The decision to leave SE seems to be more predominant among females than their male counterparts. Hilton and Lee (1988) reported that both women and minorities left SE programs at higher rates than men and nonminorities.

Degree attainment in SE has increased for women over the past few decades, largely due to the decreasing number of men pursing SE degrees. Among SE degrees awarded in 2000, women accounted for 50%, 43%, and

38% of Bachelor's, Master's, and Doctor's degree, respectively (NSB, 2004a). In 1977, the percentages were 35%, 24%, and 18%, respectively. At first appearances, women have achieved parity at the Bachelor's level and near parity at the Master's level. However, this picture of equality can be misleading due to the inclusion of psychology and social science in the definition of SE.

A closer examination of fields within SE reveals that not all disciplines have achieved desired participation and completion rates. Women still remain underrepresented in critical areas such as physical science, engineering, and computer science (NSB, 2004a; Huang, Taddese, & Walter, 2000). The increasing number of women enrolled in PSE, the increasing interest in SE among women, and the higher attrition rate of women provides higher education a unique opportunity to bring about change in the production of female SE participants and completers in areas where they still remain underrepresented.

Previous Research on Women in Science and Engineering

Most of the past research has focused on differences between males and females. Initially gender differences were believed to be due to biological differences in abilities. The argument was that women were biologically inferior in their ability to do math and science; therefore, they had lower rates of participation and achievement (Hanna, 2003). The next generation of gender equity research examined social and cultural barriers that might prevent women from participating and achieving in the sciences (Hanna). This generation of research promoted the belief that if the barriers were removed or lowered then the number of women participating and achieving in science would increase (Xie & Shauman, 2003).

Numerous studies have identified factors that affect women's entry and persistence in SE fields. The factors identified from these studies are usually grouped into broad categories such as family and environment influences (including societal factors), students' individual attributes (including cognitive abilities and attitudes), and school/institution characteristics (Huang, Taddese, & Walter, 2000). Weidman's undergraduate socialization model (1989) was selected as a guiding conceptual model because it incorporates these broad categories as part of the socialization process. The model incorporates four socialization processes that are important in influencing PSE outcomes, such as career choice. Since this model is serving as a conceptual guide, there are five areas of literature that are pertinent to this study. First, a brief discussion of Weidman's model is needed for clarity and to frame the study. Second, a review of the literature as it pertains to the four socialization processes and related educational experiences of women in SE will be presented.

Weidman's Undergraduate Socialization Model. Weidman's model (see Figure 1) depicts undergraduate socialization as a process that begins when the student, who possesses certain aptitudes and aspirations, enters a postsecondary institution. The student in the collegiate environment is influenced by a variety of variables such as relationships with faculty and peers, institutional characteristics, and the college community. While in this environment, the student continues to be influenced by parents and non-college reference groups. The influences are linked in a bidirectional causal mechanism, and the influence of each of the four socialization processes is expected to be different for each student. The model is concerned primarily with socialization outcomes. An outcome of particular importance for this study is career choice, whether that is graduate school or employment. However, a strong element of career choice is the process involved in selecting a major, which is a vital component of the proposed study.

Student Background Characteristics. Student characteristics include academic preparation and performance, as well as various psychological characteristics such as attitudes, aspirations, and self-efficacy. Academic preparation/performance and self-efficacy constructs have received considerable attention in the past and are considered important influences on women's decision to pursue SE fields. Therefore, the review of literature for background characteristics will be limited to only these two variables.

Grades are one of the best predictors of bachelor degree obtainment, graduate school attendance, and advanced degree attainment (Pascarella &Terinzini,1991). Grades obtained in quantitative subjects have traditionally been used as a predictor of academic success in SE fields, and female performance has typically lagged behind that of males. However, the gender gap in quantitative performance has started to change. The 1999 National Assessment of Educational Progress (NAEP) (Campbell, Hombo, & Mazzeo, 2000) report shows only small differences in math and science test scores. Xie and Shauman (2003) noted that gender differences in math and science achievement are relatively small. However, in their study, there was a significant underrepresentation of women in the top 5% of highest achievers in math and science achievement. The results from these studies raise an important question about the relationship between math and science grades and one's choice of a SE major.

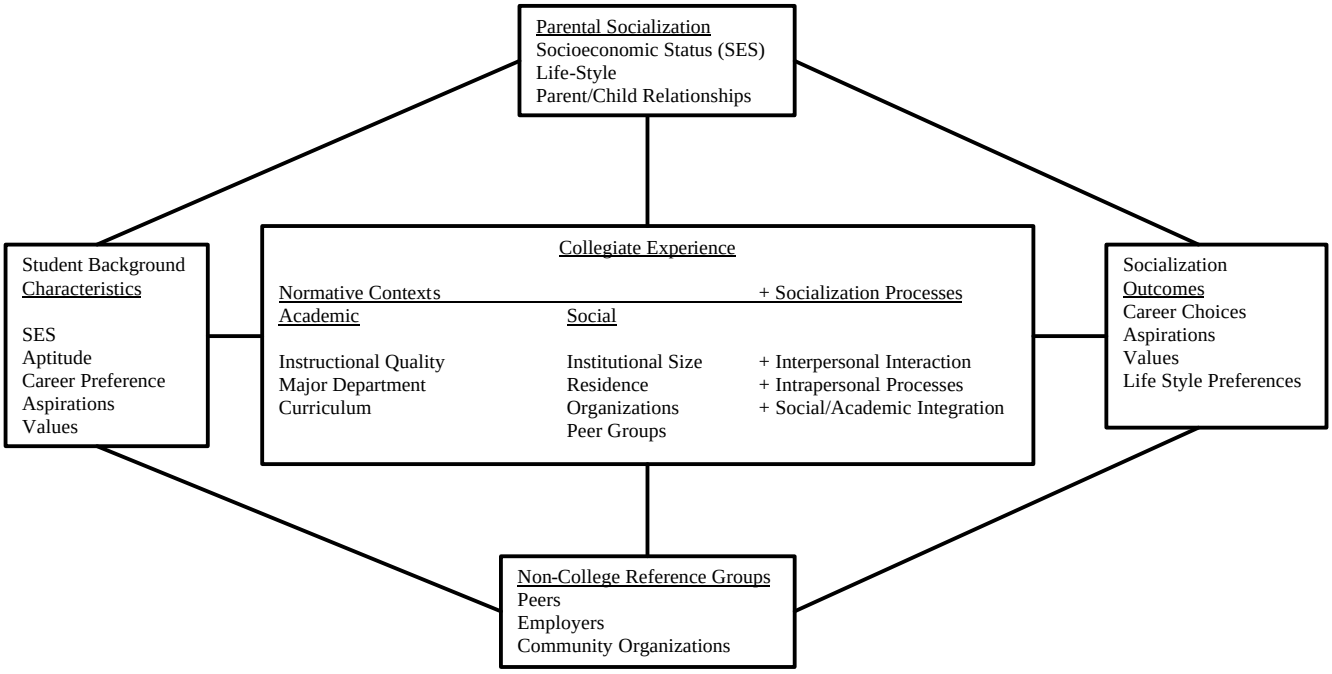

Figure 1. Weidman's Undergraduate Socialization Model.

Horn, Kojaku, and Carroll (2001) examined the relationship between high school academic curriculum and persistence of undergraduates three years after entering a 4-year institution. They found that students who completed a rigorous curriculum that included 4 years of mathematics (pre-calculus or higher), 3 years of science (biology, chemistry, physics), and at least one advanced placement course showed a significant educational attainment advantage over those who took less rigorous courses. In particular, mathematics preparation has been identified as being a strong predictor of degree completion. The importance of math and science preparation for successful educational attainment in any field has been noted (Adelman, 1998; Adelman, Daniel, Berkovits, & Owings, 2003). Again, women have traditionally not pursued math and science at that level. Results from Huang et al. (2000) revealed that women are less likely to have taken advanced coursework in math and science than white males. However, this conflicts with the results from the NAEP (2000) report, which indicates that females are taking advanced math and science courses at the same rate as males. The Congressional Commission (2000) report concluded that women have the ability and academic preparation to succeed, but they lose interest somewhere along the SE path.

Other research (NSB, 2004a; Xie & Shauman, 2003; Bae, Choy, Geddes, Sable, & Snyder, 2000) examining math and science coursetaking patterns of high school students reported no gender differences in advanced math preparation but noted differences in advanced science preparation. Xie and Shauman found females were more likely to have taken advanced biology courses than males, but males were more likely to have completed a physics course. Bae et al. indicate that males are more likely to take advanced calculus, physics, and computer science.

In regards to self-efficacy, some clarification of terminology is in order. Hansford and Hattie (1982) conducted a meta-analysis on the relationship between self and achievement and found 15 different terms used to describe "self" constructs. For the purposes of this proposal, self-efficacy will be used as an inclusive term for all self constructs. Self-efficacy refers to an individual's perception of their ability to successfully act in a way to bring about the desired outcome and has been linked to persistence and achievement (Bandura, 1977; Bandura, 1986; Lent & Brown, 1996). It is acquired through personal performance accomplishments, vicarious learning experiences, social persuasion, and emotional arousal (Bandura, 1977); however, personal performance exerts the greatest effect on self-efficacy (Lent & Brown, 1996). Self-efficacy influences one's choice of activities, expectation of success, and ability to cope, and as a consequence, strong self-efficacy results in vigorous effort and persistence (Bandura, 1977).

Independent of one's sex, students' science and math self-efficacy is influenced by confidence level, self-esteem, sex-role attitudes, and career expectations (Hanson, 1996). Unfortunately, these factors seem to affect females more negatively than males (Frieze & Hanusa, 1984; Matyas, 1985a; Sax, 1994). As early as the eighth grade, girls show a lower self-efficacy in their math and science abilities than boys show, despite performing just as well in these subjects (Congressional Commission, 2000). Additionally, math self-efficacy has been suggested as being the most important predictor of performance on math test, which has in turn been correlated with women's entry into SE fields (Ethington, 1988; Matyas, 1985b; Ware, Steckler & Lesserman, 1985).

Parental Socialization. Parental expectations and socialization influence the career preferences that students bring into the collegiate environment (Bengston, 1975; Winch & Gordon, 1974). The tendency of parents to discourage females from SE fields has been documented (Tenenbaum & Leaper, 2003; Vetter, 1996). The study by Tenenbaum and Leaper found that parents believed daughters were less capable in science than sons and that parents' beliefs were a significant factor in predicting children's interest and self-efficacy in science. In Seymour

and Hewitt's (1994) qualitative study of college students in SE, they reported that females were more influenced by parents' expectations than their male counterparts. Similarly, Trusty, Robinson, Plata, and Ng (2000) reported a stronger association between socioeconomic status (SES) and major for women than for men. Additionally, higher SES and higher education level of the parents have been linked to females choosing nontraditional majors and careers (Gruca, Ethington, & Pascarella, 1985; Trusty et al.; Ware, Steckler, & Lesserman, 1985).

Non-college Reference Groups. Ties to significant others, employers, and community can influence one's educational path. The large variety of potential influences in this area prevents a review of individual factors. Instead, this socialization area will be addressed broadly as the influence of society on women's struggle to balance family and career. Societal expectations of women force them to balance the sometimes competing and conflicting demands between career and family (Frieze & Hanusa, 1984; Lips, 1992; Seymour & Hewitt, 1997). There is some evidence that college women who major in science are less likely to place a high priority on personal life and family responsibilities than women who don't major in science (Ware & Lee, 1988). For unknown reasons, there seems to be a perception that balancing family and career in science is more difficult than that of other career fields (Seymour & Hewitt, 1997).

Collegiate Experience. The impact of higher education on students and their decision of a major or career is a complex, multifaceted issue. Many students enter college with particular interests and aspirations that are based on previous educational experiences, family influences, and influences of significant others. However, their decision to persist and complete their chosen course is heavily influenced by the collegiate experience.

Weidman's model (Figure 1) indicates that undergraduate socialization consists of formal and informal interactions. The formal interactions include an academic and social component. The following review of collegiate experience will focus only on formal interactions. Those most important to this proposal are institutional type, financial support, student-faculty interactions, intervention programs, and student involvement.

Institutional type can have a significant impact on students' success in PSE. In general, evidence suggest that attending a 2-year institution decreases one's probability of completing a bachelor's degree in comparison to those who attend a 4-year school (Pascarella & Terenzini, 1991; Astin, 1977). More specific to SE, Adelman (1998) noted that engineering students who complete bachelor's degrees overwhelmingly attended only 4-year institutions. Other reports indicate that Women's colleges, liberal arts colleges, and historically black colleges have a better record of promoting SE degree attainment than state and research institutions due to factors such as enrollment

selectivity, lower student-faculty ratios, higher student-faculty interactions, and support for those inadequately prepared (Astin, 1977, 1993; Office of Technology Assessment, 1988, 1989; Trent & Hill, 1994).

Some of the financial problems affecting student persistence are increasing cost of higher education, declining student aid, and shifting emphasis to loans rather than grants (Seymour & Hewitt, 1997). Seymour and Hewitt noted that engineering students were more adversely affected by finances than those in other science areas because the time to degree completion was longer. Furthermore, their study revealed that financial debt affected students' educational outcomes by forcing many to delay graduate school in order to pay off student loans.

Research on student-faculty interactions indicates that faculty norms, values, and attitudes impact students' persistence and degree attainment (Pascarella & Terenzini, 1991). Interaction with faculty in the classroom affects students' educational attainment through the use of instructional methods which promote student engagement and learning (Pascarella & Terenzini, 1991). Work by Rosser (1990) and Tobias (1990) suggest that current SE teaching practices encourage competition, which may alienate many students, and create the perception that science is isolating and demanding.

The faculty also exerts an influence on students through the departmental culture/climate. Traditional SE culture values masculine qualities, and women have had to assimilate or leave their chosen SE field (Barber, 1995). Faculty can alter the culture/climate to enhance student involvement and learning by creating an environment where interactions are frequent and friendly (Pascarella & Terenzini, 1991). Seymour and Hewitt's (1997) study concerning SE attrition supports the conclusion that classroom climate and activities are critical influences on student persistence in SE majors. Among the factors given by students in their report for leaving SE are poor teaching and inadequate advising or help with problems, thereby lending credibility to the important role of these two variables.

Another variable of student-faculty interactions is the lack of role models and mentors for women. Though male scientist can mentor female students, female mentors appear to have more of an impact on women in SE than male mentors (Seymour & Hewitt, 1997), but women have fewer opportunities for same-sex mentoring. In SE areas where there is more potential for female mentoring, often times these mentors are not in influential positions of power or authority in the academic ranks (Astin & Sax, 1996).

Institutions often design special programs to promote the academic achievement of students. According to Pascarella & Terizini (1991), there is consistent evidence from the literature that college intervention programs have

a statistically significant positive effect on grades and persistence. However, Davis and Rosser (1996) state that very little is really known about how effective SE interventions programs are. Over 300 SE intervention programs have been identified and less than half were evaluated for effectiveness (Matyas & Malcom, 1991). Some of the more traditional forms of these programs are research internships, mentoring programs, career workshops, and comprehensive programs which use a combination of interventions (Davis & Rosser). Additionally, some programs are field specific whereas others are broadly focused on women's issues in SE (Davis & Rosser). Interestingly, of the 300 programs identified by Matyas and Malcom, only a small number address changing the way science is taught. In other words, most efforts have been directed at helping women overcome barriers instead of tearing down the one barrier than may be the most important of all: the way science is taught. This is important considering the growing body of research that supports curriculum reform in order to attract all types of students and increasing funding from government and private organizations to reform science curriculum (Astin & Astin, 1993; Davis & Rosser; Seymour & Hewitt, 1997).

Student involvement can be evaluated by looking at residence status and extracurricular participation. On-campus residence shows a statistically significant positive relationship to persistence and degree attainment even after controls are made for student characteristics (Pascarella & Terenzini, 1991). The suggested causal mechanism is that living on campus facilitates socialization in the academic and social environment of the institution. Astin's (1977) earlier work goes as far as stating that on campus residence is the most important environmental influence on persistence. Astin's findings also suggest that involvement in extracurricular activities such as research, honors programs, and fraternities positively affects persistence. Related to this, some institutions have developed residential communities specifically for women in SE programs for the purpose of facilitating interaction between women who share a common interest and creating a supportive environment (Davis &Rosser, 1996).

Deficiencies of Previous Studies

Much research has been conducted to determine factors that influence women's entry and completion of SE programs. The research includes examining structural, individual, and environmental barriers that women face in SE. It has been documented that women are well represented in the soft sciences (at least at the Bachelor's and Master's level), but they still remain underrepresented in the hard sciences. However, none of the research to date has focused on understanding why women have been disproportionately drawn to the soft sciences or, alternatively, repelled by the hard sciences. Moreover, most studies have not viewed the issue through the lens of higher

education. Some notable exceptions to this are Seymour and Hewitt (1997), Astin and Sax (1996), and Huang et al. (2000). However, each of these studies has limitations that this proposal seeks to overcome. One, Seymour and Hewitt's study is qualitative, limited to seven campuses, and lumps SE fields together. Two, Astin and Sax's final sample was followed up after only four years of student participation in PSE, and it analyzes higher education influences from a female versus male perspective. Lastly, the report by Huang et al. included only two institutional factors and considered results in terms of gender differences.

As a result of this brief review of the related literature, a number of questions arise. 1) Are the small differences in math and science achievement along with the lower number of females among the highest achievers accountable for the underrepresentation of females in hard sciences? 2) Are there differences in course-taking patterns between women in the soft SE sciences versus those in the hard SE sciences? 3) Is there a difference in math and science self-efficacy between women in soft sciences versus those in hard sciences? 4) Does parental socialization (beliefs, expectations, SES, education) affect women in soft sciences differently than women in hard sciences? 5) Do women in soft sciences place a higher value on personal life and family than women in the hard sciences? 6) Are there differences in the type of institution attended by these two groups of women? 7) Are there differences in financial support? 8) Do women in soft sciences interact differently with faculty than women in hard sciences? 9) Are the culture/climate experiences different for these women? 10) Are these two groups of women differently involved in PSE through intervention programs, residence, and/or extracurricular activities?

In an attempt to answer these questions, a series of relevant research variables have been identified for further investigation: age, parental education, parental income, high school math/science grades, high school math/science courses, SAT/ACT scores, institutional type, institutional climate, program of study, degree program, type of degree received, time to complete degree, full-time or part-time enrollment, left before completion, college academic performance, interaction with faculty, involvement in education environment, residence type, financial support, employment during enrollment, graduate enrollment, post-enrollment employment, personal goals, and educational goals.

b. Proposal of work and database of interest

Objectives for the proposed work are to illuminate why women are disproportionately represented between hard and soft sciences by investigating higher education's influence on persistence, degree attainment, and outcomes of these two SE groups. The previous section identified important research questions and related variables. From

the Beginning Postsecondary Students Longitudinal Study: 1996-2001, a combination of background, high school, aid source/type, education performance, education experiences, institution, parent, student goals, and employment variables will be selected. To investigate the questions previously identified, a general conceptual framework (see Figure 2) including the variables of interest has been created.

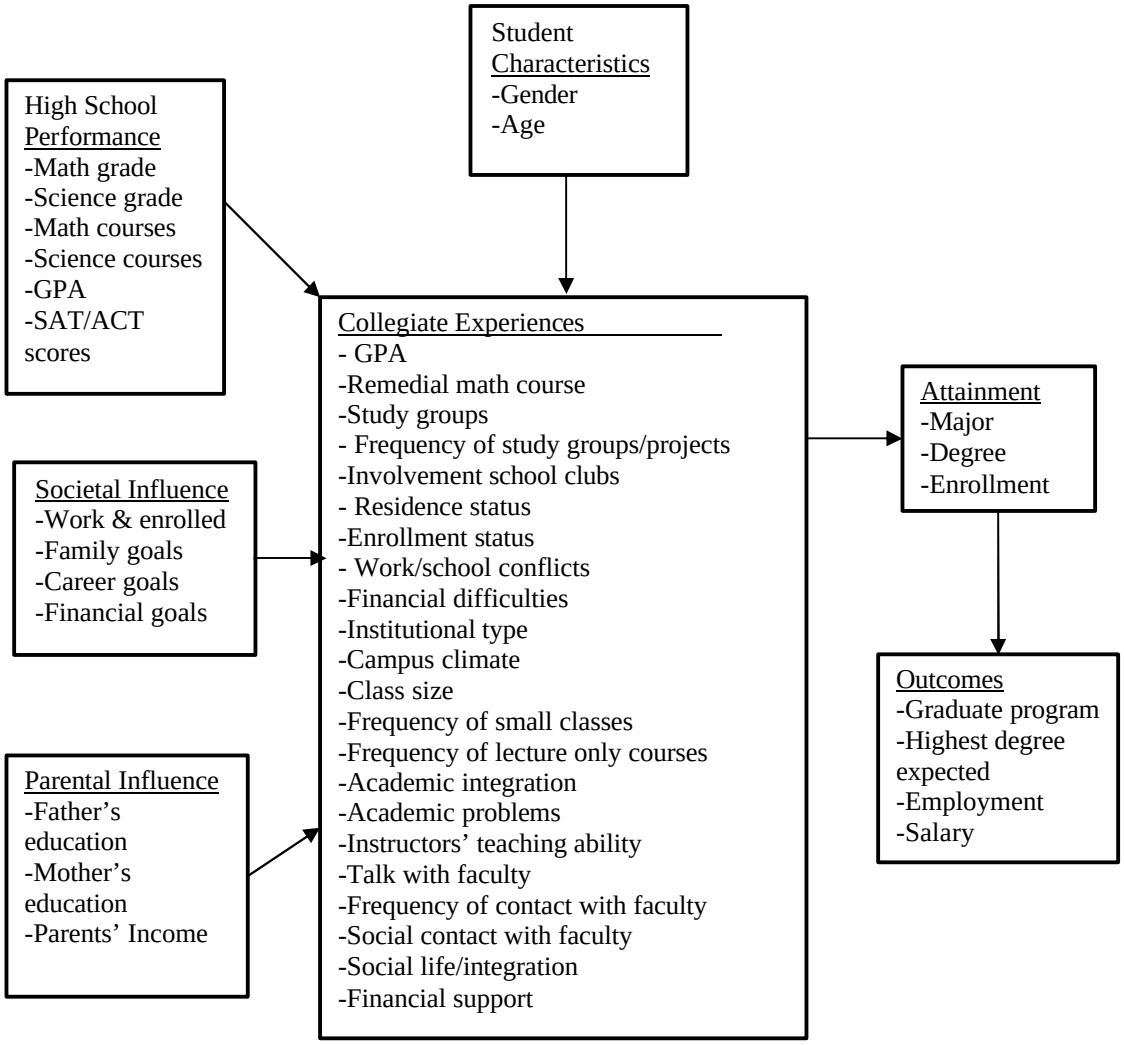

Figure 2. Conceptual framework incorporating variables from BPS:1996/2001 dataset.

Due to limitations of the dataset, some important variables are not available for consideration. For example, no variable was found to measure math self-efficacy or self-efficacy in general. Also, there were no variables that really got at the heart of teaching practices or instructional methods. Other factors not available are

role-model influences and intervention program participation. These variables are vitally important to the success of women in SE, but the proposed study will not be able to access their impact simply due to the constraints of available variables.

Statistical analysis will begin with logistic regression for the purpose of identifying predictor variables for membership in hard or soft SE majors. A causal model will then be constructed on the basis of these results, Weidman's model, and previous research in order to explain women's selection of hard or soft SE fields. Path analysis will be used to test the model fit. To explore differences in educational outcomes between hard and soft SE degree recipients, factorial MANOVA will be used. The significant expectations are that particular SE path chosen by women will be better understood and as a consequence, more effective policies, programs, and methods will be devised to increase women's participation in the hard SE fields.

Schedule of tasks for the proposed work is as follows:

- 6/1/05-7/31/05: Submit security plan, license application and notarized affidavits to obtain restricted BPS data; conduct exploratory data analysis on dataset.
- 8/1/05-2/28/06: Conduct multivariate data analysis.
- 3/1/06-5/31/06: Complete dissertation, write and disseminate research; conference presentations and preparation of scholarly articles.

c. Dissemination plan

Results of this study will be communicated through dissertation defense, presentations at professional conferences, and journal articles. Research findings will be submitted for presentation consideration at the 2006 annual conferences of the Association for Institutional Research, Association for the Study of Higher Education, and the American Educational Research Association. Research manuscripts will be submitted for publication consideration to peer-reviewed professional journals such as Research in Higher Education, Journal of Higher Education, and Review of Higher Education.

d. Description of policy relevance

According to the U.S. Commission on National Security in the Twenty-First Century (2001), "More Americans will have to understand and work competently with science and math on a daily basis…the inadequacies of our systems of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine" (p. 12). The U.S. has historically drawn from an

international pool of talent to meet human resource demands of the SE workforce (NSB, 2003), but the future of this resource is uncertain due to global competition for international talent, other countries increasing their investment in SE education and workforce, and increasing security restrictions due to the events of September 11 (NSB, 2004b). Since the events of 2001, the number of international students attending American institutions has dropped significantly. Therefore, the need to recruit and retain more Americans, especially women and minorities, is pressing. The Math and Science Partnerships, created as part of the No Child Left Behind policy, are directly related to the recruitment of underrepresented groups into SE. Educators from K-12 schools and institutions of higher education will work together to develop programs that will encourage underrepresented groups to pursue careers in math, science, engineering, and technology. The results from this study will help in that process by focusing on factors that lead women either in or out of hard sciences, which is where they are still underrepresented. Armed with this knowledge, educators can design more effective programs to encourage female participation in the hard sciences.

e. Discussion of innovative concepts of project

Previous research on women in SE has been dominated by studies on gender differences. In addition, these studies group different fields of SE into one category. The proposed study is innovative in that it moves away from the male versus female parallel and shifts to examining differences between women who enter soft versus hard SE fields. Therefore, the old question of why do women continue to be underrepresented in science is replaced by a new question of why do women continue to be underrepresented in the hard sciences. A second innovation is that the proposal is based on a conceptual model of undergraduate socialization that includes non-collegiate factors and outcomes as part of the higher education experience. Few of the previous studies have taken such a holistic approach. Additionally, the literature is replete with studies using nonrepresentative samples and simple, descriptive statistics. That's not to say those studies don't have value and add to the knowledge base of women in SE. However, the proposed study is more innovative in that it will use a national, longitudinal dataset, which is more suitable for studying dynamic processes such as the one being proposed.

f. Discussion of audience to whom the project will be important

Findings from this research will be important to agents of K-12 school districts, state educational agencies, higher education institutions, and business/industry. The results will give them guidance on the development of federal, state and institutional policies and practices, as well as innovative MSP. Knowledge gained from this study

can be used by SE faculty to initiate change at the departmental level and in the classroom. The outcome of the proposed study will assist members of these audiences to create an environment that will encourage increased participation of women in the hard sciences.

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6. BIOGRAPHICAL SKETCHES OF PRINCIPLE INVESTIGATOR AND DISSERTATION CHAIR

Amanda Camp is currently working on completing an Ed.D. in Higher Education at the University of Arkansas at Little Rock. She is in the beginning phase of writing her dissertation and expects to graduate by May, 2006. She also holds an M.S. degree in Chemistry from Oklahoma State University (1995) and a B.S. degree in Chemistry from the University of Arkansas at Pine Bluff (1991).

Amanda is a member of two professional organizations: Association for Institutional Research and American Educational Research Association. In 2001, she was selected as a participant to the AIR/NSF/NCES Summer Institute where she gained experience with national datasets and completed a small project using data from the NSF's Scientists and Engineers Statistical Data System. As part of the coursework at UALR, she has completed a couple of original research projects using the national datasets Schools and Staffing Survey and Teacher Followup Survey.

While at Oklahoma State, Amanda received support as a Teaching Assistant and Research Assistant. As an undergraduate at Pine Bluff, she worked as a research assistant and received two student awards through the Chemistry department. Amanda's educational experiences have given her opportunities to present research results at local, state, regional and national meetings. In addition, she has co-authored three articles published in scientific journals.

Amanda's professional career includes working as an environmental scientist for General Physics Corporation (2003-present), where she is involved with the demilitarization of chemical stockpiles. From 2001-2003, she functioned as a forensic chemist at the Arkansas State Crime Lab. Prior to that, she taught chemistry and physics at North Little Rock High School (1996-2001) and was a technical editor of scientific journals (1995-1996).

Diane Suitt Gilleland
Associate Professor of Higher Education
University of Arkansas at Little Rock

Dr. Diane Gilleland teaches courses in finance, governance, law and academic policy and advises eight dissertation students in the higher education doctoral program at the University of Arkansas at Little Rock.

Dr. Gilleland served as the Deputy Director for Academic Affairs of the Illinois Board of Higher Education from 1999-2003 and as the State Higher Education Executive Officer for Arkansas from 1990-1997 and as the Chief Finance Officer of the Arkansas Department of Higher Education from 1986-1990. In those state level positions, she led statewide policy and funding initiatives that included: redesigning and integrating Illinois' state level quality assurance and accountability programs; developing and implementing a statewide policy requiring assessment of student learning in all undergraduate, graduate and general education and led the effort for Illinois' participation in the National Forum on College-Level learning; providing statewide leadership on P-16 issues and collaboration, including authoring and being awarded a $5 million Teacher Quality Enhancement Grant.

As the Chief Higher Education Officer in Arkansas, Dr. Gilleland led: the statewide reform of mathematics and science education, securing a $10 million State Systemic Initiative Grant from the National Science Foundation; the restructuring and transformation of fourteen vocational-technical schools to North Central Association-accredited community and technical colleges; the development of an Academic Cost Accounting System; and the creation of five new financial aid programs to address strategic needs of the state, including an early intervention program for high-risk eight graders, a college-prep curriculum and preparation program, and four minority forgivable loan programs at the bachelors, masters, and doctoral level.

As a Senior Fellow for the American Council on Education in 1997, Dr. Gilleland led the development of four policy initiatives: P-16 and teacher education reform; college tuition and costs; civic responsibility; and faculty roles and rewards.

At the Institute for Higher Education Policy and the Academy for Educational Development in Washington, DC., Dr. Gilleland served as a consultant to several state coordinating boards, national higher education organizations, and to the ministries of higher education in South Africa and Mexico. She co-authored publications on transforming funding in post-apartheid South African institutions of higher education, developing a

new funding formula for institutions of higher education in Mexico, and several other publications on remediation and college costs.

Dr. Gilleland has also served in various positions of leadership at the University of Arkansas at Monticello and Southern Illinois University at Carbondale. Dr. Gilleland's areas of research interests are governance, finance, P-16 issues, and student preparation and performance. She received her bachelors and masters degrees in education with a major in English from the University of Arkansas, Fayetteville and a Ph.D. in higher education from Southern Illinois University at Carbondale.

7. BUDGET

Dissertation Fellowship Project Title:
Higher Education's Impact on Women's Educational Attainment and Outcomes Across Science and Engineering Disciplines

a. Salaries and Wages	
Principal Investigator: 12 months @ $1,100/month	$13,200
b. Travel (AIR Forum)	$ 1,500
c. Other Direct Cost	
Materials and Supplies	$ 150
Publication/Documentation/Dissemination	$ 150
Total Amount Requested	$15,000

8. CURRENT AND PENDING SUPPORT

There is no other current or pending support planned for the proposed project.

9. FACILITIES, EQUIPMENT AND OTHER RESOURCES

Jim Vander Putten serves as the Principal Project Officer for several restricted-access NCES datasets held by the UALR Higher Education Doctoral Program. These holdings include High School & Beyond (1980-92), National Survey of Postsecondary Faculty (1988, 1993, 1999), National Postsecondary Student Aid Study (1995-2000), National Educational Longitudinal Study (1988-2000), and Baccalaureate & Beyond (1993-97).

Dr. Vander Putten serves on Ms. Camp's dissertation committee and will provide guidance on the data analysis. Dr.Vander Putten has completed the AIR/NCES Advanced Research Studies Seminar (1995), participated as a Research Fellow in the AIR Summer Institute on NSF Databases (2000), and conducted research using NCES national datasets. His expertise will be a valuable resource to this project. All research work will be conducted at the University of Arkansas at Little Rock.

10. SPECIAL INFORMATION AND SUPPLEMENTARY DOCUMENTATION

Letter of recommendation from Dissertation Chair is included.