A study of factors associated with science persistence in successful female baccalaureate degree recipients at Iowa State University

Diane Lynn Doidge

Iowa State University

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A study of factors associated with science persistence in successful female baccalaureate degree recipients at Iowa State University

by

Diane Lynn Doidge

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY

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For the Graduate College

Iowa State University
Ames, Iowa

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CHAPTER I
INTRODUCTION

Following the launch of Sputnik in 1959, science became a national concern. One response to this concern was to encourage, motivate, and train more students to enter science careers. However, because two out of every three college students were men and because women did not appear to be inclined to enter fields of science, nor were they overly encouraged, the prospective pool of future scientists was male dominated (Lovely, 1987).

Recently, the United States has focused on ways to increase the number of students who major in science, mathematics, and engineering in college (Gordon, 1990) because the status of science education has once again become a national concern (Lovely, 1987). The composition of the pool from which prospective scientists can be drawn, however, has changed dramatically since the late 1950s (McDonald, 1990). Changes in this pool can be attributed to a decrease in the number of college aged students, a decrease in the proportion of white males, and an increase in the number of female college students. In 1990, women constituted 54 percent of the students in college.

As greater numbers of women have participated in higher education, issues associated with their low enrollment in traditionally male fields, the decline in their academic and career aspirations during college, and their pursuit of graduate education have become more important issues for study ("Signs of Trouble," 1983). Some of this interest in female students has arisen because they now constitute the majority population in American colleges.
and universities. However, much of this interest is attributed to what has been called a crisis in American science education. National interests have recognized that there has become a greater gap between the need for scientific literacy in society and the ability of schools and colleges (Steen, 1991) to graduate students who can meet society’s needs. The education and participation of all students, but particularly the education and participation of women in science are, therefore, important and pertinent issues in need of study.

The pursuit of science education by females is believed to be influenced by a large number of factors. Some of these factors guide the female student into science in the freshman year of college and others are associated with either persistence in a science field or attrition from one during the undergraduate years. The time of graduation is important for those women who persist in science to earn undergraduate degrees. At this time they will make critical decisions that will affect their future incomes and roles in society and their choice of lifestyle (Baird, 1976).

One choice that college seniors of both sexes must make is whether or not to pursue graduate school. If the decision is made to attend graduate school there will be various other related issues that need to be addressed. Some of the necessary decisions will involve choosing the specific field of study, the type of degree sought (master’s, doctorate, or professional), and the kind of school to attend. Other decisions are of a nonacademic nature and include the acknowledgment of whether or not it is necessary to work while in school and whether it is possible to be married and/or have children while being a student.
One indicator of the number of students pursuing graduate education is the number of PhDs awarded annually. Available figures indicate that women continue to earn an increasing number of PhDs. In 1992, 14,420 doctoral degrees were awarded to females (Ries & Thurgood, 1993). This represents an almost doubling of PhDs earned by women from fifteen years ago and a total of 37 percent of all doctorates awarded in 1992 (Magner, 1993).

Of the seven broad fields profiled in the “Summary Report 1992: Doctorate Recipients in United States Universities” (Sciences: Physical Sciences, Engineering, Life Sciences, Social Sciences; Nonsciences: Humanities, Education, Professional and other fields), the life sciences areas (Biological Sciences, Health Services, and Agricultural Sciences) produced the largest number of PhDs (Ries & Thurgood, 1993). Within the sciences the physical sciences, social sciences, and engineering produced the next largest numbers of PhDs, respectively. An examination of the science degrees awarded by gender indicates that women earned 39.3 percent of the degrees in the life sciences, 19.7 percent of the degrees in the physical sciences, 47.4 percent of the degrees awarded in the social sciences, and 9.3 percent of the degrees awarded in engineering (Magner, 1993). In both the science areas and the nonscience areas, the number of doctoral degrees awarded to men outnumbered those awarded to women in all fields in 1992 except education (Ries & Thurgood, 1993).

When these figures are examined in relationship to the trends in participation of the past several years it is apparent that although women have made strides in the total number
of PhDs earned, their strides in the sciences have not been as great. The share of all PhDs earned by women was lowest in the 1950s which coincided with the postwar baby boom and a large number of servicemen using the G.I. bill to pursue graduate education (Ahren & Scott, 1981). In the 1960s, there was a sharp increase in the number of PhDs earned by women because of increased federal funding in the post-Sputnik era (11.6 percent of all doctorates from 1960-1969), but the largest increases have occurred since 1971. From a total of 14 percent of the total doctorates awarded in 1971 (“Signs of Trouble,” 1983), the percentage of females earning doctorates increased to 33.2 percent in 1983 (Chipman & Thomas, 1987) and to the latest available total of 37 percent in 1992 (Magner, 1993).

Although growth in women's participation in science has contributed to these increases, from 3 percent of all earned PhDs in science from 1920-1973 (Tidball, 1976), to 26 percent in 1986 (Oakes, 1990), and 28.5 percent in 1992 (Magner, 1993), growth in the social sciences has contributed to much of this increase (Ahren, 1981, “Signs of Trouble,” 1983). In other scientific fields, with the exception of biology (“Data Points,” 1992), the number of doctorates earned by women has remained depressed because of their low participation in higher education at this level (Chipman & Thomas, 1987).

“To become a scientist, students must choose science and mathematics as early as middle school and keep choosing them again and again” (Culotta, 1992, p. 1201). A study of the sophomore high school class of 1977 demonstrated that this does not occur for the majority of students with an early interest in the natural sciences and engineering. Of 730,000 high school sophomores interested in natural science and engineering, 206,000
earned bachelors’ degrees in these areas by 1984, 46,000 were projected to earn masters’
degrees by 1986, and only 9700 were projected to earn PhDs by 1992 ("The Science and
Engineering," 1987). This “leaking” that occurs out of the science and engineering pipeline
represents denied opportunities for talented females and the loss of potential scientific talent
for the country.

Because the potential for educational opportunities is a lengthy one, from grade
school through graduate school, there are numerous junctures in the educational experience
where females can leave the science and engineering pipeline. Because these numerous
junctures present themselves over a long period of time the factors that are associated with
persistence or attrition in science are not only numerous as well, but as the literature reveals,
are complex and cumulative in nature. A listing of some of the factors considered to be
obstacles to persistence provides some insight into the complexity of this issue. These
factors include:

(1) Lack of support from parents, advisors, teachers, and peers for the self-concept
of science ability in a young girl (Manis, 1989).

(2) Negative influence of parents on student plans after high school (Ethington &
Wolff, 1987).

(3) Depiction of science as being masculine in nature (McNamara & Scherrei, 1982).

(4) Competitive nature of science classes leading to the perception that science is an
unfriendly area (Tobias, 1990).
(5) Sexist attitudes of students and professors contributing to the presence of a “chilly classroom climate” (Holmstrom & Holmstrom, 1974).

(6) Demands of marriage, family, and career leading to role conflict (Kaplan, 1982).

(7) Decreased availability or awarding of financial aid for females (Wong & Sanders, 1982).

(8) Sex differences in the mathematics section of aptitude tests (Lee, 1987).

(9) Low participation in science and mathematics courses in high school leading to inadequate preparation for future college work in these areas (Gordon, 1990).

(10) Lowered sense of competence in science, as perceived by females and males (Morgan, 1992).

(11) Internal placement of blame for difficulties or lack of enjoyment in college science courses (Ware, Steckler, & Leserman, 1985).

(12) Lack of information concerning what to study in graduate school (Kaplan, 1982).

The Problem Statement

Although women’s participation in science education has increased through the years, they continue to be underrepresented in all areas of graduate scientific study as judged by their numbers and movement through the science and engineering pipeline. In more recent years, these numbers have been linked to the larger problem of what has been called a crisis in American science education. First, a concern developed within the scientific community
when it recognized that there was a marked decrease in support for education during the Reagan administration ("Science and Engineering," 1980). Since then, two factors that have reinforced one another and intensified the public's concern are science literacy and education for the general public, and the need to fill the scientific personnel pipeline in the future (Krieger, 1990). By the year 2010 it is expected that there will be a shortage of 560,000 professionals in science and engineering ("Getting Women," 1994). Both the need to increase science literacy and to produce professional workers are important to the country's future. It is through the education of America's citizens and the placement of citizens in scientific jobs that research and development initiatives may be undertaken that can enhance the competitiveness of the United States in the world community (Krieger, 1994).

As women continue to constitute a larger proportion of students in higher education, and workers in America's labor market, their underrepresentation in science becomes more pronounced. Responsibility for increasing the parity of women in science should be assumed by various groups, including the state and federal governments, industry, the public, and the academic community. Higher education represents the last juncture where females may be lost from the science and engineering pipeline, may enter it, or be retained through graduate school. Identifying factors associated with attrition or entrance of women at this last level of education solves three problems. First, from a practical perspective, it is logical to recognize women as the population from which to draw future scientists because of their prominence, by number, in higher education and the workforce. Second, from an educational perspective, the issues associated with women in science need to be further elucidated to ensure that the
educational community becomes informed of practices that encourage or discourage women’s participation in science. Third, from an ethical perspective, it is important to recognize, define, and eliminate barriers that may exist to women’s participation in science so that the full potential of America's citizens may be realized.

Significance of the Study

The impetus for this study of women in science developed partially from questions this researcher asked of herself. As a young person interested in science this researcher had positive experiences with science classes, but did not receive encouragement from school counselors or parents to pursue an education in science. The messages were clear—there were traditional pathways of education for females to pursue which would be compatible with marriage and family, but these did not include education in the sciences. Therefore, an important personal question that developed through the years was “Why did I pursue a science career, both at the bachelor and graduate levels?” Since then, this researcher has discussed with women their experiences in both science and nonscience classes and the significance of various issues that guided their educational and career choices. It became obvious that many bright women were discouraged from science and mathematics education and careers by teachers and guidance counselors in the public schools, parents, male companions, and college professors. This study is partially significant, therefore, because it is piqued from personal experiences. However, the study of women in science has a much broader significance as it is related to a number of practical, educational, and ethical issues.
First, the practical significance is related to the question of "Who will do science in the years ahead?" (Sloat, 1990, p. 4). An examination of demographic trends allows prediction of an answer to this question.

Because youth have already been born who will make up the traditional source of college students in the future, it is possible to estimate the size of the college age population in the next decade ("Educating Scientists," 1988). Projections by the Census Bureau indicate that there will be a decrease in the number of American born 18-year-olds until the mid1990s, with recovery occurring in the following decade. The composition of this youth pool is expected to change, with American born minority groups forming an increasingly larger proportion of this population (Porter, 1990).

Between 1980 and 1989 the traditional college age cohort of 18 to 24-year-olds decreased by 12 percent (Carter & Wilson, 1990). Within this cohort the number of whites and African Americans decreased while the number of Hispanics increased by 39 percent. White males will make up less than one-third of this cohort by the year 2010 (Sloat, 1990).

As the size of the traditional college age cohort has declined it is important to acknowledge changes that have occurred in the college enrollment rate for these various groups. The college enrollment rate refers to the actual number of students enrolled in college (Carter & Wilson, 1990). Between 1986 and 1988, for all institutions of higher education, white and African American enrollment increased by less than 5 percent and Hispanic by 10 percent. During the decade of 1978 to 1988 women in all ethnic and racial
groups experienced larger increases in total college enrollment than males. Their enrollment grew approximately four times as fast as the growth for males.

It is possible to estimate the number of future scientists and engineers by multiplying the historical proportion of college students who major in science and engineering by the population of college age people in the birth cohort. This type of extrapolation can also be used to determine participation in graduate school and the production of PhDs in science and engineering. It has been predicted that there will be a decline in the output of scientists and engineers which leads some groups to believe there will be personnel shortages in certain areas of science and engineering ("Educating Scientists," 1988).

The military was the first group to become aware of the potential effects of this decrease on their skilled resources (Porter, 1990). Industry has also become concerned as its workforce becomes threatened by these demographic trends ("Changing America," 1988). Industry employs two-thirds of the country's scientists and engineers and utilizes three-fourths of all research and development monies.

Between 1986 and the year 2000 it is estimated that there will be a 36 percent increase in the demand for scientists, engineers, and technicians, with the greatest demand being for scientists (Leggon, 1989). By the year 2010 there could be a shortage of 560,000 science and engineering professionals in the United States ("Changing America," 1988). Past sources of recruits for these areas have been the cohort of traditional college age students, but specifically, the recruits have been white males within this cohort (Sloat, 1990). With the estimated decrease in size of this cohort, and the anticipated increase in demand for
scientists and engineers, the question that arises is “How will supply keep up with demand in these areas?”

The Task Force on Women, Minorities, and the Handicapped in Science and Technology reported that strengthening the science and engineering workforce is one of America’s most urgent tasks (“Changing America,” 1988). The Task Force stated that “The educational pipeline—from prekindergarten through the PhD—is failing to produce the workers needed to meet future demand “ (“Changing America,” 1988, p. 3). The ability to supply PhDs for future needs in science and engineering has caused much of the current concern to be focused on the ability of graduate schools to recruit baccalaureate recipients to their PhD programs (Atkinson, 1990).

In the next few years, a decrease in the number of new faculty needed to teach a declining number of college students will probably offset an increase in demand for new PhDs in nonacademic areas (Atkinson, 1990). However, projections by Bowen and Sosa (1989) indicated that beginning in 1997 the demand for PhDs will greatly exceed supply from that point on. They believed this will occur because the enrollment in colleges will increase at the same time large numbers of faculty members will be retiring.

Vaughn and Rosenzweig (1990-91) stated that there are three ways to reduce the projected shortages of PhDs: reduce demand, rely on the labor market to equilibrate supply and demand, or intervene to increase supply. The only viable option they indicated, however, was to increase the supply of PhDs. Therefore, in answer to the question of “Who will do science in the years ahead?” (Sloat, 1990, p. 4) demographic trends point toward women and
minorities as forming the greatest potential pool (Sloat, 1990) because these groups represent an increasing percentage of undergraduate and graduate students. As women become one of the target groups it is imperative that issues associated with their participation in science be studied.

Second, this study is significant from an educational perspective because it will provide evidence to test the validity of previous research findings. Examination of the literature reveals a number of studies that have addressed factors associated with the participation of women in science. However, it is evident that past research not only has resulted in the development of contradictory conclusions regarding the role these factors play in facilitating or hindering science participation, but it has also failed to clarify or identify other factors that are pertinent to the issue of women in science. One area in which the results appear to be inconclusive at this time is parental support. Other potential supporting influences in the student's environment that need further clarification are the factors of high school teacher and guidance counselor support, college personnel support, and peer support.

Regarding the issue of faculty support, Girves and Wemmerus (1988) indicated that the relationship between faculty and students needs further study, particularly as a function of academic discipline. If critical aspects of this relationship are identified, it will then be possible to make faculty aware of the importance of their actions and attitudes regarding their relationship with students, and the impact these factors have on student progress. Girves and Wemmerus stated that the faculty-student relationship is closely linked to the norms and expectations of individual departments. Even earlier, before the issue of women's
participation in science came under national scrutiny, Solmon (1976) stated that individual departments should be studied to determine if areas of discrimination exist regarding a number of factors. When links between the college environment and student persistence become more fully clarified, pedagogical techniques, institutional programs (Sax, 1992), and faculty attitudes and actions may be purposely altered to enhance the learning process and provide a more conducive environment for student persistence in science.

Although several studies have identified the marital rates and patterns of women in higher education, some areas are in need of further study. For example, for females who have high family and marriage aspirations, it is uncertain what factors they see as hindrances toward attempting graduate school. Also, although there have been several studies examining the issue of financial aid for graduate students, it appears that further study is needed to identify whether or not college seniors perceive the factor of financial aid to be an obstacle to graduate school enrollment. Another area that needs clarification is the factor of self-confidence in science. It is unclear to what extent a decreased sense of competence in science, if it exists in high achieving females, affects their persistence to graduate school.

In addition to the many factors already studied this research project will examine an area that has been overlooked in previous studies—that of the nature of science and the processes associated with scientific inquiry as they relate to the enjoyment of science as a discipline. Although some studies have addressed the competitive nature of the science classroom (Manis, 1989; Tobias, 1990) most of these studies have focused on how the presence of male classmates and male instructors influence persistence in science. Ware and
Lee (1988) suggested there may be many factors that are important for women's participation in science that have not yet been identified. By adding the variable, "enjoyment of science as a discipline" this study is significant because it can provide data on an additional factor possibly related to persistence that has been overlooked in previous studies.

Further, this study is significant from an educational perspective in that it will attempt to address two limitations of previous studies. The first is related to the choice of population for study. Various studies have focused on graduate students or on doctoral recipients. As Solmon (1976) noted, little is known about the student who drops out prior to entrance or completion of graduate school. Because more recent studies have not fully studied the issue of barriers that face women who have dropped out of the educational pipeline after successfully earning bachelors' degrees in science, the current study will address this limitation by including these women in the population for study.

The second limitation of other studies that will be addressed in this research project is the lack of focus on what happens to the female student after enrollment in graduate school. Girves and Wemmerus (1988) stated that there has not been an emphasis on the factors associated with graduate student retention or degree progress. The current study will include in the population students who are in graduate school, and therefore, it will address factors associated with their retention and progress of study.

Finally, this study is significant from an ethical perspective because it will add to the body of knowledge that strives to explain factors associated with equity, regarding the education of women in science. It is in the best interests of American society to identify,
understand, and correct any factors that are forms of discrimination directed toward the student who constitutes the majority of the college enrolled population.

**Purpose of the Study**

Although previous research has identified a multitude of factors believed to be associated with women's persistence in science, the body of knowledge related to this issue is at times inconclusive and has failed to study potentially important factors. Also, the literature is scant regarding the barriers faced by women who have completed undergraduate degrees in science, but failed to pursue a graduate education in science, or who dropped out before graduate degree completion. Along with addressing these failings of other studies, several other limitations of previous research will be addressed by this research project. Specifically, these include: studying successful students; studying science students within a narrow range of majors, not including mathematics and engineering; studying only females; separating graduates into masters' and doctoral programs, and into programs of advanced graduate studies and professional programs of study. The primary purpose of this research, therefore, is to incorporate these factors into a study concerned with attempting to clarify the significance of previously identified barriers to women's participation in science, in addition to introducing new factors not previously identified or well studied by researchers.

Specifically, this study will be devoted to the following research interests:

1. To examine the importance of role models and significant others in the persistence of successful females in science in progress toward earning their undergraduate degrees;
2. To
identify and characterize reasons why successful females in science fail to persist in science beyond the baccalaureate degree; (3) To identify factors nonpersisters believe could help attract more females to persist in science beyond the baccalaureate degree; (4) To determine the extent to which successful females in science enroll in programs of further science study after earning the baccalaureate degree; (5) To identify factors that were most influential in helping successful females in science to persist in science studies beyond the baccalaureate degree; (6) To identify factors that persisters believe make it difficult for females to be successful in graduate or professional school; (7) To identify experiences in graduate or professional school in science that could hinder persistence of females in science while they are enrolled in these programs; (8) To determine if there are any significant differences between two groups of science graduates: persisters and nonpersisters, and those graduating with distinction or not graduating with distinction, on each of six factors related to undergraduate experiences, and to determine whether persistence and GPA have a combined effect on each of these six factors; (9) To determine if these six factors could be used to predict persistence in science; and (10) To determine if there are any differences between females who pursued advanced graduate studies and females who pursued professional programs of study on the six factors related to undergraduate experiences. The six original factors were attitudes toward the “enjoyment of science as a discipline,” “relationships with science professors,” “self-confidence for science studies,” “nature of the science classroom,” “sex discrimination in the science classroom,” and “academic advising experiences.”
Research Hypotheses

Purposes of the study numbered 8-10 in the previous section have been formulated into research hypotheses for testing. Research hypotheses 1-6 are designed to address purpose 8, research hypothesis 7 is designed to address purpose 9, and research hypotheses 8-13 are designed to address purpose 10. These research hypotheses are listed below.

1a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward the enjoyment of science as a discipline.

1b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward the enjoyment of science as a discipline.

1c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward the enjoyment of science as a discipline.

2a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward relationships with science professors.

2b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward relationships with science professors.

2c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward relationships with science professors.
3a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward self-confidence for science studies.

3b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward self-confidence for science studies.

3c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward self-confidence for science studies.

4a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward experiences with the nature of the science classroom.

4b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward experiences with the nature of the science classroom.

4c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward experiences with the nature of the science classroom.

5a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward sex discrimination in the science classroom.
5b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward sex discrimination in the science classroom.

5c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward sex discrimination in the science classroom.

6a: There is a significant difference between thepersisters and nonpersisters in a science program of study on their attitudes toward academic advising experiences.

6b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward academic advising experiences.

6c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward academic advising experiences.

7: There is a relationship between the mean ratings of females in science on their attitudes toward "enjoyment of science as a discipline," "relationships with science professors," "self-confidence for science studies," "experiences with the nature of the science classroom," "sex discrimination in the science classroom," and "academic advising experiences," and their persistence to further science study after earning the baccalaureate degree.
8: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the enjoyment of science as a discipline.

9: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward relationships with science professors.

10: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward self-confidence for science studies.

11: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward experiences with the nature of the science classroom.

12: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward sex discrimination in the science classroom.
There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward academic advising experiences.

**Basic Assumptions**

The following assumptions are acknowledged as they pertain to this research project.

1. Students chosen for this study are successful females in science who are capable of persisting in science beyond the bachelor’s degree.

2. Females receiving bachelors’ degrees in various science majors from 1986 through the summer of 1994 are capable of recalling their experiences, thoughts, and actions from their undergraduate years, therefore, allowing for the retrospective nature of this research project.

3. Females who are undergraduate science majors are likely to persist in science if they attend graduate or professional school.

**Organization of the Study**

This dissertation is comprised of five chapters. Chapter I serves to introduce the factors associated with the problems of attraction, persistence, and attrition of women in the science and engineering pipeline. It also gives the problem statement, states the significance and purpose of the study, the research hypotheses, basic assumptions, and describes the organization of the dissertation.
Chapter II represents a review of the literature. This chapter begins by stating the purpose for this literature review and by introducing the reader to the organization of the chapter. The introduction is followed by the subheading “The Context,” which serves to place the issue of women's participation in science in perspective. “The Context” contains the subsections: “The science and engineering pipeline” which projects the problem of attrition of women in science and engineering; and the “Historical perspective” which describes the education of women historically. The subheading that follows is “Factors Influencing the Participation of Women in Science” which examines some of the factors that have been associated with women's participation in science. This latter section is further organized into three additional subsections: “Factors associated with motivation;” “Factors associated with access;” and “Factors associated with ability.” Within the subsection of motivation “Parental support, Academic environment support, and Peer support” are addressed, as well as the “Perceptions of science, scientists, and the science classroom,” and “Role conflicts.” Within the subsection of access “Financial aid” is reviewed. The last subsection, ability, briefly examines “Performance” and “Participation” and also the “Perceived level of ability and self-confidence.” Because the subsections reviewing support, perceptions of science, role conflicts, financial aid, and ability are lengthy, each of these subsections is followed by a brief summary. Finally, Chapter II concludes with a summary of the literature review.

Chapter III describes the methodology of this research project. The chapter begins by describing the research design, the research population, and the research sample. This is
followed by a description of the survey instrument, data collection, data analysis, and statistical tests. The chapter concludes with a summary of the methodology.

Chapter IV states the research findings of this study. It begins with a preliminary analysis of the data, followed by descriptive analyses of the data and finally, the results of the testing of the null hypotheses. The chapter concludes with a brief summary of the research findings.

The last chapter begins with a brief overview of the purpose and organization of the study. This is followed by a discussion of the findings which is organized according to the stated purposes of the study. Conclusions for these findings are then stated. The chapter ends by stating the research contributions, implications and recommendations, limitations of the research, and suggestions for future research.
A review of the literature is necessary for a research project of this nature to
(1) establish the basis for the research questions and hypotheses that are developed
(2) ascertain if conflicting lines of evidence are present and (3) acknowledge what research
questions are in need of further study. The literature review that follows is lengthy for two
reasons. This particular research project involves both the study of women who decided to
persist in science beyond the bachelor’s degree, and those who have not. Therefore, the
literature that focuses on both groups must be reviewed. Also, the factors that have been
identified which are related to women’s participation in science appear to be both cumulative
and complex in nature. The cumulative nature of the effects of these factors makes it
necessary to review studies on women prior to their senior year of college, thus lengthening
this review. The reader should also be aware that studies which have been reviewed may
appear at first to not be pertinent to this research project because some of them involve
males, non-science students, and engineering and mathematics students. However, very
frequently, these subjects are included in research projects on women’s participation in
science. With these considerations in mind, this chapter is devoted first to an examination of
the context of the research problem. The next section examines the factors of motivation,
access, and ability as they relate to the issue of women in science. Within the section on
motivation factors associated with support, perceptions of science and scientists, and role
conflicts are reviewed. The section on access reviews the factor of financial aid and the section on ability contains the subsections of performance, participation, and perception of science ability and self-confidence. The longer sections are followed by a brief summary. Finally, the chapter concludes with a summary of the literature review.

The Context

In response to the Soviet challenge of the 1950s and 1960s (Tanner, 1989), predominantly because of the launching of Sputnik, massive curriculum reform was initiated in the United States (Shamos, 1984). With the aid of the National Defense Education Act of 1958 and the National Science Foundation (NSF) (Tanner, 1989) a multibillion dollar federal initiative was launched to reform science and mathematics education (Shamos, 1984). The objectives of this effort were to stimulate an interest in science in order to alleviate the manpower shortage in science that existed, and second, to increase the level of scientific literacy by making science teaching more effective. Shamos (1984) stated that the first objective was satisfied over the following two decades, but that attainment of the second objective was a failure.

Another wave of curriculum reform arose in the 1980s in response to the Japanese challenge. National educational reports declared the need to reform the educational curriculum and to endorse the development of our citizen's literacy (Tanner, 1989). In 1983, a report examining the status of American education reported that “Our nation is at risk” (“A Nation,” 1983, p.5) because of a decrease in the quality of education in the United States.
Some calls for reform challenged colleges and universities regarding their general education requirements. William Bennett (1986) criticized Harvard University for not ensuring that its graduates leave as educated men and women. Bennett faulted the lack of a good general education as being responsible for this situation. Ernest Boyer and Arthur Levine (1981) stated that general education is important to both our society and colleges and that a positive sign was a willingness of the academic community to reexamine its general education requirements.

Other calls for reform have focused specifically on science education. Westheimer (1987) criticized Harvard University for the minimum role of science in the university’s core curriculum. He contended that the majority of students who graduated from Harvard are uneducated because they know little about science. However, Westheimer concluded that this condition is also present in graduates of other colleges and universities.

In 1980, the Secretary of Education and the director of the NSF issued a science policy report for President Carter (“Science and Engineering,” 1980). This report compared the United States and the Soviet Union on the quality and number of scientists, technicians, and engineers being educated. Also, the technical illiteracy of America’s high school and college graduates was cited. Because the report focused on science education generally, and compared the two countries, attention began to increase on science education. This attention intensified when a marked decrease in support for science education occurred during the Reagan administration (Shamos, 1984). Other factors that contributed to this concern were the issues of science literacy and education for the general public and the need to fill the
science and engineering pipeline in the future (Krieger, 1990). Because these factors impact on competitiveness of the United States and because there is concern for our country’s education in general, Krieger stated that expressions for science reforms may continue to deepen, leading to a change in “science education in the U.S. from cradle to college” (Krieger, 1990, p. 27).

The science and engineering pipeline

As students move through the educational system they may be considered to pass through a pipeline. This pipeline model is a process that takes crude student talent and turns out finished products, as measured by bachelors’, masters’, and doctorate degrees. Although the maximum size of the science and engineering talent pool appears to be reached before high school, migration into the pool continues to occur during grades 9 through 12. After this point, however, there is primarily a migration out of the talent pool. During the undergraduate college years, and in the transition between undergraduate and graduate school major losses to the science and engineering pool occurs ("Educating Scientists," 1988).

The Office of Technology Assessment analyzed data from the U.S. Department of Education’s “High School and Beyond” survey. This longitudinal study surveyed students from two nationally representative samples every two years to collect data on their educational progress and careers. The Office of Technology Assessment chose to study the sample of students who were high school sophomores in 1980. According to the analysis,
overall college freshmen enrollment was steady. However, there was a decline in the number of college freshmen planning careers in science and engineering, with interest falling faster in the physical sciences, engineering, and mathematics than in the social and life sciences. In high school, more than half of the students indicated an interest in science and engineering as sophomores, but changed their subject interest by their senior year. In 1986, entering college freshmen showed less interest in science and engineering than in 1978. From 1978 to 1986 the level of interest dropped from 27 percent to 24 percent ("Educating Scientists," 1988).

Analysis by the NSF of 4 million students attending tenth grade in 1977 determined the pattern of attrition through the natural science and engineering pipeline. Of the 4 million high school sophomore cohort, 730,000 indicated an interest in science and engineering as sophomores. This number decreased to 590,000 by the high school senior year. College freshmen with science and engineering intentions only numbered 340,000, and those actually earning baccalaureate degrees in these areas by 1984 totalled 206,000. Between the baccalaureate degree and graduate study the numbers were projected to decrease to 61,000. Of the original cohort, 46,000 were projected to receive masters' degrees and 9700 were projected to receive doctorate degrees ("The Science and Engineering," 1987).

Because only five percent of bachelor's degree graduates in science and engineering persists in education in these fields to earn PhDs, much of the current focus centers on the ability of graduate schools to recruit students into their doctoral programs (Atkinson, 1990). Atkinson stated it is possible that an increased demand in the nonacademic areas for PhDs
will be offset by a decreased demand for PhDs in academic areas in the next few years. This is associated with a decline in the number of students enrolled in college. However, projections by Bowen and Sosa (1989) predicted this situation will be temporary. It is expected that after the mid-1990s the demand for PhDs will exceed supply in the academic areas as college enrollment increases coincide with the retirements of a large number of faculty members.

Because the number of women attending college increased by over 90 percent from the early 1970s through the 1980s they came to constitute 54 percent of the students in college by 1990 (McDonald, 1990). This group became the most obvious one, therefore, to be targeted for strategies aimed at increasing conferral rates of baccalaureate and doctoral degrees because it is the group in which large increases can be expected (Atkinson, 1990). Women and minorities also represent an increasing percentage of potential workers (“Changing America,” 1988). By the year 2000, 85 percent of the country’s workforce will be women and members of minority groups.

Until recently, the role of women and minorities in science and engineering has only been an issue of equity (“Changing America,” 1988). Today, underrepresentation of these groups in the sciences is one of national discourse because of scientific personnel shortages and the need for international competitiveness (Sloat, 1990).
Historical perspective

In order to gain a perspective on the position women hold today in the sciences, their positions in education, historically, should be examined. When women began to be admitted to higher education in the midnineteenth century, and up to the 1960s, the major rationale for their education was to make them better mothers and better wives for their educated husbands ("Climbing the Ladder," 1983). Very few women received true career preparation, especially in the sciences.

Three major surges in college enrollments in the United States, and therefore, conferrals of baccalaureate degrees have occurred since 1900. By implication, these surges have coincided with an increased production of scientists and engineers. Following World Wars I and II the return of veterans, and their subsequent enrollment in college, caused two of these increases to occur. During these times increasing federal investments created new opportunities for scientists and engineers and there was an expansion of government and industrial research laboratories. The third major increase in college enrollments occurred in the 1960s, encouraged by the presence of the baby boom generation and a continuation of the national commitment to science and technology from the postSputnik era (Atkinson, 1990).

The time period between WW II and the mid1960s coincided with a large increase in the production of male PhDs ("Climbing the Ladder," 1983). It is this time period following World War II that is considered to be the beginning of the prospering of American science (Atkinson, 1990). Part of the increase in the production of PhDs during this time can be attributed to bills that broadened educational participation for men ("Climbing the Ladder,"
1983). Specifically, The Serviceman’s Readjustment Act of 1944 (also known as the G. I. Bill) (Olson, 1974), and successors to the bill following the Korean and Vietnam wars, provided aid to returning veterans (“Climbing the Ladder,” 1983). Even though some women were entitled to these benefits, 99 percent of the World War II veterans who received aid were males. Women continued to finance their own education, but higher education had become available to men regardless of their economic status. In 1950, approximately 25 percent of PhDs awarded in science were earned through primary support from the G.I. Bill (Harmon, 1968).

The number of PhDs earned by women has increased continuously since 1900, but the increase has been overshadowed at times by the trends in the education of males. Partially because of disparate support for men and women, the proportion of PhDs earned by women in each decade reached an historic low in the 1950s. However, since 1970 the number of science PhDs earned by women has increased while the number earned by men has decreased (“Climbing the Ladder,” 1983).

In order to achieve in science or any other area at least two factors must be present—opportunity and ability. After World War II, especially for men in science, there was a belief that scientific talent should be nurtured, and also, that it was in the national interest to do so. These assumptions, however, have not in the past been applied in the same way to careers of women in science (“Climbing the Ladder,” 1983).

A basic tenet to our nation’s educational system is that all students with interest and ability should have access to education. It was not until passage of the title IX amendment to
the 1972 Higher Education Act, known as the Women's Educational Equity Act, that this tenet included women. Prior to this time the access of women to college and graduate study could be legally restricted. This occurred partly through the use of quotas and sex differences in financial aid (Homig, 1987).

In the last decade there was an increase in the inclination of women to choose degrees in science or engineering. Two factors have most likely contributed to this tendency. These are the ending of formal sex discrimination in higher education, and the perception by women of their equality, making it more rewarding for them to commit to the investment of a career in these areas (“Climbing the Ladder,” 1983).

Recent studies have demonstrated that the number of baccalaureate degrees earned by women in science and engineering between 1976 and 1986 increased by 29 percent, compared to a 2 percent increase for men (Lane, 1990). The largest gains were made in computer science and engineering. During this same time period there was an increase of 59 percent in the number of masters' degrees earned by women, compared to less than 2 percent for men. Between 1978 and 1988 there was an increase in women earning PhDs in all areas of science and engineering. However, in 1985 only 8 percent of the number of PhDs awarded in physics went to women, and only 4.7 percent of PhDs were earned in engineering by women (Ivey, 1987).

The current trends for women employed in science and engineering indicate that their representation has been increasing. In 1978, women constituted 9 percent of all scientists and engineers employed in this country, and by 1988 their representation had grown to 16
percent (Lane, 1990). However, women continue to be underrepresented in the workforce in these areas because in the overall workforce in the United States women constitute approximately 45 percent of all workers.

Sheila Widnall (1988), speaking as president of the American Society for the Advancement of Science summarized current trends in the fields of science and engineering. Widnall stated that because of a decrease in the number of white college age males, the dominant members of the science and engineering baccalaureate degree holders who attain the PhD degree, increased competition will probably occur between industry and universities for the baccalaureate degree holders. This competition has already been a predominant reason for the decrease in students earning the PhD in engineering. Because the number of minorities is increasing in the college age cohort, and they are underrepresented in graduate programs in science and engineering, the drop in science PhD recipients is expected to be severe. According to Widnall, women are available to fill scientific personnel vacancies because of their increased participation in the science and engineering areas.

Factors Influencing the Participation of Women in Science

"The final step in the academic pipeline is graduate school, where again, more women and minorities drop out than white males" (Selvin, 1992, p. 1201). A study by Hilton and Lee (1988) analyzed nationally collected data on students who were high school seniors in 1972 and 1982. Using follow-up surveys the persistence rate for students in mathematics, science, and engineering was determined. The results indicated that of six time
periods studied, the largest leak from the science pipeline was during the transition from high school to college, and that the second largest loss was between undergraduate to full-time graduate level status. Although the Hilton and Lee study demonstrated that a higher proportion of males than females enrolled in graduate school in a mathematics, science, or engineering major, the study was not a causal analysis, and therefore, the researchers were not able to cite statistical inferences about why students, particularly women, leave science at these junctures.

One critical point in the science pipeline for women, therefore, is between undergraduate and graduate education (Hilton & Lee, 1988; Lane, 1990). Homig (1987) stated that three major factors govern whether a student will continue in education to earn an advanced degree: motivation, access, and ability. Various other factors may be related to these three such as demographic and socioeconomic factors, however, a correlation that is well recognized is that females have a decreased chance of completing a PhD. This is true for almost all fields of study.

The large number of factors that have been identified to date as being associated with women's participation in science, as well as the apparent complex nature of their interactions make it cumbersome to study the issues associated with women's participation in science. In order to simplify the understanding of these issues this researcher will use Hornig's categories of motivation, access, and ability. That is, each of the previously identified factors associated with women's participation in science that are pertinent to this research project will be reviewed under one of Hornig's categories. This will provide the reader with
an organizational framework in which to examine what is known or unknown, or what is in dispute, concerning the issues associated with women's participation in science.

**Factors associated with motivation**

Numerous factors have been associated with the motivation of science students. Research studies have noted the importance of parents, teachers, high school guidance counselors, college faculty, and peers as influencing agents. Motivation also appears to be influenced by perceptions that students have about the nature of science as a discipline, and on the nature of scientists, themselves. Throughout the educational process students are exposed to various science courses and types of instructors. Student motivation has been found to be affected by the enjoyment of science classes and by the interaction students experience with members of the scientific community. In some cases women have experienced sexist attitudes from professors and have complained about a "chilly classroom climate." Women also appear to be plagued by role conflicts associated with being students, spouses, mothers, and professionals in their careers.

**Parental support** There is a paucity of studies that have examined parental influence on science students who have reached the level of graduate education. An early study by Astin (1969) surveyed doctoral recipients, and through an analysis of autobiographical sketches Astin concluded that parents' behaviors and encouragement were important factors that influenced women's educational and career decisions. Also, the career
of the mothers was an important determinant in the choice of field of study selected by women in this study.

A later study by Berg and Ferber (1983) demonstrated the supporting influence of parents for students in the sciences and nonsciences. These researchers surveyed both science and non-science graduate students at one university. For females in the physical and biological sciences only 16 percent reported receiving moral support from their mothers, while 73 percent of females in education believed they had strong maternal support. In comparison to paternal support, approximately 50 percent of females in the sciences reported having their father’s support, but this increased to approximately 66 percent for females in education. Males sampled in this study reported receiving a great deal of moral support from both parents, with the support being nearly the same (40 to 50 percent) for students in the science and non-science areas.

O’Connell, Betz, and Kurth (1989) analyzed data from undergraduate female students in nursing (traditional field of study) and from graduate students in engineering and veterinary medicine (nontraditional field of study). The only observation made to parental influence was indirect. Their study found that the fathers of the nontraditional students had significantly more education than the fathers of the traditional students.

The majority of studies that have examined parental influence as a factor in the participation of science have surveyed high school or undergraduate students. Two of these studies (Ethington & Wolfle, 1987; Ware & Lee, 1988) analyzed data from the “High School and Beyond” survey. Ethington and Wolfle chose their sample from women who
participated in all three time periods of surveying: in 1980 as high school sophomores, in 1982 as high school seniors, and in 1984 as undergraduates attending a postsecondary educational institution. They concluded that females whose parents had the most influence on their plans after high school were less likely to enter quantitative fields of study. Ware and Lee sampled both male and female students who were seniors in 1980 and were enrolled in college in 1982. They limited their sample, however, to students they considered to have high levels of academic ability. This was accomplished by only choosing individuals who scored at or above the 50th percentile on a high school senior test which was a composite measure of achievement. Students were chosen because of the researchers’ assumption that these students were the most likely to choose a science major. In this study, females who were less likely to choose a science major had parents who were more involved in their academic work.

Morgan (1992) studied perceptions of undergraduate students regarding why there is low participation of women in science and engineering. She sampled females and males at three universities and determined that the third most cited reason by both sexes was that parents discouraged their daughters from entering these fields.

Manis (1989), in a study of seniors at a large university reported that 85 percent of females who were majoring in science strongly rejected the statement that “parents had not encouraged me to go into science.” In this study, females were more likely than males to agree that their parents encouraged science study. Manis also found that females in science were more likely to believe they resembled their fathers in terms of interests and abilities.
Data from this study also suggested to Manis (1989) that parents have other influences over their children than approval or encouragement of science interest. Manis believed that mothers, particularly, placed more emphasis on wanting their daughters to be happy, rather than their sons. This suggested to Manis that daughters may be limited from achieving high status career goals.

The findings of a recent study of science majors attending highly selective institutions (Strenta, Elliott, Adair, Mattier & Scott, 1994) concur with Manis (1989) regarding parental support. In this study females, more so than males, believed that their parents were important for their decisions to study science.

Sax (1992) failed to support the conclusion by Manis (1989) and Strenta et al. (1994) that females were supported to a greater extent by their parents than were males, regarding science persistence. Sax (1992) concluded that parents had more effect on male persistence than on female persistence in science. Sax used data from the Cooperative Institutional Research Program (CIRP) surveys of 1985 college freshmen who also participated in a follow-up survey in 1989. Analysis of this data from over 15,000 students demonstrated that for men, but not women, “parents wanted me to go to college” was a significant factor related to persistence of a career in the hard sciences (engineering, natural, and physical sciences). The careers of parents had varied effects on male and female science persistence in the Sax study. Having a father who is an engineer was a positive predictor for both males and females. For men however, but not women, having a mother who is a research scientist was a positive predictor of persistence in science. Sax speculated that fathers may act as
mentors or role models for their children, or, by having high expectations for their children, may apply pressure towards persistence in a science career. Sax found it odd, however, that a mother in the role of research scientist was not a positive predictor for a daughter's science persistence.

Compared to the studies cited in this literature review regarding the significance of parental support and science entry or persistence, the findings of Fitzpatrick and Silverman (1989) suggested that parental support for women was less important than in earlier time periods. Their study sampled high achieving women in three fields of study: high nontraditional (engineering), typical nontraditional (science), and more traditional (humanities and social sciences). Although Fitzpatrick and Silverman demonstrated that parental support and a father acting as a role model were important factors in women's selection of careers in engineering, these factors were found to be less important for women selecting science careers. This finding suggested to these researchers that trends found earlier may have changed during the 1980s. Other factors studied by Fitzpatrick and Silverman also demonstrated that frequent differences existed between engineering and science majors. This suggested to Fitzpatrick and Silverman, as well as to this researcher, that a limitation of many studies (Astin, 1969; Ethington & Wolfle, 1987; Manis, 1989; Morgan, 1992; Ware & Lee, 1988) is related to the failure to separate subjects into groups within the sciences, rather than clumping students together and viewing science and engineering students as a homogeneous group.
**Academic environment support** Types of individuals in the academic environment who influence women’s college plans include teachers at the precollege level, guidance counselors in high school, college advisors, and professors. In junior and senior high not only parents, but guidance counselors and teachers can be instrumental in advising females to take science courses (Ivey, 1987). In college, faculty acting as advisors represent additional potential sources of information and guidance (Stansbury, 1986). Faculty members also represent role models who may be instrumental in motivating females to persist in science.

Although most studies on women’s participation in science involve data collection through the use of survey instruments, qualitative studies can yield from study participants statements that are rich in description, thus providing the researcher with information unavailable through quantitative research techniques. Sandler (1994) stated that in particular, instances of discrimination can be documented by listening to women describe their experiences. However, she did acknowledge that it is possible to combine the survey format and qualitative data. Sandler believed this is possible by using open-ended questions on the survey instrument. Qualitative research, therefore, helps the researcher to gain a “feel” for data collected through quantitative methods (A. Netusil, personal communication, November 30, 1993). For this reason, studies utilizing both types of research are important for inclusion in a literature review of this type.

A study that utilized both quantitative and qualitative data was undertaken by the National Association of Biology Teachers Committee (Kahle, 1983). Female and male
students of women high school biology teachers who were recognized as having had a successful record with women in science were studied. In addition to qualitative assessment of students this population was studied through spatial visualization tests, cognitive and locus of control tests, and through science attribution, attitude, and anxiety scales. A second population studied consisted of former students of the successful biology teachers. These former students were pursuing science majors in college or science related courses. After analyzing data collected from former students regarding the importance of certain people in their lives (science and mathematics teachers, others teachers, parents, counselors, and others) influencing their decision to persist in science and pursue science careers, researchers concluded that in all cases high school teachers were ranked first by students. In almost all cases students believed these teachers encouraged further educational endeavors. This study might be considered biased because the former students who were studied had been recommended by the high school biology teachers chosen to participate in the study. However, the study is important because for those students persisting in science, descriptions provided by the study participants were rich in detail and example, therefore, allowing important insights into the feelings of study participants.

In high school not only teachers, but guidance counselors as well influence interest in science. Researchers associated with the Kahle study (1983) also concluded that both female and male students considered their teachers to be important in providing career information, but females especially liked this aspect of their biology classes. Regarding guidance from high school counselors on plans after high school, although females indicated having talked
somewhat more frequently to their counselors than male students, these students in general found teachers, friends, and family members to be more important sources of career information and advice than their school counselors.

Further support for the contention that high school teachers and guidance counselors influence student interest in science is found in studies cited previously in this literature review. Fitzpatrick and Silverman (1989) found that of the three student groups they studied (engineers, science majors, and humanities and social science majors), science majors were most likely to report that high school teachers had a strong positive influence on their career choice. Coupled to this finding the data indicated that parental influences were less important for science majors. Ware and Lee (1988) considered one of the most important findings of their study on college students to be the influence of high school teachers and guidance counselors on women's persistence in science and mathematics. Their data indicated a negative association between the choice of a science major and being influenced by high school staff regarding college plans. Manis (1989) reported that one-third of college women respondents considered lack of support from teachers and counselors to be a serious problem for women, with almost one-fifth of respondents stating it was personally a serious problem. These studies support the contention that the presence of support from professionals in high school influences women's decisions about science later in their educational experience.

Manis (1989) also analyzed data from college seniors regarding counseling at the college level. While she failed to demonstrate that women in science believed they had
worse counseling experiences than other groups of students, Manis did find that women in
general, and to a greater degree than men, believed the counseling process was too
impersonal. Analysis of qualitative data indicated that women believed counselors were not
interested in the student as a person, nor were helpful in aiding the student to develop
individual courses of study.

Beyond the undergraduate level Kaplan (1982) studied women over age 30 enrolled
in graduate level programs at the University of California, Berkeley, and in a professional
program at the University of California, San Francisco School of Medicine. Kaplan
considered her data to be generalizable to mature women in graduate and professional
schools across the country because her sample was comparable to a sample drawn for a 1975
national survey by the Carnegie Council on Higher Education. Respondents in Kaplan’s
study reported pursuing advanced education in fields that were of interest during their
undergraduate education. Therefore, the majority were enrolled in the traditionally feminine
fields of education and humanities, as opposed to the traditionally masculine fields of
science, mathematics, or engineering. In general, these women regarded their undergraduate
counseling experiences to be almost nonexistent regarding selection of a field choice prior to
graduate school entry.

Based on these studies it appears that high school counselors, teachers, and faculty
members acting as advisors are important sources of influence on the participation of females
in science. Besides guidance in field of study, however, faculty members can impact on the
development of characteristics or qualities associated with student development.
Didion (1994) recently reported on a university campus visit to evaluate the current climate for female students and faculty. One insight gathered from this visit indicated that female students craved more faculty interaction. Students reported that in their physics classes there was a lack of attention and guidance by faculty. Also, it became apparent that talented students struggled with the factors of self-confidence and a sense of belonging to the department. When faculty were confronted with these feelings they expressed disbelief that talented students felt this way.

A study by Stansbury (1986) demonstrated a link between women's self-confidence and assertiveness, and the quality of advisor relations. Stansbury examined relationships between the supportive aspects of science and engineering student environments at Stanford University and the student's level of self-confidence and assertiveness. One independent variable studied that represented a supportive feature of the academic environment was the quality of the relations students had with their advisors. For females, Stansbury concluded that the quality of advisor relations was inversely related to the level of stress experienced in graduate school. Positive relationships were demonstrated between the quality of advisor relations and the levels of self-confidence and assertiveness for these females. Because the results of Stansbury's study suggested that females are sensitive to supportive features of the academic environment, he stated that the relationship between advisor and student should be improved, particularly for women in a nontraditional environment, so that crucial information can be conveyed from advisor to student. Thus, the advisor acts as a rich source of valuable information and guidance to the student.
Although faculty play critical roles as advisors to students, they are also an important part of the academic environment because they may act as role models. As role models they can provide support and encouragement to females which may be important for their retention in the science pipeline ("Getting Women," 1994). Using the definition of Shapiro, Haseltine, and Rowe, role models may be described as "individuals whose behaviors, personal styles, and specific attributes are emulated by others" (Shapiro et al., 1978, p. 52). Shapiro et al. further stated that for many women, female role models are a significant variable in the successful resolution of feminine self-concept and professional identity for female professionals in male dominated professions. Using the premise that successful resolution of these issues facilitates the progress of women entering the professions, efforts have been directed toward the creation and facilitation of role model relationships for women students.

Girves and Wemmerus (1988) stressed that student-advisor relationships are critical to a student's educational and professional development. However, in graduate school faculty members not only serve as advisors, but by also serving as role models act as the primary socializing agent for the department that has enrolled the student. By establishing norms and standards for the student, and by interacting with students as professional colleagues, involvement in the doctoral program is increased, and therefore, facilitation of graduate degree progress occurs. By studying graduate students across 12 colleges within a midwestern university, Girves and Wemmerus concluded that the student-faculty relationship
is powerful enough to predict doctoral progress indirectly, through the extent of student involvement.

Two additional questions that have been addressed in the literature concerning faculty involvement with students concern differences that may exist because of sex and differences that may exist because of field of study. In an early retrospective study Centra (1974) failed to demonstrate differential interest by faculty members toward female and male graduate students. However, this study only surveyed students who had been successful in completing their degrees, and did not take into account those students who failed to persist to degree completion. Because differences may exist between female and male students who are in graduate school, and who may or may not complete their degrees, studies like Centra's of only successful students, as defined by degree completion, are limited in nature.

Berg and Ferber (1983) concluded that one of the most significant differences to emerge from their study of male and female graduate students was the extent of student interaction with faculty. They found, particularly, that differences existed in their institution's most male dominated fields of the biological and physical sciences. Although males claimed to have more interaction with faculty members than females in all 32 academic departments sampled at their university, differences were statistically significant for the biological, physical, and social sciences. Questions that attempted to ascertain the extent of interaction of students with faculty of the same or opposite sex resulted in statistically significant differences for the biological and physical sciences. Males reported being treated as a junior colleague by male faculty members more so than females. When
asked to report interaction with female faculty members, females reported this to a greater extent than males. It was clear to these researchers that students interact most comfortably with faculty of the same sex. Because the number of male faculty members exceeded that of females for all fields and type of discipline for this study, Berg and Ferber concluded that female students are at an inescapable disadvantage in finding mentors or role models.

**Peer support** Two additional studies examined both faculty and peer influence on students. Fitzpatrick and Silverman's study (1989) of high achieving women studying science failed to demonstrate that college professors or peers of the same sex had a positive influence on career choice. Rather, these students reported their same sex college professors and peers as being neutral influences. This finding concerned Fitzpatrick and Silverman because they considered a professor's influence to be important for encouraging persistence in a field, or for career aspiration.

Ethington and Smart (1986), using some of the core constructs of Tinto's persistence/withdrawal model examined factors that impact on the decision to enter graduate school. The variable "social integration," which included involvement with peers and faculty was considered to be part of the undergraduate experience. Analysis of CIRP data for this study indicated that "social and academic integration" are both important factors in facilitating entry into graduate school. For women, the impact of "social and academic integration" were nearly identical for the impact on graduate school attendance. For men, "academic integration" played a much greater role. This study, however, although important because of the large sample size, failed to separate peer and faculty involvement with
students, therefore, limiting its significance for the understanding of the importance of faculty acting as role models, or of the importance only of peer influence. Other studies related to peer influences have not been found.

To summarize the research on parental, academic environment, and peer support, the literature reveals that students do acknowledge parental support as being an influencing factor on educational goals and science persistence. There is support for the concept that females in science receive less parental support than do men in science (Berg & Ferber, 1983; Sax, 1992), however, the findings of Manis (1989) revealed that males in science believed they received less parental support than did their female counterparts. There is some data to support the contention that there is differential support from mothers and fathers regarding science persistence. Berg and Ferber (1983) concluded that females in science believed they received more paternal than maternal support. Manis (1989) concluded that for females in science, if a mother expressed a desire for her daughter to be happy, this may curtail the daughter from achieving high status career goals. Sax (1992) demonstrated that mothers who are research scientists supported their sons more so than their daughters in science persistence. Both Fitzpatrick and Silverman (1989) and Sax (1992) demonstrated the importance of paternal support. Fitzpatrick and Silverman noted this for a female's selection of an engineering major, and Sax noted that engineering fathers had a positive influence on both female and male science persistence. The issue of parental influence becomes more confusing when researchers demonstrated that females in quantitative fields of study believed their parents had a higher level of influence on them
than students in nonquantitative fields of study (Ethington & Wolfle, 1987), and when it was
demonstrated that high ability females were less likely to choose a science major when they
believed their parents had a high level of influence (Ware & Lee, 1988).

The findings on parental influence appear, therefore, to be inconclusive at this time.
It is Fitzpatrick and Silverman’s belief (1989), as well as the belief of this researcher, that
one way this issue could be clarified would be to separate the study of science and
engineering majors so that both are not included in the same research design. Also, it is
apparent that what is missing from these studies is the revelation of what influence students
in science believe their parents have on future educational plans. The studies cited here have
focused primarily on student persistence in science or choice of science major at the
undergraduate level. There is a lack of data that seek to ascertain parental influence on
student plans after earning the undergraduate degree.

Regarding the issue of support from high school teachers and counselors, and college
personnel, the research results appear to be somewhat inconsistent at this time. Although
Kahle (1983) and Fitzpatrick and Silverman (1989) reported that high school teachers had a
major positive influence on female science persistence, Ware and Lee (1988), studying a
population similar to the one of Fitzpatrick and Silverman (high ability college students)
found a negative association between the influence of high school teachers and counselors on
science persistence. Manis (1989) also cited lack of support from high school teachers and
counselors, and along with Kaplan (1982) and Fitzpatrick and Silverman (1989) determined
that college counseling was not helpful, nonexistent, or had no effect on science persistence.
If, as Stansbury (1986) determined, women are sensitive to supportive features of the academic environment, the apparent lack of effective counseling at the college level needs to be addressed. It is distressing that this literature review did not reveal more studies examining the issue of college faculty acting as role models. Perhaps the results of such studies would bear out the expected findings—that females interact best with faculty of the same sex. Although Berg and Ferber (1983) reached this conclusion, and Girves and Wemmerus (1988) determined that student-faculty relationships can affect doctoral progress, little work has been done in this area. This researcher failed to find studies that attempted to elucidate the relationships women science students have with their college professors, either of the same or opposite sex.

**Perceptions of science, scientists, and the science classroom** Researchers have studied the perceptions held by women regarding the nature of science, the characterization of scientists, and the atmosphere of the science classroom. The environment of the science classroom appears to be affected not only by a competitive nature, but by the attitudes of professors and student peers. Data, however, are limited at the undergraduate and graduate level.

Movement of females through the science and engineering pipeline is restricted to some extent by the perception that science, mathematics, and engineering are masculine in nature (McNamara & Scherre, 1982). Two different types of studies have demonstrated that science and mathematics have a masculine image (Kahle & Matyas, 1987). One type of study asks students to rank school subjects on a masculine-feminine scale. Studies indicate
that physics is seen as the most masculine academic subject, followed by chemistry and
mathematics. Biology is seen as a neutral subject. The second type of study asks students to
draw a scientist, which is more pertinent for younger children. Kahle and Matyas contended
that regardless of how the masculine image of science and mathematics is gained, teachers,
schools, professors, and universities help the image to be sustained, along with support by
various types of media.

A few studies at the high school or college level (Kahle, 1983; Manis, 1989;
McNamara & Scherrei, 1982) provide evidence to support the contention of Kahle and
Matyas (1987) that science is perceived as being masculine in nature. Kahle's study (1983),
representing students at the high school level reported that although a large percentage of
these students had considered science careers (females, 55 percent; males, 80 percent), they
still perceived science and engineering as masculine in nature. This was particularly true for
the female students. Manis' study (1989), representing college seniors, reported that a
minority of females perceived the unfeminine nature of science to be a problem for women,
and that only a few women considered this to be a personal problem. Data for the
McNamara and Scherrei (1982) study were derived from an eight year longitudinal study of
7000 women who entered college expressing an interest in science, mathematics, and
engineering. Analysis of data led these researchers to conclude that the flow of women into
the science and technical fields is partly restricted by the masculine image of these areas.

One way to examine the character of scientists is to judge the extent of their
sociability. Kahle (1983), Manis (1989), and Lips (1992) all failed to demonstrate that this
was a significant negative factor in women’s participation in science. Former students currently pursuing science careers in the Kahle study did not hold strong stereotypic views of scientists. A minority of respondents in the Manis study believed scientists were cold and impersonal, and contrary to prediction, Lips’ study of college freshmen found that females in the study believed less in the asocial nature of scientists than their male counterparts. In Lips’ study, for both females and males, belief in the sociability of scientists was positively predictive for mathematics and science pursuit. Only one study (Sax, 1992), in an indirect manner, demonstrated a correlation between persistence and the asocial nature of scientists. Interestingly, this held true only for men where it was found that men who had rated themselves low on popularity were more likely to persist in science, compared to males ranking themselves as more popular. Sax speculated that science may be attractive to males who may not want a lot of social contact, as she assumed that the image of scientists is one of loners and asocial individuals.

Sexist attitudes of students and professors can contribute to the “chilly classroom climate” (Brush, 1991) which can be an obstacle to science persistence. The “chilly classroom climate” can be defined as “A classroom climate that is not conducive to learning, one that does not spark interest in students and one that can and does cause students, especially minorities and women, to change their area of study or to leave the institution,” (Jackson, 1989, p. 61). Jackson believed that this environment, although detrimental to all students, is particularly harmful to females and minorities, especially those who are in the sciences.
Faculty members can contribute to this type of climate by discouraging or preventing students from seeking help outside the classroom, and also by discouraging participation in class (Jackson, 1989). There are some faculty members in science and engineering who believe that women do not belong in graduate school (Widnall, 1988). These feelings can be quickly transmitted to female students. Studies have shown that inside as well as outside classroom experiences aid academic progress. The presence of a "chilly classroom climate" can decrease career aspirations and confidence and can dampen the development of the student.

Sheila Tobias (1990), author of the book *They're Not Dumb, They’re Different*, utilized case histories to describe the climate of science classrooms. In a unique approach, seven postgraduates were chosen to audit a calculus based chemistry or physics course. With one exception, these individuals avoided science in college and had chosen other fields of study. One assumption in the Tobias study was that all of the students, whom she called the second tier, were not second rate. These students were described as serious in career goals and learning, and were high achievers. All students had taken four years of science and mathematics in high school and one year of college calculus. However, for various reasons, each had chosen a field outside of science.

The Tobias study (1990) was designed with the belief that it is important to analyze not only who the students are that do not participate in science, but also why students do not participate in science. After analysis of her data Tobias concluded that a female participant in her study considered the science classroom to be an unfriendly place, and to a greater
extent than her male participants, appeared to desire a more cooperative, interactive classroom environment, rather than one of competition. These findings, Tobias concluded, were similar to those of a University of Michigan study involving almost 300 female students. Other findings of the Tobias study indicated that participants felt an absence of community in large, introductory science classes. Both large class sizes and low enthusiasm of the students for the subjects being studied contributed to this perception. Participants stated that they felt the need for more depth, excitement, and attention in the science classroom.

Tobias (1990) speculated that the perception by women that science is competitive and unfriendly could contribute to the high attrition of women considering a science major. Further, she indicated that scientists have a narrow vision of what attributes they believe a true scientist should possess, and if women and minorities are to be recruited to science, school reform will need to take place.

Although it is highly questionable whether these findings are generalizable, a reading of the Tobias book (1990) illustrates the usefulness of qualitative data for broadening the understanding of a subject under study. This book contains a multitude of excerpts regarding participants' experiences and perceptions associated with the science classroom. If the Tobias study evokes criticism because of its narrow sample, it is useful to recognize a statement by Tobias: “If the sciences are to attract any new group of students to science, either to meet the projected shortfall or to solve the science illiteracy problem, the effort must begin by getting to know some of 'them,' and well” (Tobias, 1990, p. 18).
Four studies give credence to the findings and speculations of Tobias. Three of these studies involving persistence in science sampled students who, upon entering college, indicated an intent to major in science. Ware et al. (1985) studied a group of college freshmen who, although indicating an interest in majoring in science upon enrollment, had a poor persistence rate. At the end of the freshmen year only 50 percent of the female participants and 69 percent of the male participants actually declared science as their major. One factor that demonstrated a strong sex difference, and was one of two factors significant for predicting science persistence was the factor that a science course in the freshmen year was the most enjoyable freshmen level class. The finding that women in this study expressed less enthusiasm for their first college science experience than men was significant, however, the reasons behind this finding were not elucidated. A similar study by Boisset (1989) followed college students for four semesters and found a high rate of attrition. Except for better grades, the most compelling factor related to attrition from science was the need for more interesting courses. A recent study (Strenta et al., 1994) of over 5000 students attending highly selective institutions found that basic science classes were perceived to be more competitive than other classes and the classroom environments were unwelcoming to questions. Females, particularly in engineering, cited the competitive nature of the science classroom.

Data collected for the fourth study (Manis, 1989) examining the perceptions of college seniors who were science persisters or detractors indicated that more females than males found the science classroom to be an unfriendly environment. Slightly over one-third
of the female participants, compared to one-fifth of the male participants, believed that the aggressive, competitive attitudes of science students was a serious problem for women. Almost one-third of the females in science reported this to be a serious problem personally, compared to almost three-fifths for females majoring in other fields.

The four previously cited studies are important for the acknowledgment that many students, both in and outside of science, perceive the science classroom to be nonstimulating and competitive in nature. However, these observations are of limited value unless the reasons behind these beliefs can be elucidated. If it is true that one out of every three females in science find the science classroom to be personally displeasing, it behooves educators to identify factors associated with these beliefs.

One critical component of the science classroom, or associated with the study of science, itself, is the teacher or professor. It is this individual who, by directing the curriculum, determining pedagogy, determining the extent of teacher-student or student-student interaction, providing direction to student research, and acting as advisor, mentor, and role model greatly impacts the life of a potential or current student of science. One area, therefore, that cannot be overlooked when there is a sex differential in the participation of science is the extent of sexism that may be present throughout the undergraduate or graduate school years.

A study cited previously (Kahle, 1983) of successful high school biology teachers provides insight into the perceptions of current and former high school biology students regarding the lack of sexism in the classrooms of the successful biology teachers. Important
findings from this study resulted in the observations that successful science teachers (1) were uniform in their expectations and treatment of females and males and (2) did not differentiate between educational opportunities for females and males. Also, the finding that females and males participated to the same extent in science fairs, science clubs, and mathematics-computer clubs was considered by Kahle to be evidence for a nonsexist educational environment.

Studies, however, involving students who were current or former science students in college provide a different perspective than the findings of Kahle (1983) regarding the issue of sexism. The literature is scant, however, regarding this issue, but the findings to date are pertinent to the topic of women's participation in science.

Holmstrom and Holmstrom (1974) provided early insights into the topic of sexism. Their study analyzed data from the 1969 ACE-Carnegie higher education study. ACE had collected data on entering freshmen college students in selected institutions since 1965, and had by 1969 collected information from over 33,000 graduate students. From this population Holmstrom and Holmstrom randomly selected approximately 2800 female students and 3400 male students and utilized data collected from them by ACE. Using stepwise multiple regression analysis these researchers identified factors that were related to emotional strain and doubts about completion of graduate work. Analysis of these data revealed that almost 50 percent of women and 40 percent of men had considered withdrawing from graduate school at least once. Further, those females who believed that
faculty did not take women graduate students seriously were more likely to have considered withdrawing at some point during their graduate school enrollment.

Two strong predictors, lack of interest and emotional strain, were related to doubts by both sexes about continuation in graduate school. When controlling for family demands, financial worries, and academic ability Holmstrom and Holmstrom (1974) reported that at least one out of three women in their study perceived that faculty have negative attitudes toward women. These women believed that this contributed to their emotional stress and decreased their commitment to remain in graduate school. Although an important finding for this study, the most significant predictor of doubts about graduate school continuance for both groups was the belief that women students were not as dedicated in their departments as men students. When the data were studied by field, as could be predicted, women studying in traditionally feminine fields were less likely to perceive this faculty attitude, while men in fields such as engineering were more likely to admit that faculty did not take women students seriously. This study should be considered important, at least for its time, because of the nationwide distribution of participating institutions and the large number of doctoral student participants. It also bears repeating, for comparisons with students of today.

Another study (Wong & Sanders, 1982) that sampled graduate students alluded to the issue of sexism, but failed to cite a cause for differential findings between female and male students. A study of all doctoral recipients from 1972-1978 at the University of California, Santa Barbara found that for male students, but not females, graduate GPA and previous graduate study were positively related to working with prestigious professors. Data from this
study also indicated that females received more equal treatment in the social sciences than in other areas, but as stated earlier, there were no reasons cited or suggested for this inequity.

In the Manis study (1989), female participants who acknowledged that the science classroom was an unfriendly environment were asked to describe why they believed this to be true. When these students were asked to describe instances of discriminatory behavior in mathematics or science classes, comments that were elicited included not being taken seriously, being ignored or patronized by professors, feeling from professors that they were less intellectual than men, and feeling that they had no talent or did not belong in science or mathematics. The study by Strenta et al. (1994), however, failed to demonstrate support for the presence of a “chilly classroom climate” as perceived by highly successful science majors. Their study failed to document a gender effect for sexual discrimination.

Morgan (1992) conducted a study during the 1990-91 school year using females and males in undergraduate classes at three universities to determine college students’ perceived reasons for the low participation of women in science and engineering. By replicating a survey instrument used in a 1964 study conducted on recent graduates of 135 colleges and universities, Morgan compared responses of students in 1964 to students of today. In 1964, the second most common perception of why there is low participation of women in science was “women’s desire for part-time work.” Today, their perception at this position is “men resent women colleagues.” Interestingly, as Morgan stated, this response had been given frequently in 1964 for women’s lack of participation in engineering, but had not been cited often for the low participation of women in science. This change may, according to Morgan,
be attributed to the larger number of women entering male dominated fields. Although Morgan did not make clear by this choice if the men referred to were in the workforce or other environments, this study is important because it demonstrated a change in perception of college students from almost 30 years ago.

To summarize the foregoing section, it appears that a significant issue associated with the nature of science or scientists, or the science classroom, is the issue of sexism. This appears to exist for both undergraduate and graduate female students, as well as for those who have persisted in science or been lost from the science pipeline. Although several studies provide data to support this contention, it is unclear at this time whether sexism has a significant enough effect on females at the end of undergraduate studies to prevent their pursuit of graduate degrees. Just as there has been an increased emphasis on this issue in the public and private sectors in recent years, further study of this issue appears to be needed in higher education.

**Role conflicts** The personal lives of female and male students may differ to some extent. For example, females may be discouraged from entering graduate school, or upon entrance to graduate school, various personal factors may impact upon the graduate school experience (Adler, 1976). Conflicts between personal demands and professional demands affect both sexes. However, while time conflicts are experienced by both sexes, women face the contradictory expectations associated with sex roles and professional roles. Adler believed that female role expectations related to marriage and family are the most
contradictory to professional role attainment, and that frequently, women must choose between the two.

The flow of women into science and technical fields could, therefore, be hindered by the belief that combining marriage, family, and a career in these areas would be too demanding (McNamara & Scherrei, 1982), resulting in decreased motivation associated with persistence in science. However, a review of the literature failed to find in-depth studies examining these factors in science students. Rather, most studies have only cited marriage rates, divorce rates, or degree of stress experienced by women students in higher education as they are related to marriage and family demands. Perhaps as Hornig (1987) stated, because it appears so obvious that marriage and parenthood would unfavorably influence women's participation in science, this issue has not been fully explored in studies of women graduate students in science and engineering. Because the issues of marriage, family, parenthood, and science persistence have not been well explored this literature review requires acknowledgment of findings from studies of women in general, rather than only from studies of science students.

Marriage, number of children, and divorce rates of women students provide some insight into the ability to balance personal and professional demands. An early study conducted on over 3600 females and males who received their doctorates (PhD or Ed.D.) in 1950, 1960, or 1968 found that women were less likely to marry than their male counterparts (Centra, 1974). From the 1950-1960 group of graduates, at the time of the 1973 Centra survey, 39 percent of the females had never married, compared to less than 10 percent of the
males. From the 1968 group of graduates, only 30 percent of the females had never married. These figures indicated to Centra that the trend of combining the roles of wife and graduate student had become more common among recent women doctorates. These dual responsibilities, however, may have contributed to a higher divorce rate than for men. Centra found that for women, 1 in 4 marriages ended in divorce, compared to only 1 in 10 for men. The highest divorce rate for women occurred prior to starting their doctoral work. Centra acknowledged that some women undoubtedly began doctoral work after marital separation, and therefore, graduate school entry may have been a result of the separation. However, for other women Centra found that pursuing a professional commitment led to marital conflicts. Although Centra cited the divorce rate for these women and provided evidence regarding when marital conflicts arose, he did not explore factors related to this issue, and therefore, the study appears weak in this area.

Ahren and Scott (1981) analyzed data from female and male PhDs. These data were obtained from a sample survey of 50,000 PhD scientists, engineers, and humanists conducted in 1979 by the National Research Council. Their sample consisted of over 5000 triads (one woman and two men) who were matched as closely as possible on a large number of selected background characteristics. Ahren and Scott found that for females receiving their degrees from 1960-1969, 59 percent were married by 1979 and only 44 percent had children. This was in comparison to females of the general population where 80 percent were married at that time. Data from graduates of the 1975-1978 years revealed that 60 percent of the females were married by 1979 and less than one-third had children. The analysis of data
from recent 1978 PhD recipients in science and engineering revealed that almost half of the women were married at the time of doctorate attainment, compared to two-thirds of the men. Only in physics and mathematics were the women doctorates married at a higher rate than men.

Studying current graduate students Berg and Ferber (1983) questioned students from the five broad fields of the biological and physical sciences, the social sciences, arts and humanities, education, and the professions who had enrolled for graduate study from 1968-1975. Their study appears to be unique for the time because it divided students into type A fields, where the master's degree confers full professional stature, and type B fields, where anyone who fails to achieve the doctoral degree is considered to be a dropout. Examples of type A and B fields are business administration and education, respectively. One finding the researchers particularly emphasized was that over one-third of the male respondents had entered the biological and physical science areas while approximately the same proportion of females had entered education. Berg and Ferber also found that in 1979, for the women in their sample who had married before or during 1970, 78 percent had entered type A disciplines. Of those women who had married later, only 37 percent entered type A disciplines. Other findings indicated that although female and male participants were nearly the same age, females were less likely to be married or to have children at the time of graduate school entry. Berg and Ferber concluded that in general, women were more likely to pursue terminal masters' degrees and were more likely to consider how the impact of attending graduate school would affect significant people in their lives.
The studies conducted by Centra (1974), Ahren and Scott (1981), and Berg and Ferber (1983) should be considered important to the study of women's persistence in higher education because of their: large sample size; documentation of trends; findings that female doctorates, including those in science and engineering, have a much lower rate of marriage than the general female population, and a lower rate than males; and findings that women doctorates have a higher rate of divorce than their male counterparts. More recent data are needed in these areas, however, to document current conditions.

Although it is important to acknowledge how many women in higher education are married or have been married at some time, it is also of interest to examine their intent to marry if they have not done so by the time they become participants in a particular study. Adler (1976) and Dublon (1983) both addressed the issue of intent to marry in their studies of graduate students. Adler stated that results obtained from graduate students who participated in both her survey questionnaires and interviews indicated not only a lower rate of marriage for females compared to males, but also a lower probability of ever marrying. Dublon, studying all female doctoral students in higher education administration enrolled in Florida schools, found that a majority of participants had marriage and family aspirations although these women expected these events to occur at a later age. To Dublon, this appeared to confirm a societal trend towards later marriage and parenthood for women.

Linked to the issue of marriage, therefore, is the desire, or lack of desire to have children. Several studies have addressed the issue of combining the desire for parenthood
and its responsibilities with educational demands, although few studies have been found for the area of science alone.

Adler (1976) concluded that for the graduate students in her study who already had children, these women, on average, desired to have fewer children than the number actually expected. This was also true for men, however, the disparity between wanted and expected numbers were not as great. In contrast to this finding, female students in this study who did not currently have children desired to have more children than they expected to have, however, this was not true for male participants. The male participants both wanted and expected to have the same number of children. It appeared to Adler, therefore, that these women had lowered their family aspirations to adjust to expected constraints. Dublon (1983) concurred with the findings of Adler’s female participants who did not have children when she found that the females in her study without children actually desired to have more than they expected. Reasons cited for this discrepancy were related to the constraints of career and family responsibilities, age, finances, and time demands.

As women become participants in the multiple roles of student, wife, and mother it is expected that conflicts between these various roles will arise. Germeroth defined role conflict “As the struggle one experiences when juggling the demands of multiple roles. Role conflict results when the demands of every role cannot be met or when a decision cannot be made regarding which role should take top priority,” (Germeroth, 1991, p.80). When Germeroth used this definition to study barriers that graduate students in communication perceived to be related to completing a dissertation she found that females perceived role
conflict to be a greater barrier to completion of the dissertation than did men. Germeroth suggested that even without marriage and children, role conflicts occur for women. She speculated that guilt associated with not being attentive to friends or family members induced emotional strain in females, but she failed to provide evidence for this speculation. After reviewing the literature it appears that this is an area that has not been addressed as it relates to women's participation in science. This would, therefore, be an interesting and apparently needed area for future studies to examine.

Kaplan (1982) offered support for the belief that the stresses associated with being a mother and student contribute to the difficulties faced by female graduate students. Kaplan found in her study of over age 30 women attending graduate or professional programs that the majority of women experienced lack of time and emotional strain, regardless of their family status. However, when children were considered there was a significant difference between the groups of married or divorced women with children and the groups of single or married women without children. The women with children experienced significantly more emotional strain based upon the role conflicts associated with family responsibilities and student responsibilities than the women without children. Associated with these findings Kaplan found that few women were enrolled in the traditionally masculine fields of science, mathematics, or engineering, and that marital status was linked to choice of field of study. That is, women who were single or divorced were more likely to be in masculine fields of study than were their married counterparts. Surprisingly, however, no significant difference
was found between women with or without children and their study in either a traditionally masculine or feminine field.

Dublon (1983) cited four roles in which females may participate--those of wife, mother, employee, and housewife. She failed, however, to demonstrate that a majority of the doctoral student participants in her study anticipated future conflicts between these various roles when they occurred simultaneously. Rather, Dublon's data indicated that her female respondents were evenly divided when asked to predict whether they anticipated the presence or absence of future conflicts between various role identities. However, among those who did anticipate conflicts, time constraints were cited as the biggest problem. For those who did not anticipate conflicts, women cited having supportive husbands and families. Dublon also found that a relationship existed between the number of roles these women expected to be involved in and the level of anticipated conflict between these roles. As expected, respondents committed to three or four roles were the most likely to implicate the development of future conflicts.

Researchers O'Connell et al. (1989) believed their data on nontraditional students strongly support a role conflict approach to work-involvement plans. The role conflict approach implies that regardless of other factors, mothers will interrupt their careers because it is expected they will care for young children. This approach also implies that married women are more interested in part-time work because this will permit time for family relationships and role expectations. Also, it is expected that women will reenter the workforce once children begin school. In support of this approach O'Connell et al. (1989)
demonstrated that for female students in both traditional (nursing) and nontraditional (engineering and veterinary medicine) fields, the work plans of students pursuing these areas of interest were similar. The nontraditional students sampled were first and second year students in veterinary medicine and juniors and seniors in engineering. The traditional students were senior nursing students. Although a minority in each field expected to work full-time when their children were of preschool age, women in the nontraditional areas had a higher commitment to full-time work than those in the traditional field of nursing. This finding held true for three family stages considered. These stages represented times when women would have preschool, grammar school, or high school age children. Related to this finding O'Connell et al. concluded that women pursuing nontraditional fields of study appeared to recognize greater potential role conflicts in balancing work and family obligations. Also, regarding marriage plans only two percent of the engineering and veterinary medicine students indicated they did not have plans to marry, and only seven percent planned not to have children. For nursing students the findings were similar. It would appear, therefore, that compared to the studies of Adler (1976), Ahren and Scott (1981), Centra (1974), and Dublon (1983) involving either graduate students or doctorates, that the plans of the younger students in the O'Connell et al. study included a greater intent to marry and have children. However, similar to the previously cited studies role conflicts for women were anticipated.

Other studies on graduate students have indirectly examined the presence of role conflicts for women by attempting to determine whether marriage or family obligations
delayed entry into graduate school, or lengthened or stopped graduate study. Wilson (1965) conducted a large study on over 1900 doctoral recipients in southern institutions for the purpose of determining what factors acted as lengthening influences on doctoral study. He concluded that one of the factors related to delayed entry into graduate school, and to interruptions in graduate study after entry was family obligation. Wilson also found differences by field of study which led him to conclude that students in the social sciences and humanities believed family obligations were more important as a lengthening influence than did students in the natural sciences. He attributed this finding to two factors: higher average ages of students in the social sciences and humanities and the higher proportion of women in those fields. It is unfortunate that this extensive and lengthy study did not separate the participants by sex for this finding, nor did it offer the students the chance to elaborate on the nature of these family obligations. It could, perhaps, be assumed that the older student ages were correlated with a higher incidence of marriage or number of children, compared to the students in the natural sciences, or that there was a difference in enrollment status. That is, perhaps science students were enrolled to a greater degree as full-time students than the social science or humanities students. These could account for the decreased effect seen in science students. These, however, were not discussed as possible causes, but it would have been helpful for interpretation of the findings of the study to have elaborated on why differences were found between groups of students.

Two studies are of interest because they failed to link the issue of marriage to doctoral progress. Mooney (1968), studying more than 3500 high achieving females who
were elected as Woodrow Wilson National Fellows from 1958-1960 failed to find support for the argument that women who marry while in graduate school will leave their studies to care for their children or to follow their husbands. Mooney also found that single and married women were very similar in their success in graduate school which was considered to be PhD attainment. This study, however, failed to separate these women by field of study. The study of Holmstrom and Holmstrom (1974) examined role conflict in female and male doctoral students and found that only for males, family responsibilities were associated with consideration of graduate school withdrawal. Interestingly, variables attributed to this were pressure from spouse and number of children, neither of which were predictors for females’ consideration of withdrawal from graduate school. The results of these two studies, therefore, make it difficult to support the belief that marriage and children will always be associated with lack of success in graduate school.

Although it is important to review studies of older students who most likely have higher rates of marriage and more children, it is also important to review studies of younger students, namely undergraduates, regarding their perceptions of the difficulties experienced in balancing multiple roles. This is important because as undergraduates, opinions have been formed, or are currently being shaped that will influence their future educational plans. Several studies have demonstrated that both females and males, and science students and nonscience students, perceive problems for women in science regarding role conflicts.

Ware and Lee (1988) sampled students with high academic ability from the 1980 senior participants of the “High School and Beyond” survey. These students, who in 1982
were attending either a two or four-year college, exhibited differences by sex, regarding concerns for future family life. Ware and Lee found that for females, concern for personal life and future family inhibited the choice of a science major, but facilitated the choice for males. These researchers concluded that female students of the 1980s who were of above average ability, and therefore, most likely to choose science for a major viewed personal and family life to be incompatible with a career.

Morgan (1992) concurred with Ware and Lee (1988). The study by Morgan compared perceptions held by students in 1964 to perceptions held by students over 25 years later and found that the perceived reason most often given for the low representation of women in science had not changed during this time period. The reason cited most frequently by females and males was “A job in this field is too demanding for a woman to combine with family responsibilities” (Morgan, 1992, p.231). However, males cited this at a slightly higher rate than females.

Two studies conducted within a few years of Morgan’s study yielded similar results. Manis (1989) found in her study of college seniors that women in science were more concerned with combining family roles and responsibilities with a career than were students in business and law. The study by Sax (1992) of science persisters and detractors found a negative association for both females and males regarding placing a priority on raising a family as a life goal, and science persistence. This association, however, was slightly higher for females than males suggesting to Sax that the trade-off of a science career and raising a family was greater for females than males. Lips (1992), however, failed to support these
findings. In her study of college freshmen Lips found that in general, both females and males did not expect it to be difficult for women to combine family roles and career, and contrary to her prediction, males perceived this to be a greater problem than did female students. This was particularly true for those males intending to study science. This finding was disturbing to Lips because it indicated that the possible spouses of females in science, that is, males in science, perceived that for women the dual roles of family responsibilities and career would be a problem. Lips also found, as predicted, that females who believed in the compatibility of combining science career and family roles were inclined to indicate further intent to study science.

In summary, it becomes obvious from the foregoing section that the issue of role conflicts for women as it relates to science persistence is in need of further study. While it is true that there have been some rather recent studies on undergraduate students which support the contention that students who place high priorities on family life will be less inclined to persist in science (Sax, 1992; Ware & Lee, 1988), it has also been found that even for science persisters there appears to be a greater concern over family and career conflicts than what is found in nonscience students (Manis, 1989). Lips (1992), however, presented an interesting finding when she did not find this to be true for college freshmen. Perhaps their younger age, less time spent in science studies, or inadequate knowledge about career compatibility with future family life could account for her finding.

Most studies in this area have not focused specifically on science students, therefore, leaving a gap in our understanding of what exactly may or may not motivate women in
science to persist to graduate school. Several studies have provided insights on women who pursue graduate studies both in and outside of science. Studies have found that these women are less inclined to marry and have lower marriage rates than males or females in the general population; have higher divorce rates than the general population; experience or anticipate greater role conflicts than other women; have lowered family aspirations than other women; and enter masters' programs more so than doctoral programs (Adler, 1976; Ahren & Scott, 1981; Berg & Ferber, 1983; Centra, 1974; Dublon, 1983; Germeroth, 1991; Kaplan, 1982; O'Connell et al., 1989). These studies, however, have failed to address one important issue. "What factors about graduate school work do these students find offensive, and what factors associated with graduate work could be changed to entice these students to pursue their studies?" Manis (1989), Sax (1992), and Ware and Lee (1988) have demonstrated that students have concerns about future role conflicts, but yet studies in the past, and those more recently have failed to address the issue of specific concerns. To develop a complete picture, however, of factors associated with women's persistence in science these concerns need to be identified through future research.

Factors associated with access

From a legal perspective sex bias, as it relates to the issue of access to higher education should not be considered to constitute a factor for women's participation in science today. As was stated earlier, formal discrimination against women's access to higher education ended with passage of the Women's Educational Equity Act, or Title IX Act of the
1972 Higher Education Amendments (Brown & Heath, 1977; "Graduate Education," 1982; Hornig, 1987). This act prohibited sex discrimination in educational programs that were federally assisted (Brown & Heath, 1977). Prior to this time it had been legal for educational institutions to maintain differential policies, by sex, regarding admission (exclusion or quotas for women) and financial aid, among other areas (Hornig, 1987).

When the extent of attrition from the undergraduate degree to the graduate degree is examined for women by field of study, however, it seems possible that structural biases still occur in some fields and not others because differential attrition is seen ("Graduate Education," 1982; Hornig, 1987). Although this literature review has already identified several factors that help to explain women's attrition from higher education, or more specifically from the sciences, the area of access is one that needs review. Because this current research study will not explore the factors associated with admission to graduate school this topic will not be addressed in the literature review. The factor of financial aid, however, will be explored in this current research study, and therefore, a review of the literature in this area follows.

**Financial aid** Hornig (1987) stated that with the exception of actual exclusion or quotas the primary factor affecting access to graduate school is financial aid. Public policy associated with the continued well-being of science has involved financial support for the training of scientists and engineers with the assumption that initial and continuing aid will guarantee an adequate supply of highly trained people for America's workforce. This support has been in place at least since World War II, and with the exception of the G.I. Bill
data on differential financial aid for men and women have not demonstrated inequities ("Graduate Education," 1982). Recent data, however, indicate this is not true for graduate support.

Solomon (1976) has described three ways in which financial aid is important for success in graduate school. First, it has obvious value for support and sustenance, and therefore, by discouraging the seeking of other types of support allows the student more time for studies. Second, the awarding of financial aid provides the recipient with a sense of worth. That is, groups within the university (professors and administrators) who are responsible for determining who receives awards, will, by their choices indicate that a recipient is a worthy investment and will be successful in the pursuit of graduate study. This, according to Solmon, fosters self-confidence and provides encouragement to the graduate student. Third, some financial aid awards because of their nature bring the students into closer contact with faculty members which Solmon believed to be a positive experience. An example of this type of financial aid is the research assistantship.

The type of primary financial support that students receive contributes to the quality of the graduate experience ("Graduate Education," 1982). Additional arguments for providing the proper type and amount of financial support illustrate how a sex bias, if it exists, or if it is perceived to exist, can create disadvantages for female students. A report by the Council of Graduate Schools in the United States ("Graduate Education," 1982) addressed this issue through the following statements: (1) students who work their way through graduate school will expend more time and energy and must maintain a higher level
of motivation than students who do not need to work (2) being dependent on a spouse or parents for primary aid reduces autonomy of the graduate student and (3) holding a teaching assistantship beyond a minimum service requirement can, for a student in science, reduce research time and contact with peers and faculty in research groups; reduce research productivity by decreasing time for presentations at professional meetings; reduce time for publication preparation; and reduce time for professional contacts.

It is of interest, therefore, to address the issue of primary support for women graduate students as well as additional types of support they may receive. The issue of sex bias is also relevant to the understanding of how financial aid is a factor in the participation of women in science.

Studies that assess the impact that financial aid has on the decision to attend graduate school are almost nonexistent. The study by Ethington and Smart (1986), therefore, is important for its contribution of findings to this area of research. Using longitudinal CIRP data from students who were freshmen in 1971, and who were followed-up in 1980, these researchers examined variables that were determinants of enrollment in graduate school. The two variables that were found to have the greatest impact were undergraduate degree completion and financial aid. This was true for both females and males. While this finding is important because it helps to confirm assumptions about participation in graduate school, the study failed to ask students how the obtainment of various types of financial aid could influence their decision to attend graduate school.
The study by Kallio (1995) is also significant because it contributes to our limited knowledge base regarding what issues are important when students are considering attending graduate school. Kallio, in her study of students accepted into masters' and doctoral programs found that students base their decision on which graduate school to attend on at least six factors. One factor they considered to be important is financial aid.

The majority of studies appear to focus on current graduate students or on those who have completed graduate work. Most data represent information on differences in financial aid by field of study, or on the type of financial aid secured by current or former students.

Solmon's study (1976) of 1972 doctoral recipients resulted in the conclusion that although women were no more likely than men to be concerned with financial aid matters, the type of aid awarded to women differed from that awarded to men. In engineering, the physical sciences, and mathematics a smaller proportion of women supported themselves through loans or family resources. In the life sciences, however, where women represented a larger proportion of students there was a greater than expected reliance on loans and family support. Therefore, less support was received from the educational institution and the government. Three other findings of the Solmon study are worth citing regarding the issue of financial aid. In the fields of engineering, the physical sciences, and mathematics women received a disproportionately larger number of financial aid awards compared to their enrollment in these fields than did women in the life and social sciences where they had a much larger proportion of enrollment. Another finding of this study determined that women consistently received fewer research assistantships than men and larger shares of teaching
assistantships and other service awards. Finally, Solmon concluded that women, overall, received less financial aid than men.

Research and teaching assistantships represent the dominant sources of financial aid in most science fields (Hornig, 1987) and are one of the most common types of financial awards that are obtained by graduate students (Hauptman, 1983). Primarily it is the doctoral student, rather than the master’s degree student who receives this type of aid. It has been argued that teaching assistantships confer a disadvantage for students compared to those students who hold research assistantships (Ahren & Scott, 1981; “Graduate Education,” 1982, Hornig, 1987, Solmon, 1976). Teaching assistantships are seen as less desirable because the time spent on teaching duties detracts from research time (Hornig, 1987). Therefore, if women hold more teaching assistantships and fewer research assistantships than males, females may be at a disadvantage (Hornig, 1987; Solmon, 1976).

Several studies at the graduate or postgraduate level have examined the effects of assistantships on graduate degree satisfaction or progress. Girves and Wemmerus (1988) hypothesized that financial support variables would influence both a student’s involvement in their graduate program and alienation. An analysis of over 900 students participating in this study allowed support of the hypothesis. Girves and Wemmerus concluded that there was a positive relationship between having assistantships or fellowships as the primary source of support, and the degree of involvement in a graduate program. This was found to be true for both masters’ and doctoral level students. Also, these researchers concluded that at the doctoral level students who were the most involved in their programs were more likely
to earn the doctorate. In this study, therefore, assistantships were important for predicting doctoral degree progress, but the researchers failed to distinguish between teaching and research assistantships, nor did they define differences between female and male students. These limitations decrease the usefulness of the findings of this study as they pertain to the importance of financial assistance on graduate degree progress.

An early study by Wilson (1965), impressive because of its sample size, number of institutions involved in the study, and thoroughness, sought to determine which factors acted as lengthening influences on progression of doctoral study. When 15 factors were examined the issue of financial aid ranked fifth. Specifically, Wilson stated that the data clearly distinguished between teaching and research assistantships with respect to lengthening time for degree attainment. Wilson determined that “working as a teaching assistant” was the second most frequently cited lengthening factor while “working as a research assistant” ranked 13 out of 15 possible choices.

Field of study influenced the choices of participants in the Wilson study (1965). Students in the natural sciences more consistently cited “working as a teaching assistant” to be a lengthening influence, compared to students in the humanities or social sciences. Specifically, students in the biological and physical sciences ranked this high. That is, 30 to 40 percent of the students cited that “working as a teaching assistant” had some lengthening influence on degree attainment. Interestingly, students in the biological and physical science areas considered financial problems to be less of a lengthening factor than students in the social sciences or humanities. Mooney (1968) stated that financial support allowing a
student to finish in consecutive years is typical for science students. Perhaps this accounts for less worry in the natural science students, yet this issue was not addressed. Also, Wilson’s study (1965), although commendable for its insights into graduate students’ perceptions of degree progress is weakened by its failure to separate students by sex on this issue.

When studies do distinguish students by sex on the issue of assistantships, conflicting conclusions have been reached. Wong and Sanders (1982) revealed that women doctorates were less likely than their male counterparts to receive research assistantships in the natural sciences. Also, although the awarding of teaching assistantships was similar for women and men across all disciplines, men had a slight advantage. In all fields women had obtained more fellowships than men, but this was especially true in the natural sciences. Centra (1974), in a study of earlier graduates had also found that women were more likely to receive fellowships or scholarships and that men were more likely than women to be teaching assistants. Ahren and Scott’s large study (1981) of persons obtaining doctorates in the 1940s through the late 1970s revealed that teaching assistantships were the most common source of financial aid for graduate students. This retrospective study revealed that for the latest group of graduates, graduates from 1978, females and males held similar numbers of teaching assistantships in the biological and physical science areas, but fewer research assistantships were held by females. In chemistry, females held both more teaching and research assistantships than males. Berg and Ferber’s study (1983) failed to demonstrate differences in the percentage of female and male graduate students who obtained assistantships or
fellowships, but this was not distinguished by type of assistantship nor field of study. Also, for students in the biological and physical sciences these researchers failed to find significant differences between females and males regarding the amount of financial aid obtained from either parents or a spouse.

Lane (1990) has provided more current information on the participation of women in the science and engineering areas. This comprehensive report was designed to deliver information to the United States Congress and Administration regarding the status of the strength of the United State’s science and engineering programs. For students receiving their doctorates in 1988 in science and engineering there were reported differences in the amount and type of financial aid between the sexes. The primary source of financial support was reported to be the universities, with fewer females than males reporting this source. Females and males held 42 and 52 percent respectively of the research assistantships and 40 and 37 percent respectively of the teaching assistantships. Of nonacademic support, females were more likely than males to rely on family or personal resources.

In summary, it would be difficult to dispute the impact that financial aid has on students, both at the undergraduate and graduate levels. If, as Ethington and Smart (1986) ascertained, financial aid is one of the two most important factors that influence graduate school enrollment, then it becomes important to address the issue of financial aid as a barrier to the participation of women in science. All of the studies reviewed in this section, except one, examined the issue of financial aid for current or former graduate students. These studies have offered evidence to support the contention that females differ from males in the
primary sources of financial aid received, particularly regarding the type of assistantships. If teaching assistantships are less desirable than research assistantships (Solmon, 1976) then the demonstration that females receive fewer research assistantships than males (Ahren & Scott, 1981; Lane, 1990; Solmon, 1976; Wong & Sanders, 1982) may be a factor in the underrepresentation of women in science at the graduate level.

A review of the literature has also failed to reveal studies that examine the perceptions held by females in science who are seniors and are close to graduation. For these students it appears to be unknown how they perceive their ability to finance graduate level studies. Are there students capable of graduate study who do not consider graduate school because of financial aid difficulties or perceived difficulties? Are there students who have applied to graduate school, but because of an inadequate financial aid package decided not to continue their education? Are there master's degree students who decide not to pursue the doctorate because of financial difficulties? These are some of the questions that have yet to be answered regarding the issue of access.

Factors associated with ability

Because this research project involves the study of high achieving women the issue of ability may not appear to be in need of study. However, the factor of ability appears to be more complicated than analyzing scores, grades, or rank that a student may have earned throughout the educational process. DeBoer (1984) hypothesized that during high school females and males develop beliefs about their competence in science. These beliefs,
according to DeBoer, could be based not only on performance levels in science courses, but also on the extent of participation in science courses and the amount of effort that was expended in these courses. The sense of competence, in turn, affects future decisions about participation in science because it is likely that students who pursue a science curriculum in college are those who believe they have ability in science. DeBoer suggested that if women have less self-confidence than men this factor may provide a partial explanation for women’s low participation in science.

Research studies that have addressed the issue of ability have focused, therefore, not only on performance, but also on the feeling of competence or self-confidence. Researchers also have linked participation in science and mathematics courses, and attribution of control, to the factor of ability as it relates to women’s participation in science. In the following section these factors will be reviewed. The review of performance, however, will be minimized because it is not the intent of this research design to study women with various levels of ability based upon an objective analysis of performance. Also, the issue of participation will be addressed briefly because of its link to grades and self-confidence.

**Performance**  To satisfy the admissions’ requirements of most selective colleges juniors and seniors in high school take the Scholastic Aptitude Test (SAT) or the American College Testing Program (ACT), or both (“Educating Scientists,” 1988). These tests are designed to predict how well students will do in their freshmen year of college. One component of these tests is the mathematics section which is believed to be a strong predictor of a student’s performance in college (Lee, 1987). It has been suggested that scores on this
section may act to limit the participation of women in science by hindering entrance to college ("Educating Scientists," 1988).

Studies have shown that although women tend to get higher high school grades than men, women earn lower scores than men in the mathematics component of these tests ("Educating Scientists," 1988). One side has argued that the tests are biased in design and administration. The other side has argued that differences in scores between the sexes can be attributed to family background and student preparation. It appears that this issue has not yet been resolved by educators and other interested parties.

Grandy (1987) studied students who scored above the 90th percentile on the mathematics section of the SAT in 1986 and concluded that from this group a greater proportion planned to study science, mathematics, and engineering compared to the proportion from the rest of the examinee population planning to study in these areas. Grandy also determined that there was a large difference, by sex, when analysis of her data revealed that only 34 percent of females, but 55 percent of males chose to major in one of these fields of study.

Lee (1987) reported what she considered to be distressing results. Her sample analyzed "High School and Beyond" data for the high school class of 1982 and found that females had a substantial score deficit for the mathematics section of the SAT after adjusting for ability, grades in high school, and coursetaking patterns. This finding demonstrated an even greater deficit for females planning to study science in college.
Another quantitative measure that has been useful for predicting science participation is grades. Gordon (1990) analyzed “High School and Beyond” data from students who were seniors in 1980 and who participated in a follow-up survey in 1986. Gordon concluded that in general, students who reported having the highest grades in high school were also those students who graduated with majors in science, mathematics, or engineering. However, grades did not appear to be the reason for the disparity between the sexes regarding participation in these areas. When females and males who had earned straight A’s in high school were studied Gordon found that approximately 25 percent of females majored in science, mathematics, or engineering in college while almost twice as many males majored in these areas. Sax (1992) analyzed CIRP data from 1985 college freshmen who were followed-up in 1989. Her findings were consistent with those of Gordon when Sax concluded that for both females and males, a high GPA in high school was positively associated with persistence in the hard sciences (those utilizing knowledge of the natural and physical sciences, and engineering), although unlike the findings of Gordon (1990), high GPA had a greater effect for females than males.

At the graduate level Mooney (1968) found that students who were undergraduate achievers were also the achievers in graduate school. Using Phi Beta Kappa attainment as the independent variable Mooney concluded that students most likely to earn a doctorate six to eight years after graduate school entrance were also those who had been elected to Phi Beta Kappa.
Participation  DeBoer (1984) studied junior and senior students at a public university and hypothesized that a sense of competence in science was critical to science decisions that students make when they enter college. DeBoer found that when more science courses were taken early in education, more science courses were taken later in high school. Also, students who took more science courses, or earned higher grades felt more competent. However, when performance and participation were controlled a sex difference existed in the self-rating of ability. Although women performed very well in chemistry and biology courses in high school compared to men, women’s performance and participation in science decreased after this time relative to men. DeBoer was unable to explain the lowered sense of self-confidence found in women.

Other studies have examined the issue of participation, linking it to choice of major, grades, and perception of science difficulty. Ware and Lee’s study (1988) of college students in 1982 demonstrated that the strongest predictor of majoring in science for both sexes was college course enrollment in science and mathematics courses. Gordon (1990) linked grades to participation and found that although females graduated from high school with higher grades they did not take the same high school courses. Specifically, males took more advanced courses in high school such as calculus and physics, but for females who followed the same pathways as males, fewer graduated from college in science, mathematics, or engineering compared to comparable males. Lips (1992), in her study of college freshmen, predicted that females would view science and mathematical careers as more difficult and demanding than males and that this perception would be negatively related to
choosing career goals or courses in these areas. However, contrary to prediction Lips concluded that females and males did not differ in their perception that science careers are difficult or demanding. Lips also found contrary to prediction that the perceived difficulty of science careers was positively related to the number of courses attempted in biology, chemistry, and mathematics, and to the choice of a career goal in science or mathematics. Analysis of the data indicated to Lips that males were primarily responsible for the difficulty effects and she contended that males in her sample, more so than females, appeared to like the idea of experiencing a difficult and demanding program of work. Overall, however, the perception of science being difficult did not deter either females or males from pursuing it.

**Perceived level of ability and self-confidence**

It is not only important to measure a student’s ability objectively and analyze it in regard to participation in science, but it is also important to determine a student’s perceived level of ability and analyze it regarding science participation. When Morgan (1992) studied university students’ perceived reasons for low representation of women in science she found that both females and males ranked as the fourth most common reason for low participation “such a job requires skills and characteristics women do not have” (Morgan, 1992, p. 231). It is interesting that not only females demonstrated lack of faith in their abilities, but that males perceived a lack of ability in females as well.

This perceived lack of ability has been studied at various levels of the educational process. A study examining the perceptions held by girls early in their education demonstrated that support from significant others was important to the self-concept of
science ability. Fish (1979) collected data from eighth grade girls in Michigan public schools and found that although there was a positive relationship between friend, teacher, and parental evaluations, and self-concept of science ability, the role of the teacher was considered to be the strongest influence. Kahle's study (1983) of high school students in biology demonstrated that boys ranked their abilities higher than girls in all areas examined, although girls ranked themselves almost as high as boys on academic ability.

At the college level several studies have demonstrated that females appear to lack confidence in their abilities. Boisset (1989) studied the persistence rates among science students and found a high attrition rate for first time enrolled science students. Although there was not a significant difference in attrition found between females and males, females who transferred out of science reported to a greater extent then males that they did not perform well. Also, more females than males attributed their failure to lack of ability and not being suited to the science area. Manis (1989) studied college seniors and found that one-third of women in science believed "lack of confidence in handling the work" was a serious problem for women in science. Seventeen percent of the women in science believed this was a serious problem for them, personally. Also, compared to the males in this study females showed slightly less confidence about their ability to do scientific work.

Students express feelings at the doctoral level similar to those of undergraduates. An earlier study by Holmstrom and Holmstrom (1974) examined women doctoral students' perceived reasons for experiencing doubts about completion of graduate school. The same women who rated the academic ability of fellow students very high were the women who
believed that emotional strain could interfere with completion of their graduate studies. Berg and Ferber's study (1983) of all graduate students enrolled at one university from 1968-1975 asked respondents questions about the importance of five factors in the selection of their field of study. One factor students were asked to respond to was their perceived ability to handle the work in their areas. Significantly more women than men indicated that this factor was very important to their choice of field of study. However, these researchers stressed that for women in the biological and physical sciences their level of self-doubt was very high—63 percent of women, but only 37 percent of men noted this. Berg and Ferber interpreted this finding to mean that women were less likely than men to take their ability to do what they wanted for granted.

Linked to student successes is the question of “attribution” or “locus of control”. “Locus of control is an expression of the extent to which individuals believe that they, rather than outside factors, control their actions and behaviors” (Kahle, 1983, p. 19). People who believe in their own control are internally oriented people while people who are externally oriented attribute control to outside forces.

Students who have been lost from science have been identified as having placed the blame both internally and externally. Ware et al. (1985) studied attrition from science in freshmen students and found that women showed a higher rate of attrition than men by the end of the freshmen year. Also, although both sexes believed the first year science of mathematics courses were difficult, women and men perceived the difficulties in different ways. Females placed the blame internally while males placed their difficulty on external
factors. These researchers suggested that a female's negative reaction to her first year science course, together with a lack of confidence that characterized these students would lead to a higher attrition from science for females than males. Boisset (1989) also studied first time enrolled science students and found a high rate of attrition for both sexes. Both sexes, but particularly females believed they had little control over their failure.

This section of the literature review has cited differences between females and males regarding their abilities as determined through objective measures, and also what they perceive their abilities to be. Studies have determined that high ability students are more likely than lower ability students to enter the fields of science, mathematics, and engineering (Gordon, 1990; Grandy, 1987; Lee, 1987; Sax, 1992). The high ability males, however, tend to enter these areas at greater rates than the high ability females (Gordon, 1990; Grandy, 1987) although at least one study (Sax, 1992) demonstrated a higher persistence rate for females than males with high GPAs for the hard sciences. One issue also addressed by researchers is the factor of "perceived science ability." This factor appears to be important for women's participation in science. Several studies have demonstrated that females rank themselves lower than males in perception of science ability (Boisset, 1989; DeBoer, 1984; Kahle, 1983; Manis, 1989; Morgan, 1992) and there is some evidence to suggest that females tend to blame themselves for their failures in science more so than do males (Ware et al., 1985). Berg and Ferber (1983) studied graduate students and found that females to a greater extent than males believed that "ability to handle the work" is an important factor in choosing a major in college. Related to this is the issue of whether females who have earned
undergraduate degrees in the sciences believe they are capable of being successful in graduate school. This review of the literature failed to find any studies that addressed this issue, and therefore, this appears to be an area overlooked by researchers in their quest for understanding what factors are important for science persistence.

**Summary**

This literature review is extensive because of the numerous factors that have been associated with women's participation in science that are pertinent to this research project, and because of the apparent cumulative and complex nature of these factors. This review began by acknowledging how our nation's status in the world community was challenged by other countries' educational and scientific achievements beginning in the 1950s. As concern about the scientific literacy of American citizens intensified, calls for educational reform began. It became obvious that as American students move through the educational system their interest in science and engineering declines so that only a small number of those interested in these areas early in high school actually graduate with undergraduate degrees in the sciences and engineering. This drop is even greater from the undergraduate degree to completion of the doctorate in graduate school. It became obvious to many concerned individuals and groups that women and minorities who continue to constitute a greater proportion of the students enrolled in college should be targeted so that their participation in science and engineering is increased.
After describing the context in which reforms for science education and concerns for women's participation in science developed, the second section of the literature review identified and offered analyses of some of the various factors that have been studied by researchers interested in women's participation in science. To facilitate an understanding of these factors this section was organized into the subsections of motivation, access, and ability under which several factors were addressed.

After reviewing the literature some observations, in general, can be offered. (1) The majority of studies that are interested in the factors associated with persistence or attrition of science students are undertaken on undergraduate students, with very few of these studies focusing on senior level students who are at the juncture of making a decision about enrollment in graduate school. (2) Although research has indicated that students who have higher grades in high school, higher scores on the mathematics section of college aptitude tests, and higher achievement in general are the students most likely to pursue science, mathematics, and engineering majors the majority of studies do not focus on these groups. (3) Many studies fail to examine factors associated with a narrow group of students, for example, those students only within the laboratory sciences rather than studying the broader groups of science, mathematics, and engineering together. It is likely that some of the experiences are different enough between groups to warrant separation. (4) Many studies are designed to compare differences and similarities between females and males although some researchers have suggested that the sexes differ enough in their attitudes and perceptions that they should be studied separately. (5) Studies on graduate students often fail to separate
students by the types of degree program, that is, by either the master's or doctoral program of study, thereby limiting the usefulness of the interpretation of findings involving these groups. (6) Studies on students beyond the undergraduate degree appear to survey either current graduate students or those who have completed doctoral programs, therefore, failing to take into account those students who may have started graduate school, but later quit before earning their advanced degrees. (7) The majority of studies fail to involve a qualitative component, therefore, decreasing the opportunity to aid in the interpretation of research findings. (8) Many studies offer descriptive findings only, rather than, for example, examining the issue of cause or the development of models associated with science persistence.

Together with these general observations cited more specific observations can be addressed regarding the findings stated in the literature review. Five of these observations are summarized below.

Several factors associated with the issue of motivation were examined. The first factor, support, encompassed parental support, academic environment support, and peer support. (1) Results are inconclusive at this time regarding how much influence students believe their parents exert on science persistence at the undergraduate level. There appears to be more consistent results over the issue of differential support, that is, females report being influenced by their fathers more so than their mothers. Also, males may receive more maternal support. There do not appear to be any studies, however, that attempted to ascertain the level of influence that parents have on pursuit of graduate school in the
There are several studies that identified lack of support, neutral, or negative influences from high school teachers and counselors, and college personnel on science persistence. If further studies bear out lack of support at the college level this appears to be an area that should be targeted as an influencing factor on women’s participation in science. The issue of faculty acting as role models, and therefore, providing support to students in the sciences has not been well studied. There do not appear to be studies attempting to elucidate the relationships that women science students have with their professors of either sex. Also, there are few studies examining the direct influence of peers on science persistence.

The second section under motivation examined the perceptions held by students about science, scientists, and the science classroom. At the college level the majority of studies did not support the belief that the masculine image of science or the associability of scientists were hindrances to women’s persistence in science. What appeared to be most significant were descriptions by females of a “chilly classroom climate” which have been provided by both undergraduate and graduate students. Instances cited by students include the competitive nature of the science classroom and the issue of sexism, regarding the relationship of female students and male professors. However, it is unclear at this time because of an absence of data whether the issue of sexism is serious enough to prevent women’s pursuit of graduate degrees in science.

The third section under motivation examined the factor of role conflicts and identified numerous studies that have addressed this issue. Many studies have demonstrated lower marriage and family aspirations, higher divorce rates, and anticipation of
greater role conflicts for students who pursue graduate studies, both in and outside of science. One important issue that has not been addressed, however, is “What, if any, factors about graduate school do these students find difficult or offensive, and what factors associated with graduate work could be changed to facilitate these students in pursuit of their graduate studies?” Answers to these questions should increase the understanding of women’s participation in science at the graduate level.

Only one factor was examined under the section of access. (4) All of the studies on financial aid involved either current or former graduate students regarding the issue of financial aid and women’s persistence to graduate school. Several of these studies offered evidence indicating that the preferred type of assistantships, the research assistantship, is held by more males than females. Although former studies have told us what is true at the graduate level, this review of the literature failed to find studies designed to determine whether financial difficulties, either present or perceived, are held by college senior women in science. Several questions should be addressed in future studies. Do these women perceive having future financial difficulties? Will inadequate financial aid packages prevent them from applying to graduate school or continuing from a master’s to a doctoral program of study?

The last section examined the issue of ability. (5) This section briefly reviewed performance as it is related to science persistence and concluded that although females tend to receive higher high school grades than males they do not obtain higher scores than males on the mathematics section of college aptitude tests. Also, data indicate that higher ability
students, more so than lower ability students, are more likely to enter the fields of science, mathematics, and engineering, but this is most likely to be true for males. Related to science persistence is the factor of participation. When more courses are taken by students and when higher grades are earned, studies indicate that students gain more competence. This affects science participation, but also appears to influence males more so than females. One factor important to the issue of ability is "perceived science ability." Berg and Ferber (1983) concluded that the graduate students in their study believed that "ability to handle the work" was important to their choice of college major. Because several studies have concluded that not only females, but also males believe that females have a decreased sense of confidence in science, the factor of self-confidence appears to influence female's participation in science. It is unclear, however, to what extent this factor influences the college senior female in her decision to pursue graduate studies. Is this a serious enough problem, as perceived by high ability females, to prevent further participation in science?

Both the general and more specific observations in this summary of the literature review reveal the extent of what is known, or is in dispute about some of the factors associated with women's participation in science. This summary has also raised questions that are pertinent for this research project as well as future studies. Table 1 lists the studies and writings addressed in the literature review by the year and/or population studied, where pertinent. Table 2 divides the factors associated with persistence into three parts: factors associated with motivation, factors associated with access, and factors associated with
ability. Studies from Table 1 addressing these factors are cited under pertinent categories within Table 2.
Table 1. Survey of studies and writings on women’s participation in science.

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahren &amp; Scott</td>
<td>1981</td>
<td>Doctoral recipients - Scientists, engineers, humanists</td>
</tr>
<tr>
<td>Astin</td>
<td>1969</td>
<td>Doctoral recipients - females only</td>
</tr>
<tr>
<td>Baird</td>
<td>1976</td>
<td>Graduate students</td>
</tr>
<tr>
<td>Baker</td>
<td>1983</td>
<td>Undergraduates - science and nonscience majors</td>
</tr>
<tr>
<td>Berg &amp; Ferber</td>
<td>1983</td>
<td>Graduate students - Science and nonscience</td>
</tr>
<tr>
<td>Boisset et al.</td>
<td>1989</td>
<td>Undergraduates</td>
</tr>
<tr>
<td>Brown</td>
<td>1983</td>
<td>Graduate students - females only</td>
</tr>
<tr>
<td>Brown &amp; Heath</td>
<td>1977</td>
<td>College freshmen</td>
</tr>
<tr>
<td>Brush</td>
<td>1991</td>
<td>Faculty &amp; nonfaculty</td>
</tr>
<tr>
<td>Centra</td>
<td>1974</td>
<td>Doctoral recipients (PhD and EdD)</td>
</tr>
<tr>
<td>DeBoer</td>
<td>1984</td>
<td>Junior and senior high students</td>
</tr>
<tr>
<td>DeBoer</td>
<td>1985</td>
<td>College freshmen</td>
</tr>
<tr>
<td>Didion</td>
<td>1984</td>
<td></td>
</tr>
<tr>
<td>Dublon</td>
<td>1983</td>
<td>Higher education administration students - female only</td>
</tr>
<tr>
<td>Researchers</td>
<td>Year</td>
<td>Population</td>
</tr>
<tr>
<td>------------------------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ethington &amp; Wolfe</td>
<td>1987</td>
<td>High School &amp; Beyond Data - 1982 high school seniors with follow-up in 1984; females only</td>
</tr>
<tr>
<td>Ethington &amp; Smart</td>
<td>1986</td>
<td>CIRP Data - 1971 freshmen; 1980 follow-up</td>
</tr>
<tr>
<td>Fish</td>
<td>1979</td>
<td>Eighth grade females - 5 year longitudinal study</td>
</tr>
<tr>
<td>Fitzpatrick &amp; Silverman</td>
<td>1989</td>
<td>Undergraduates - science, engineering, nonscience majors; high achieving females</td>
</tr>
<tr>
<td>Girves &amp; Wemmerus</td>
<td>1988</td>
<td>Graduate students - Masters and doctoral</td>
</tr>
<tr>
<td>Gordon</td>
<td>1990</td>
<td>High School &amp; Beyond Data - 1980 high school seniors with follow-up in 1986</td>
</tr>
<tr>
<td>Grandy</td>
<td>1987</td>
<td>Top 10% of students taking SAT from 1975-86</td>
</tr>
<tr>
<td>Hill, Pettus, &amp; Hedin</td>
<td>1990</td>
<td>Middle school and high school students</td>
</tr>
<tr>
<td>Hilton &amp; Lee</td>
<td>1988</td>
<td>High School &amp; Beyond Data - 1972 and 1982 high school seniors with follow-ups</td>
</tr>
<tr>
<td>Holmstrom &amp; Holmstrom</td>
<td>1974</td>
<td>Graduate students - all areas</td>
</tr>
<tr>
<td>Iadevaia</td>
<td>1989</td>
<td>Community college students</td>
</tr>
<tr>
<td>Ivey</td>
<td>1987</td>
<td></td>
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</table>
Table 1. (continued)

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Year</th>
<th>Population</th>
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</thead>
<tbody>
<tr>
<td>(27) Kahle</td>
<td>1983</td>
<td>High school females and their Biology teachers</td>
</tr>
<tr>
<td>(28) Kahle &amp; Matyas</td>
<td>1987</td>
<td>Masters and doctoral students</td>
</tr>
<tr>
<td>(29) Kallio</td>
<td>1995</td>
<td>Graduate students - PhD and professional degree programs; over age 30 females</td>
</tr>
<tr>
<td>(30) Kaplan</td>
<td>1982</td>
<td>College freshmen - science and nonscience majors</td>
</tr>
<tr>
<td>(31) Lane</td>
<td>1990</td>
<td>Undergraduates</td>
</tr>
<tr>
<td>(32) Lee</td>
<td>1987</td>
<td>High School &amp; Beyond Data - 1982 high school seniors</td>
</tr>
<tr>
<td>(33) Lips</td>
<td>1992</td>
<td>College seniors - science and nonscience majors</td>
</tr>
<tr>
<td>(34) Lovely</td>
<td>1987</td>
<td>High School &amp; Beyond Data - Sophomores and high school seniors</td>
</tr>
<tr>
<td>(35) Manis</td>
<td>1989</td>
<td>College freshman in 1971 - 8 year longitudinal study; females only</td>
</tr>
<tr>
<td>(36) Marion</td>
<td>1988</td>
<td>Woodrow Wilson National Fellowship Electees</td>
</tr>
<tr>
<td>(37) McNamara &amp; Scherrei</td>
<td>1982</td>
<td></td>
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</table>
Table 1. (continued)

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>(39) Morgan</td>
<td>1992</td>
<td>Undergraduates - science and engineering students</td>
</tr>
<tr>
<td>(40) O'Connell, Betz &amp; Kurth</td>
<td>1989</td>
<td>Nursing, veterinary medicine, engineering students - females only</td>
</tr>
<tr>
<td>(41) Sandler</td>
<td>1994</td>
<td></td>
</tr>
<tr>
<td>(42) Sax</td>
<td>1992</td>
<td>CIRP Data - 1985 freshmen; 1989 followed</td>
</tr>
<tr>
<td>(43) Solmon</td>
<td>1976</td>
<td>Doctoral recipients - all areas</td>
</tr>
<tr>
<td>(44) Stansbury</td>
<td>1986</td>
<td>Undergraduates - science and engineering</td>
</tr>
<tr>
<td>(45) Strenta, Elliott, Adair, Matier &amp; Scott</td>
<td>1994</td>
<td>Undergraduate science majors</td>
</tr>
<tr>
<td>(46) Tobias</td>
<td>1990</td>
<td>Graduate students outside science chosen to take science courses</td>
</tr>
<tr>
<td>(47) Ware &amp; Lee</td>
<td>1988</td>
<td>Undergraduates - science and nonscience majors</td>
</tr>
<tr>
<td>(48) Ware, Steckler, &amp; Leserman</td>
<td>1985</td>
<td>College freshman</td>
</tr>
<tr>
<td>(49) Wilson</td>
<td>1965</td>
<td>Doctoral recipients</td>
</tr>
<tr>
<td>(50) Wong &amp; Sanders</td>
<td>1982</td>
<td>Doctoral recipients</td>
</tr>
<tr>
<td>Researchers</td>
<td>Year</td>
<td>Population</td>
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<td>-------------</td>
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</tr>
<tr>
<td>(51) Zwick</td>
<td>1991</td>
<td>Doctoral students</td>
</tr>
</tbody>
</table>
Table 2. Studies and writings on women's participation in science categorized by factors associated with persistence.

**Factors Associated with Motivation**

<table>
<thead>
<tr>
<th>Lack of Support</th>
<th>Lack of Information</th>
<th>Stereotyped Views</th>
<th>Masculine Image of Science, Math and Engineering</th>
<th>Sexist Attitudes of Students and Professors</th>
<th>Competitive Nature of Science Classes</th>
<th>Demands of Marriage, Family, and Career</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Advisor</td>
<td>Counseling</td>
<td>Sociability of Scientists</td>
<td>24, 28, 35, 37</td>
<td>24, 27, 29, 35, 39, 45, 50</td>
<td>6, 26, 35, 45, 46, 48</td>
<td>Masters Students</td>
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<tr>
<td>19, 35, 44, 47</td>
<td>27, 30, 35</td>
<td>27, 33, 35, 42</td>
<td></td>
<td></td>
<td></td>
<td>5, 38</td>
</tr>
<tr>
<td>Faculty</td>
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<td></td>
<td></td>
<td>PhD-Terminal</td>
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<tr>
<td>10, 13, 18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Junior Colleagues</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Married (In School)</td>
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<td>5, 19</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>PhD - 1, 2, 3, 10</td>
</tr>
<tr>
<td>Parents</td>
<td></td>
<td></td>
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<td></td>
<td>Family First</td>
</tr>
<tr>
<td>2, 5, 7, 18, 35, 39, 40, 42, 45, 47</td>
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<td></td>
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<td>24, 42, 47</td>
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<td>Peers</td>
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<td>Stress - Marriage</td>
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<tr>
<td>16, 18</td>
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<td></td>
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<td>10, 14, 24, 30, 33, 35, 39, 49</td>
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<td>High School Teachers</td>
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<td>Degree Completion</td>
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<td>17, 18, 35, 47</td>
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<td>38</td>
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<td>Guidance Counselors</td>
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<td></td>
<td></td>
<td>Intent to Work</td>
</tr>
<tr>
<td>35, 47</td>
<td></td>
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<td></td>
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<td></td>
<td>40</td>
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<tr>
<td>Academic Department /Environmental</td>
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<td>44</td>
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<tr>
<td>Role Models</td>
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<td></td>
</tr>
<tr>
<td>5, 16, 17 (no study), 19, 35, 42</td>
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<td>49 (no study)</td>
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</table>
Table 2. (continued)

<table>
<thead>
<tr>
<th>Factors Associated with Access</th>
<th>Factors Associated with Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of Financial Aid</td>
<td>Competence in Science</td>
</tr>
<tr>
<td>8, 16, 29, 38</td>
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</tr>
<tr>
<td>R.A./T.A.</td>
<td></td>
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<tr>
<td>1, 10, 30, 37, 43, 49, 50</td>
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</tr>
<tr>
<td>Related to Involvement</td>
<td>Ability to handle work</td>
</tr>
<tr>
<td>5, 19</td>
<td>5, 27</td>
</tr>
<tr>
<td>Fellowships/Scholarships</td>
<td>Fellow Students Better</td>
</tr>
<tr>
<td>10, 50</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Lack of Skills</td>
</tr>
<tr>
<td></td>
<td>6, 11, 35, 39, 42</td>
</tr>
<tr>
<td></td>
<td>Difficulty of Science</td>
</tr>
<tr>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Science Careers</td>
</tr>
<tr>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Time/Effort/Long Preparation</td>
</tr>
<tr>
<td></td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Self Confidence</td>
</tr>
<tr>
<td></td>
<td>11, 17, 36, 44</td>
</tr>
</tbody>
</table>

* Numbers refer to the studies or writings cited in Table 1.
CHAPTER III

RESEARCH METHODS AND PROCEDURES

The purpose of this chapter is to describe the research methodology used in this research project. The chapter begins by discussing the research design. This section is followed by a description of the research population, the research sample, the survey instrument, data collection, data analysis, and statistical tests. The chapter concludes with a summary of the methodology.

The Research Design

According to Borg and Gall (1989) there are four types of research designs: descriptive, causal-comparative, correlational, and experimental. The causal-comparative design was used for this research project. This method allows a comparison of subjects who exhibit a particular characteristic with subjects who exhibit this to a limited degree, or in whom it is missing.

Data were collected by a survey instrument or questionnaire. The survey instrument consisted of four types of questions, as indicated by Dillman (1978). These questions can be categorized as questions regarding attitudes, beliefs, behaviors, and attributes. Each of these will be discussed later in this chapter in the section on the survey instrument.
The data were treated to both descriptive and inferential analyses. Inferential tests of the research hypotheses included two-way analysis of variance (two-way ANOVA), multiple regression, and the t-test for independent means.

The Research Population

The research population for this study consisted of female graduates of Iowa State University from 1986 through the summer of 1994. Specifically, these females earned Bachelor of Science degrees from the College of Liberal Arts and Sciences in various science majors. The science majors were limited to those that are considered to be laboratory sciences, therefore excluding mathematics and engineering majors which have frequently been included in previous research studies. The selected majors were biochemistry, biology, biophysics, botany, chemistry, genetics, meteorology, microbiology, physics, and zoology. Double majors were included in the population if one of the majors was in one of these areas of interest.

The population was further restricted to females who were identified as American citizens or foreign born females who were educated in the United States prior to their college years. The population also was restricted to females who were considered to be "successful" graduates of Iowa State University. To be considered a successful graduate the female needed to have earned a 3.00 or greater cumulative GPA at the time of graduation.

The procedure for identifying the population involved examining all the graduation booklets for the years of interest. Any major in the College of Liberal Arts and Sciences that
was a laboratory-based major in the biological or physical science fields was studied carefully in order to choose all students who were female. If the gender was uncertain the name was chosen for further sex verification by the Registrar’s Office. Foreign names were excluded from the preliminary list of names only after consultation with the Registrar’s Office, and only if this office could verify that a graduate was not a United States citizen. The section on survey development discusses how a question in the survey was used to verify whether or not the graduate was American educated prior to college.

The preliminary list of names was then forwarded to the Registrar’s Office to identify female students who had earned a cumulative GPA of 3.00 to 3.49 at the time of graduation. Students who graduate with a 3.50 or higher GPA from Iowa State University are designated as graduating “with distinction” and could be identified in the graduation booklets by an asterisk. As indicated in the literature review, high achieving or successful students are those most likely to persist in science, and therefore, it is these students who are the most obvious ones to target when examining factors associated with science persistence beyond the bachelor’s degree. By having persisted and graduated with science degrees they are the most likely to offer insights into factors responsible for science persistence.

The final list from the Registrar’s Office, therefore, represented graduates with the following restrictions: (1) females graduating in selected majors from 1986 through the summer of 1994 (2) females graduating with a 3.00 to 3.49 cumulative GPA and (3) American citizens. This researcher also requested a list of approximately five names of females who met the criteria for inclusion in the population, but who had graduated in
December 1994. These names were required in order to ask for assistance in performing the pilot study.

The final list of names for the population was a combination, therefore, of names verified through the Registrar’s Office and names obtained from the graduation booklets which were marked with an asterisk, indicating graduation with distinction.

The Research Sample

Because the preliminary investigation of females meeting criteria for selection into the research population did not yield a large number of names, a decision was made to sample the entire population. Therefore, the final list of names was given to the Alumni Office so that mailing addresses and labels could be obtained. The Alumni Office provided further verification of sex by providing the label of Miss, Ms., or Mr. before each name. This resulted in the elimination of two males not previously identified by the Registrar’s Office. The Alumni Office could not locate one female by name. The office considered her not to be a graduate, and stated that her inclusion in the research population was an error. The sample, therefore, consisted of 221 females representing the entire population. The Alumni Office was able to provide mailing addresses for 100 percent of the sample. The distribution of these females by major and level of cumulative GPA at the time of graduation is included in Table 3.
Table 3. Distribution of research sample by major and level of cumulative GPA at the time of graduation.

<table>
<thead>
<tr>
<th>Major</th>
<th>3.50 - 4.00</th>
<th>3.00 - 3.49</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Total*</td>
<td>n</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>5.43</td>
<td>12</td>
</tr>
<tr>
<td>Biology</td>
<td>9.50</td>
<td>21</td>
</tr>
<tr>
<td>Biophysics</td>
<td>0.45</td>
<td>1</td>
</tr>
<tr>
<td>Botany</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chemistry</td>
<td>2.71</td>
<td>6</td>
</tr>
<tr>
<td>Genetics</td>
<td>0.45</td>
<td>1</td>
</tr>
<tr>
<td>Meteorology</td>
<td>0.45</td>
<td>1</td>
</tr>
<tr>
<td>Microbiology</td>
<td>4.98</td>
<td>11</td>
</tr>
<tr>
<td>Physics</td>
<td>0.90</td>
<td>2</td>
</tr>
<tr>
<td>Zoology</td>
<td>12.67</td>
<td>28</td>
</tr>
<tr>
<td>Biology and French</td>
<td>0.45</td>
<td>1</td>
</tr>
<tr>
<td>Biology and Music</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biology and Environmental Studies</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biophysics and Microbiology</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Physics and Math</td>
<td>0.45</td>
<td>1</td>
</tr>
<tr>
<td>Zoology and Psychology</td>
<td>0.90</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>39.37</td>
<td>87</td>
</tr>
</tbody>
</table>

*Total = 221
The Survey Instrument

Because of the anticipated wide geographic dispersion of members of the research sample it was necessary to develop a survey instrument to collect data on the desired variables of interest. The development of this survey was a complicated task because of the seemingly complex nature of factors associated with women's persistence in science, as outlined by the literature review; the desire of the researcher to study a large number of variables in this research project; the desire to include a variety of question types in the survey instrument; and the desire to achieve a high rate of return of completed questionnaires.

As stated previously, Dillman (1978) has described four types of questions that can be used in survey development. These questions allow for the assessment of attitudes, beliefs, behaviors, and attributes. Attitudes can be measured by questions that solicit answers of right or wrong, good or bad, prefer or not prefer, should or should not, and agree or disagree. In this study attitudes have been measured on a Likert Scale. The scale that was chosen utilized seven points: (1) Strongly disagree (2) Disagree (3) Somewhat disagree (4) Somewhat agree (5) Agree (6) Strongly agree and (7) No opinion. This scale was favored because it has six good points of discrimination on level of agreement, and a position where no opinion can be indicated if the individual wishes to do so.

Beliefs, according to Dillman (1978) can be assessed by soliciting answers of no or yes, or variations of yes (example: never, seldom, usually, always). For purposes of this study beliefs were assessed by no, yes, or variations of yes responses; by offering fixed
responses in which one response could be chosen; by offering fixed responses in which more than one response could be chosen; and by open-ended questions that would be developed by the respondent.

A third type of question, according to Dillman (1978), measures behavior. Questions of behavior involve measuring what someone did or did not do, what the person might be doing, or what the person could do in the future. Behavior, for purposes of this study was measured by one no or yes question.

A fourth type of question measures attributes (Dillman, 1978). Attribute type questions assess characteristics that cannot be manipulated at will (Ary, Jacobs, & Razavieh, 1990). Attributes that were requested for purposes of this study included marital status and characteristics of a partner or spouse, degree status beyond the baccalaureate degree, and various demographic variables.

One particular attribute type question should be addressed here. This question asked any respondent who indicated a country of birth other than the United States “When did you come to the United States?” For purposes of this study this question was used to eliminate respondents who were not American educated prior to college. For respondents to be included in this study they needed to have undertaken all of their education prior to college in the United States.

There are several factors that must be considered when constructing a survey instrument. Two of these factors are face validity and content validity. A common definition of validity “is that it is the degree to which a test measures what it purports to
measure" (Borg & Gall, 1989, pp. 249-250). Face validity is a subjective judgment of whether the instrument appears to measure what it purports to measure (Borg & Gall, 1989). This is important because it has been found that individuals react more favorably to instruments with high face validity. Face validity can act to supplement information about content validity which is a measure of how well the content of an instrument measures what it is designed to measure.

Several experts were consulted in order to help establish validity of an early draft of the survey instrument. These individuals included a professor in higher education, a professor in research and evaluation, and the Director of Institutional Research at Iowa State University. The Director of Institutional Research is a female who earned a PhD in the physical science area, and therefore, was an important expert for determining content validity.

After the survey was refined using feedback from the panel of experts, attempts were made to reduce bias introduced by the survey itself. For example, when an open-ended question was chosen along with questions offering a variety of responses on the same topic, the open-ended question was asked first. This was an attempt to avoid influencing the respondents' first choices. Also, questions on the same topic were mixed regarding a positive or negative tone. This was to detect item response bias. A further attempt to reduce survey bias was undertaken by mixing questions of related constructs together when they were intended to be contained within the same content area of the questionnaire.
Because a high rate of return from respondents was desired many technical details associated with the formatting of the survey were scrutinized. This researcher consulted an individual who has arrangements with a firm to routinely take various types of surveys. This individual helped with the "readability" of the survey which involved the arrangement of questions, the size of letters, spacing considerations, and placement of responses. Because the survey was lengthy this person was also asked to take the survey as if she were a participant in the study, and to provide feedback on the time required for completion. After receiving suggestions from this individual and incorporating them into the survey, the survey was revised into the final form that would be used for the pilot study.

Two December 1994 graduates agreed to participate in a pilot study. Their names were obtained from the Registrar’s Office after it was determined that they met all criteria for inclusion in this research project, except that the December 1994 class was not chosen to be in this study. The survey instrument was administered to both graduates, individually. They were given the survey in the same form that would be received by the research sample. That is, the survey was presented to each participant in an envelope containing the intended cover letter and the envelope designated for return of the survey. The participants were timed as they took the survey. The approximate time required to complete the survey was 15 minutes. Each person was then asked to provide feedback on both the cover letter and survey and to provide suggestions for improvement of design, content, and delivery. After incorporating these suggestions the survey was modified into its final form. The final form
of the survey consisted of seven parts. Each of these is described in Table 4. The cover letter is in Appendix A. The final form of the survey instrument is in Appendix B.

**Data Collection**

Approval for this research project was obtained from the Human Subjects Review Committee at Iowa State University prior to mailing of the survey. The first mailing occurred on January 4, 1995. Each mailing contained a transmittal letter, the survey, and a return envelope. The surveys had been coded with a small number in the lower right corner of page one, prior to mailing. This was to enable the researcher to determine which surveys had or had not been returned. The return envelopes were addressed to the RISE office at Iowa State University. Each return envelope contained a mark in the upper left corner that would identify the envelope as one containing a survey for this particular research study. Therefore, the returned surveys could be forwarded to this researcher without being opened by personnel in the RISE office.

There were 95 usable surveys returned in the first group, received by January 20. On January 23 a postcard was mailed to the entire sample thanking each person for returning their survey or reminding them to do so. By February 1 another 26 usable surveys were returned. By March 21 another 44 usable surveys were returned. A third mailing on February 16 contained a new letter, again asking the person to participate in the study, and included another copy of the survey coded in the same manner as the first survey.
Table 4. Description of the survey instrument.

<table>
<thead>
<tr>
<th>Part</th>
<th>Purpose of the section</th>
<th>Group of respondents answering this section</th>
<th>Question number/item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>To ask an applicable, easy question to generate interest.</td>
<td>All respondents</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>To determine the influence that various individuals have had on science persistence up to and including the undergraduate college years</td>
<td>All respondents</td>
<td>2-5</td>
</tr>
<tr>
<td></td>
<td>Definition of role model - “Individuals such as high school teachers or counselors, college professors, parents, relatives, friends, or others who have exhibited personality traits, behaviors, and attitudes that have been positive influences on your persistence in science.” (Provided to answer questions 2-4)</td>
<td>Only those respondents who were married or had a male or female companion while earning their bachelors degrees.</td>
<td>6-8</td>
</tr>
<tr>
<td>II</td>
<td>To assess experiences in the science classroom.</td>
<td>All respondents</td>
<td>(9-26)</td>
</tr>
<tr>
<td></td>
<td><strong>Construct #1</strong></td>
<td>Enjoyment of science as a discipline.</td>
<td>9, 12, 15, 18, 21, 24, 26</td>
</tr>
<tr>
<td></td>
<td><strong>Working definition</strong></td>
<td>Refers to respondents' attitudes toward the laboratory, experimentation, and research.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Construct #2</strong></td>
<td>Relationships with science professors.</td>
<td>10, 13, 16, 19, 22, 25</td>
</tr>
<tr>
<td></td>
<td><strong>Working definition</strong></td>
<td>Refers to respondents' attitudes toward their science professors.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Construct #3</strong></td>
<td>Self-confidence for science studies.</td>
<td>11, 14, 17, 20, 23</td>
</tr>
<tr>
<td></td>
<td><strong>Working definition</strong></td>
<td>Refers to respondents' attitudes toward their abilities to be successful in science.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4. (continued)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Purpose of this section</th>
<th>Group of respondents answering this section</th>
<th>Question number/item</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>To assess experiences with and influences of a “chilly classroom climate.”</td>
<td>All respondents</td>
<td>(27-40)</td>
</tr>
</tbody>
</table>

**Definition** - “The climate that exists in the science classroom which causes a decrease in female student interest in science, leads to anxiety in females, is considered by females to be a form of sexism, or can cause females to consider changing majors, or to terminate their studies in college.”

(Provided to answer questions 27-40)

This section on the “chilly classroom climate” is divided into two subsections, and therefore, two constructs.

**Construct #4**
**Nature of the science classroom.**

**Working definition**
Refers to respondents' attitudes toward the friendliness of the science classroom and the ability of the science classroom to stimulate an interest in science.

**Construct #5**
**Sex discrimination in the science classroom.**

**Working definition**
Refers to respondents' attitudes toward sex discrimination from their male science professors.

To determine whether experiences with a “chilly classroom climate” affected persistence in a science major.

All respondents | 27-32 |
All respondents | 33-39 |
All respondents | 40 |
<table>
<thead>
<tr>
<th>Part Number</th>
<th>Purpose of this section</th>
<th>Group of respondents answering this section</th>
<th>Question number/item</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>To determine whether the academic advising experience at ISU facilitates the persistence of females in science.</td>
<td>All respondents</td>
<td>41-47</td>
</tr>
<tr>
<td></td>
<td><strong>Construct #6</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Academic advising experience.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Working definition</strong></td>
<td>Refers to respondents' attitudes toward their academic advising experiences at ISU.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To divide respondents into two groups: (1) those who have at some time been enrolled in a science program of study in graduate or professional school and (2) those who have not.</td>
<td>All respondents</td>
<td>48</td>
</tr>
<tr>
<td>V</td>
<td>To assess factors associated with failure to persist in science studies.</td>
<td>Respondents who have never been enrolled in a science program of study in graduate or professional school.</td>
<td>49-67</td>
</tr>
<tr>
<td></td>
<td>To assess which factors could be changed to attract more females to persist in science.</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>VI</td>
<td>To assess factors associated with persistence in science studies.</td>
<td>Respondents who have at some time been enrolled in a science program of study in graduate or professional school.</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>To assess factors believed to hinder the persistence of females in science.</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>To assess attitudes toward graduate or professional school experiences.</td>
<td></td>
<td>71-87</td>
</tr>
<tr>
<td></td>
<td>To determine area of study and level of achievement for persisters in science studies.</td>
<td></td>
<td>88-89</td>
</tr>
<tr>
<td>VII</td>
<td>To obtain demographic information.</td>
<td>All respondents</td>
<td>90-98</td>
</tr>
</tbody>
</table>
A total of six mailings were returned because they failed to reach their intended destinations. An additional survey was returned, unanswered, because the individual indicated that she was an elementary education major. Therefore, her name should not have been included in the population or research sample. Another survey was determined to be unusable because the respondent indicated in the survey that she was foreign born and had come to the United States after high school.

The final tally can be summarized as follows. The number in the sample was reduced from 221 to 219 because of the incorrect inclusion of the elementary education major and the elimination of the foreign born, foreign educated female who was never intended to be in the population or sample. Both of these individuals had been designated in the graduation booklets as biochemistry majors, graduating without distinction. Of the 219, there were six mailings unable to reach their destinations. The total of 165 usable surveys returned represented 75 percent of the sample of 219.

**Data Analysis**

The responses for all usable surveys were coded for entry into the mainframe computer at Iowa State University. The statistical package chosen to analyze the data was the Statistical Package for the Social Sciences (SPSS). The three open-ended questions required special treatment prior to coding. All responses were typed and grouped according to the question asked. After it had been determined that no further surveys, if received, would be included in the study, the written responses were cut apart. For each question the
pieces of paper with the individual responses were grouped, subjectively, into categories with common associations between responses. Question number 49 resulted in the development of 15 categories, question number 69 resulted in the development of 17 categories, and question number 70 resulted in the development of 12 categories. Within each question, every category was given a number. These numbers were then transcribed onto the original survey responses for entry into the computer. Appendix C lists the categories of responses for these three questions.

Three additional questions received special treatment. For question number 89 it was determined that an additional response was needed. Respondents were asked “Have you, or are you studying to earn a degree other than a Master’s degree?” As these responses were being typed for use in this study it was discovered that some respondents persisted to further science study (example, medical technology), but not to earn an advanced graduate level degree (example, PhD) or an advanced professional degree (example, M.D.). Therefore, an additional response category was developed for these respondents. Appendix C lists the categories for this question.

Question numbers 97 and 98 (highest degree completed by mother and father, respectively) required the development of six categories for coding because this researcher allowed an open-ended question and not one with fixed responses. Appendix C lists the categories of responses for these two questions.

Because one intent of this study was to examine differences between graduates entering programs of advanced graduate studies and graduates entering professional
programs of study, an additional question needed to be developed to separate these groups of respondents for coding into the computer. This became question number 101. Appendix C lists the categories of study for females who persisted in science after earning the baccalaureate degree.

Once all data entry had been completed frequencies were calculated to ensure data accuracy and to obtain descriptive statistics. A response in the Likert Scale of 7 (no opinion) was removed prior to calculation of the mean. Also, because questions were worded in both a positive and negative tone it was necessary to perform recoding on the negatively worded items so that the various means could be compared.

A reliability coefficient was calculated for each factor or construct. Two items were eliminated upon examination of the reliability coefficients. These results are reported in Chapter IV.

Construct validity of the survey instrument was determined through factor analysis. The method used was Unweighted Least Squares Extraction. This procedure utilizes the items of the survey instrument which are chosen by the researcher to be included in the analysis (Ary et al., 1990). In factor analysis a correlation matrix is developed which computes the correlation of every item with every other item. Through factor analysis a clustering together of variables with high intercorrelations occurs, but with low correlations between the clusters. This allows for the reduction of a large number of items into a smaller number of clusters or factors. Factor loadings are then determined which represent correlations between the identified factors and the original items. Varimax rotation was used
to make the factors more interpretable. Some items, and therefore factors, were eliminated based upon examination of the factor analysis. Three criteria were used for these eliminations: (1) the factor loaded below a cutoff point of .40 (2) there were fewer than three items in the factor or (3) examination of the Scree plot indicated that the factor represented an error. The reliability coefficients were then reexamined. These results are reported in Chapter IV.

**Statistical Tests**

Descriptive analysis of the data was performed to yield frequency distributions and measures of central tendency and dispersion. Three types of inferential tests were performed on the data to test the research hypotheses of the study. These were two-way ANOVA, multiple regression, and the t-test for independent means. A .05 level of significance was chosen for rejection of the null hypotheses.

**Two-way ANOVA**

Two-way ANOVA is used to test a research hypothesis with two independent variables and one dependent variable (Hinkle, Wiersma, & Jurs, 1988). When the combined effects of two or more independent variables are of interest to the researcher a factorial design is used (Ary et al., 1990). When each of the independent variables has two levels of interest chosen by the researcher and not randomly selected from a larger population of
levels, a fixed-effects model is present (Hinkle et al., 1988). For this study a 2 x 2 factorial design, fixed-effects model was used.

Two-way ANOVA is used to determine whether there is a significant difference between the mean scores on a dependent variable across the levels of one independent variable; whether there is a significant difference between the mean scores on a dependent variable across the levels of a second independent variable; and whether the two independent variables have a combined effect on the dependent variable in question. The first two analyses are called the main effects and the last is called an interaction effect.

These three analyses yield three F-ratios, two for the main effects and one for the interaction effect. The F-ratio represents a ratio of variance between groups to variance within groups, and is based upon the assumption that the total variation of scores is attributed to these two sources. The F-ratio is considered to be significant if it exceeds the critical value of F. If this is found to be true, a null hypothesis stating that there is no significant difference between groups can be rejected. Normally, if a significant difference between groups is found to be present, post hoc tests are performed to determine which groups are significantly different. For this study, however, because there are only two groups (persisters or nonpersisters; females graduating with distinction or not) it was unnecessary to perform post hoc tests.
Multiple regression

Multiple regression is used to predict the dependent, or criterion variable using two or more predictor variables. One procedure that can be used to select the independent variables for the multiple regression equation is called stepwise selection. Stepwise selection was used for this analysis. In this procedure, the variable with the largest correlation (either positive or negative) with the criterion variable is selected for entry first. If it is determined that this variable contributes significantly to the prediction of the criterion variable, then the variable with the next highest correlation with the criterion variable is selected. This occurs after first controlling, statistically, for the correlation between the first predictor and the criterion variable. These stepwise selections occur until it is determined that no more variables meet the criteria for entry.

T-test for independent means

A t-test for independent means is conducted to determine whether the means of two groups associated with a dependent variable differ significantly from one another. A significant difference is considered to be present between two groups if the observed difference between the two means is significantly greater than what would be expected by chance alone.
Summary

This study consisted of sampling the entire population of interest. Data were collected from 165 of the 219 females selected for the study for a return rate of 75 percent. Data were collected by a survey instrument that had been evaluated by a panel of experts and two female graduates who participated in a pilot study. Both reliability and construct validity of the survey instrument were determined, resulting in the elimination of some survey items. Descriptive analysis of the data was performed for all variables. Inferential statistics were used to test the research hypotheses as stated in Chapter I, or modified after examining the results of the factor analysis. These included two-way ANOVAs, multiple regression, and the t-test for independent means. A .05 level of significance was chosen by the researcher as the level for accepting or rejecting the null hypotheses. Chapter IV presents the results of these analyses.
CHAPTER IV
RESEARCH FINDINGS

The purpose of this chapter is to present the research findings of this study. The chapter begins with the results of the preliminary analysis of the data. This is followed by a presentation of the results from descriptive analyses of the data. The last section presents the results from the testing of the null hypotheses. The chapter concludes with a summary of the research findings.

Preliminary Analysis

Reliability coefficients for each of the scales used to measure the original six constructs were computed. Cronbach’s alpha, a reliability coefficient that measures the internal consistency of a test was chosen because it requires only one administration of a test.

Two items were eliminated based upon examination of Cronbach’s alpha if the item was deleted. This increased the reliability of the scale. Item 31 was deleted from the scale measuring the construct “nature of the science classroom.” Item 39 was deleted from the scale measuring the construct “sex discrimination in the science classroom.” The reliability coefficients for each scale after deletion of the items are reported in Table 5. Deleted items are listed below.
Table 5. Reliability coefficients for the scales before factor analysis.

<table>
<thead>
<tr>
<th>Scale/Construct</th>
<th># of items in the scale</th>
<th>Cronbach alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment of science as a discipline</td>
<td>7</td>
<td>0.83</td>
</tr>
<tr>
<td>Relationships with science professors</td>
<td>6</td>
<td>0.75</td>
</tr>
<tr>
<td>Self-confidence for science studies</td>
<td>5</td>
<td>0.62</td>
</tr>
<tr>
<td>Nature of the science classroom</td>
<td>5</td>
<td>0.72</td>
</tr>
<tr>
<td>Sex discrimination in the science classroom</td>
<td>6</td>
<td>0.70</td>
</tr>
<tr>
<td>Academic advising experiences</td>
<td>7</td>
<td>0.93</td>
</tr>
</tbody>
</table>

#31 During my senior of college I was more interested in science than I had been in previous years.

#39 Male professors enjoyed establishing a competitive environment in my science classes.

**Factor analysis**

Construct validity of the survey instrument was tested through factor analysis. Factor analysis was performed using all items numbered 9 through 47, with the exception of items 31, 39, and 40 (not a part of any construct scale). These selected items were chosen because they constituted the six original constructs developed by the researcher and the six dependent variables intended to be tested in research hypotheses 1 through 6, as stated in Chapter I.
Nine factors emerged as the result of the factor analysis. Six items were deleted after examination of the analysis. Items 47 and 37 (factor 7), items 9, 12, and 36 (factor 8), and item 20 (factor 9) were eliminated using the criteria established in Chapter III. The deleted items are as follows:

#47  Iowa State advisors do more to encourage the development of male scientists than female scientists.
#37  Male professors made remarks in class that degraded females.
#9   I sometimes felt frustrated in the laboratory because I did not understand the purpose of the laboratory experiments
#12  Often times I believed laboratory experiments were long and tiresome.
#36  Male professors appeared to like female students.
#20  There was not much competition in the science classroom.

Six factors were retained which explained 54.2 percent of the variance. These factors, however, represented a clustering of items that were somewhat different than those defined in the original constructs. The originally defined constructs of "academic advising experiences," "enjoyment of science as a discipline," "relationships with science professors," and "self-confidence for science studies" were retained. However, the original construct "sex discrimination in the science classroom" was changed to the new construct
"masculine nature of the science classroom," and the original construct "nature of the science classroom" was changed to the new construct "sexist nature of the science classroom."

New constructs require that new working definitions be developed. The working definition for the new construct "masculine nature of the science classroom" refers to "respondents' attitudes toward the lack of female students and professors in the science classroom which can lead to a decrease in science interest." The working definition for the new construct "sexist nature of the science classroom" refers to "respondents' attitudes toward the presence of sexism in the science classroom, either as a result of the actions of male peers or the actions of male professors." These new constructs are incorporated into Table 6 which gives the results of the factor analysis.

Index scores were computed for each factor. These scores represent the total score for the factor divided by the number of items. These scores were used for testing of the null hypotheses.

The development of new constructs also requires that research hypotheses be restated to reflect these changes. Research hypotheses 4, 5, 7, 11, and 12 have been restated and are listed below.

4a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward the sexist nature of the science classroom.
Table 6. Factor loadings, means, and standard deviations for the survey items.

<table>
<thead>
<tr>
<th>Factor and survey items</th>
<th>Factor loading</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic advising experiences</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41. My advisor was helpful in answering questions about my science major.</td>
<td>.88</td>
<td>4.24</td>
<td>1.54</td>
</tr>
<tr>
<td>42. My advisor was interested in me as a student.</td>
<td>.88</td>
<td>4.27</td>
<td>1.58</td>
</tr>
<tr>
<td>44. My advisor was a good source of information about job possibilities in science.</td>
<td>.85</td>
<td>3.33</td>
<td>1.59</td>
</tr>
<tr>
<td>46. Advising sessions with my advisor were not helpful for gaining information about graduate school.</td>
<td>-.82</td>
<td>3.34</td>
<td>1.59</td>
</tr>
<tr>
<td>43. My advisor was not a source of encouragement for my persistence in science.</td>
<td>-.80</td>
<td>3.17</td>
<td>1.72</td>
</tr>
<tr>
<td>45. My advisor thought females should be in science.</td>
<td>.54</td>
<td>4.97</td>
<td>.95</td>
</tr>
<tr>
<td><strong>Enjoyment of science as a discipline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. I enjoyed performing and learning new laboratory techniques and procedures.</td>
<td>.85</td>
<td>4.80</td>
<td>1.01</td>
</tr>
<tr>
<td>26. I enjoyed learning about scientific principles and applying those principles in the laboratory setting.</td>
<td>.78</td>
<td>4.88</td>
<td>.90</td>
</tr>
<tr>
<td>18. I enjoyed the challenges associated with carrying out a well designed experiment.</td>
<td>.77</td>
<td>4.78</td>
<td>.93</td>
</tr>
<tr>
<td>15. In laboratory sessions I found it interesting to collect data and interpret that data.</td>
<td>.75</td>
<td>4.54</td>
<td>.98</td>
</tr>
</tbody>
</table>
Table 6. (continued)

<table>
<thead>
<tr>
<th>Factor and survey items</th>
<th>Factor loading</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enjoyment of science as a discipline</strong> (continued)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Performing laboratory experiments was the most interesting part of studying science.</td>
<td>.71</td>
<td>3.46</td>
<td>1.28</td>
</tr>
<tr>
<td><strong>Relationships with science professors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. I was comfortable asking questions in my science classes.</td>
<td>-.73</td>
<td>3.69</td>
<td>1.31</td>
</tr>
<tr>
<td>25. If I needed help I felt comfortable seeing my science professors outside of class.</td>
<td>-.72</td>
<td>4.09</td>
<td>1.40</td>
</tr>
<tr>
<td>10. My science professors did not care about me as a person.</td>
<td>.67</td>
<td>3.03</td>
<td>1.33</td>
</tr>
<tr>
<td>33. I was sometimes intimidated by my male professors.</td>
<td>.61</td>
<td>3.57</td>
<td>1.37</td>
</tr>
<tr>
<td>13. My science professors respected me as a student.</td>
<td>-.46</td>
<td>4.77</td>
<td>1.02</td>
</tr>
<tr>
<td>22. My science professors were more interested in teaching students than in their research.</td>
<td>-.40</td>
<td>2.97</td>
<td>1.04</td>
</tr>
<tr>
<td><strong>Masculine nature of the science classroom</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. I would have liked to have had more female science professors as my instructors.</td>
<td>.73</td>
<td>5.07</td>
<td>.87</td>
</tr>
<tr>
<td>29. I believe that the science classroom is biased towards males.</td>
<td>.66</td>
<td>2.77</td>
<td>1.18</td>
</tr>
<tr>
<td>35. I believe males were treated more fairly in my science classes than were females.</td>
<td>.61</td>
<td>2.36</td>
<td>.90</td>
</tr>
<tr>
<td>Factor and survey items</td>
<td>Factor loading</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
<td>----------------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Masculine nature of the science classroom (continued)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. I felt more comfortable with female science professors than with male science professors.</td>
<td>.56</td>
<td>2.82</td>
<td>1.17</td>
</tr>
<tr>
<td>32. I would have liked to have had more female students in my science classes.</td>
<td>.51</td>
<td>4.02</td>
<td>1.06</td>
</tr>
<tr>
<td>11. It was more difficult for females to be successful in science than it was for males.</td>
<td>.49</td>
<td>2.54</td>
<td>1.23</td>
</tr>
<tr>
<td>30. Sometimes my science classes failed to stimulate or help me maintain my interest in science.</td>
<td>.42</td>
<td>3.47</td>
<td>1.29</td>
</tr>
<tr>
<td>Self-confidence for science studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Although I received good grades in my science classes I found it difficult to compete with other students in the science classroom.</td>
<td>.80</td>
<td>2.55</td>
<td>1.25</td>
</tr>
<tr>
<td>23. It was difficult for me to be successful in science.</td>
<td>.71</td>
<td>2.22</td>
<td>1.05</td>
</tr>
<tr>
<td>14. In my science classes I was more capable, intellectually, than most of the other students.</td>
<td>-.59</td>
<td>4.07</td>
<td>1.02</td>
</tr>
<tr>
<td>Sexist nature of the science classroom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Male students made me feel welcome in my science classes.</td>
<td>-.76</td>
<td>4.66</td>
<td>1.04</td>
</tr>
<tr>
<td>27. Male students in my science classes made sexist remarks either to me or to other female students.</td>
<td>.72</td>
<td>2.12</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Table 6. (continued)

<table>
<thead>
<tr>
<th>Factor and survey items</th>
<th>Factor loading</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sexist nature of the science classroom (continued)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38. Male professors did not use sexist language in class.</td>
<td>-.53</td>
<td>4.84</td>
<td>.95</td>
</tr>
</tbody>
</table>

4b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward the sexist nature of the science classroom.

4c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward the sexist nature of the science classroom.

5a: There is a significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward the masculine nature of the science classroom.

5b: There is a significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward the masculine nature of the science classroom.

5c: There is an interaction between persistence in science and GPA status at time of graduation on attitudes toward the masculine nature of the science classroom.
7: There is a relationship between the mean ratings of females in science on their attitudes toward "enjoyment of science as a discipline," "relationships with science professors," "self-confidence for science studies," "sexist nature of the science classroom," "masculine nature of the science classroom," and "academic advising experiences," and their persistence to further science study after earning the baccalaureate degree.

11: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the sexist nature of the science classroom.

12: There is a significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the masculine nature of the science classroom.

Because factor analysis resulted in some clustering of items unlike the original intent of the researcher it became necessary to determine the reliability of the factors after having performed factor analysis. These results are presented in Table 7.
Table 7. Reliability coefficients for the scales after factor analysis.

<table>
<thead>
<tr>
<th>Scale/Construct</th>
<th># of items in the scale</th>
<th>Cronbach alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment of science as a discipline</td>
<td>5</td>
<td>0.85</td>
</tr>
<tr>
<td>Relationships with science professors</td>
<td>6</td>
<td>0.79</td>
</tr>
<tr>
<td>Self-confidence for science studies</td>
<td>3</td>
<td>0.69</td>
</tr>
<tr>
<td>Sexist nature of the science classroom</td>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>Masculine nature of the science classroom</td>
<td>7</td>
<td>0.68</td>
</tr>
<tr>
<td>Academic advising experiences</td>
<td>6</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Descriptive Analyses of the Data

Respondents

Of the 165 respondents who participated in this study the majority were Caucasian (n = 157, 95.2 percent) who were between the ages of 24 and 27 (n = 83, 50.6 percent). Slightly more than half of the respondents did not graduate with distinction (n = 92, 55.8 percent). The majority majored in biology (n = 52, 31.5 percent) or zoology (n = 39, 23.6 percent), with 10 respondents indicating they had earned a double-major. Only a few (n = 2, 1.2 percent) earned both majors in the science majors sampled for this study.

Respondents were asked to indicate the time at which they first became interested in science. Thirty five percent first reported becoming interested in science in elementary school, 32 percent in middle or junior high, 29 percent in high school, and only 4 percent developed their first interest in college.
Approximately two-thirds of the respondents persisted in a science program of study after earning the baccalaureate degree ($n = 112$, 67.9 percent) while 53 (32.1 percent) failed to do so. Thirty three respondents (29.5 percent) had earned or were currently earning a master’s degree at the time of participation in this study. Seventy one (63.4 percent) had earned or were currently studying to earn degrees other than masters’ degrees. Two respondents (1.8 percent) indicated they had quit graduate school before earning any advanced degree. Six respondents (5.4 percent) pursued further science study, but not at the graduate level. Their areas of study included a second baccalaureate degree ($n = 1$), medical technology ($n = 4$), and a bachelor of nursing degree ($n = 1$). Based upon participants’ responses to the question regarding types of education pursued it was determined that 63 (56.3 percent) had entered professional programs of study. These areas included: veterinary medicine, osteopathy, dentistry, M.D., physical therapy, physicians assistant, pharmacy, medical technology, and bachelor of nursing degree. Most of the respondents entered the medical field ($n = 32$). Forty five respondents (40.2 percent) pursued advanced graduate studies by entering masters’ and/or doctoral programs of study. Twenty six of these pursued doctoral programs of study. None of these programs were outside the area of science. Demographic characteristics of the respondents are found in Table 8.
Table 8. Demographic characteristics of the respondents.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group</td>
<td>20-23</td>
<td>11.6</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>24-27</td>
<td>50.6</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>28-31</td>
<td>32.9</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>32-35</td>
<td>1.8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Over 35</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
<td>95.2</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>African American</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Asian American</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Hispanic American</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Native American</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Year of graduation</td>
<td>1986</td>
<td>6.7</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1987</td>
<td>12.1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>1988</td>
<td>13.3</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>1989</td>
<td>5.5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>17.0</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>1991</td>
<td>7.9</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>1992</td>
<td>17.0</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>1993</td>
<td>11.5</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>1994</td>
<td>9.1</td>
<td>15</td>
</tr>
<tr>
<td>Major</td>
<td>Biochemistry</td>
<td>12.1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Biology</td>
<td>31.5</td>
<td>52</td>
</tr>
<tr>
<td>Variable</td>
<td>Categories</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Major (continued)</td>
<td>Biophysics</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Botany</td>
<td>1.8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Chemistry</td>
<td>7.3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Environmental Studies</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Genetics</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Meteorology</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Microbiology</td>
<td>14.5</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zoology</td>
<td>23.6</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Biology and Environmental Studies</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Biology and French</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Biology and Microbiology</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Biology and Secondary Education</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Chemistry and Secondary Education</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zoology and Anthropology</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zoology and Health Sciences</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Zoology and Psychology</td>
<td>1.2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No indication of major</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>GPA at graduation</td>
<td>3.00 - 3.49</td>
<td>55.8</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>3.50 - 4.00</td>
<td>44.2</td>
<td>73</td>
</tr>
</tbody>
</table>
Table 8. (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Categories</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence in science study</td>
<td>No</td>
<td>32.1</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>67.9</td>
<td>112</td>
</tr>
<tr>
<td>Currently employed</td>
<td>Nonscience related job</td>
<td>5.2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Science related job</td>
<td>94.8</td>
<td>110</td>
</tr>
</tbody>
</table>

**Influence of others on science persistence**

Part one of the survey instrument was designed to determine to what extent various individuals influenced persistence in science up through the undergraduate college years. The first section provided participants with a definition of role models. Role models were considered to be individuals who were positive influences on science persistence up to and including the undergraduate college years. Participants first indicated what individuals acted as role models for them, and second, through nine fixed responses, indicated how these role models were important to their persistence. Participants also were asked to indicate whether they had received support from a spouse, or male or female companion while earning their baccalaureate degree, and to what extent this support was received.

**Role models** Almost all respondents (n = 150, 90.9 percent) believed that one or more individuals, acting as role models, were important to their persistence in science up through the undergraduate college years. High school teachers (n = 117, 70.9 percent), college
professors (n = 96, 58.2 percent), and parents were indicated most often as being positive influences. Pertaining to high school teachers, 39 percent of respondents reported being exposed only to male role models and 7 percent reported being exposed to only female role models. Pertaining to college professors, 23 percent of respondents reported being exposed only to male role models and 4 percent reported being exposed to only female role models. Although high school teachers were chosen more than any other group as exerting a positive influence on science persistence, high school guidance counselors were not (n = 16, 9.7 percent). Also, respondents saw little difference between maternal (n = 91, 55.2 percent) and paternal influences (n = 88, 53.3 percent). Friends and fellow students were considered by approximately one-third of the respondents to be role models. Teaching assistants and job supervisors were chosen by approximately one-fourth of the respondents. Spouses (n = 11, 6.7 percent), male companions (n = 23, 13.9 percent), and female companions (n = 14, 8.5 percent) were considered to be role models by only a small number of respondents. These results are reported in Table 9.

The most important reason cited regarding how role models were important for science persistence was “they were enthusiastic about the study of science” (n = 130, 78.8 percent). “Encouragement for science studies” (n = 109, 66.1 percent) and “participation in science activities” (n = 72, 43.6 percent) were also considered to be important for science persistence. Almost 40 percent (n = 65, 39.4 percent) reported that “working with role models” was important for persistence. A “role model’s success” (n = 84, 50.9 percent) and
Table 9. Role models considered to be important for science persistence through the undergraduate college years.

<table>
<thead>
<tr>
<th>Response</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school teachers</td>
<td>70.9</td>
<td>117</td>
</tr>
<tr>
<td>College professors</td>
<td>58.2</td>
<td>96</td>
</tr>
<tr>
<td>Mother</td>
<td>55.2</td>
<td>91</td>
</tr>
<tr>
<td>Father</td>
<td>53.3</td>
<td>88</td>
</tr>
<tr>
<td>Friends</td>
<td>33.9</td>
<td>56</td>
</tr>
<tr>
<td>Fellow students</td>
<td>29.7</td>
<td>49</td>
</tr>
<tr>
<td>Teaching assistants</td>
<td>26.1</td>
<td>43</td>
</tr>
<tr>
<td>Other relatives</td>
<td>24.8</td>
<td>41</td>
</tr>
<tr>
<td>Job supervisor</td>
<td>21.8</td>
<td>36</td>
</tr>
<tr>
<td>Grandparents</td>
<td>17.6</td>
<td>29</td>
</tr>
<tr>
<td>Male companion</td>
<td>13.9</td>
<td>23</td>
</tr>
<tr>
<td>High school guidance counselors</td>
<td>9.7</td>
<td>16</td>
</tr>
<tr>
<td>Female companion</td>
<td>8.5</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>7.9</td>
<td>13</td>
</tr>
<tr>
<td>Spouse</td>
<td>6.7</td>
<td>11</td>
</tr>
</tbody>
</table>

* Respondents chose all that applied, and therefore, percentages reflect the number who responded within each category.

"dedication to their work" (n = 64, 38.8 percent) were also ranked as being moderately important for influencing science persistence. These results are reported in Table 10.

**Support from significant others**  Almost 71 percent of respondents reported being either married (n = 15, 9.3 percent) or having a male (n= 97, 60.2 percent) or female
Table 10. Descriptions of how role models were important for science persistence.

<table>
<thead>
<tr>
<th>Response</th>
<th>%*</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>They were enthusiastic about the study of science.</td>
<td>78.8</td>
<td>130</td>
</tr>
<tr>
<td>They encouraged me to study science.</td>
<td>66.1</td>
<td>109</td>
</tr>
<tr>
<td>They were successful in their work.</td>
<td>50.9</td>
<td>84</td>
</tr>
<tr>
<td>They encouraged me to participate in science activities.</td>
<td>43.6</td>
<td>72</td>
</tr>
<tr>
<td>They allowed me to work with them.</td>
<td>39.4</td>
<td>65</td>
</tr>
<tr>
<td>I admired their dedication to their work.</td>
<td>38.8</td>
<td>64</td>
</tr>
<tr>
<td>They helped me with science projects.</td>
<td>28.5</td>
<td>47</td>
</tr>
<tr>
<td>They allowed me to watch them in their work.</td>
<td>25.5</td>
<td>42</td>
</tr>
<tr>
<td>I could identify with their job.</td>
<td>14.5</td>
<td>24</td>
</tr>
</tbody>
</table>

* Respondents chose all that applied, and therefore, percentages reflect the number who responded within each category.

...companion (n = 2, 1.2 percent) during the undergraduate college years. Forty seven respondents (29.2 percent) did not have any partners. Although only 38.6 percent (n = 44) of the spouses or companions were studying science, and therefore, might be considered to be strong supporters of science persistence, a much larger number of respondents (n = 96, 89.7 percent) reported receiving either moderate or strong support from their partners for their science studies.
Nonpersisters in science studies beyond the baccalaureate degree

Respondents who did not persist in science studies beyond the baccalaureate degree (n = 53, 32.1 percent) were asked to give three reasons why they believed they had not done so. Fifteen categories of responses were generated to this question. Following this question respondents were given 13 choices that could have affected their decision not to persist. These choices were answered on a Likert Scale. Next, questions were asked to solicit how marriage or the possibility of marriage affected persistence. Finally, participants were asked to respond to 12 statements related to ways in which graduate or professional schools could be changed to attract more females to study science.

Most influential factors related to failure to persist

The most common reason cited for failure to persist in science studies was “money.” Over one-third of the respondents (n = 20, 37.0 percent) indicated that “lack of money,” “cost,” or “couldn’t afford to continue” were prohibitive factors. Approximately the same number (n = 19, 35.2 percent) indicated that they either wanted to “get a job;” “interested in joining workforce;” “wanted to see what jobs were available with a bachelors degree;” “wanted to work, not continue education immediately,” or that they already had: “found a decent job;” “got a good job offer that I couldn’t pass up,” or were “busy working.” “Marriage, family, relationships, and friends” also ranked as obstacles to persistence (n = 18, 33.3 percent). Half of these respondents indicated that further study would interfere with “raising a family.” Seven of these respondents failed to persist because of their spouse or fiancee. In some cases this involved travel with a spouse, job opportunities for the spouse, or “fiancee didn’t want me to
move far away.” “Lack of information” hindered approximately 30 percent of respondents (n = 16, 29.6 percent). All of these indicated they were “not sure of what area to pursue.” Fifteen respondents (27.8 percent) considered “lack of motivation” to be a problem. “Tired of school,” “burnt out from studying,” and “tired of getting no sleep” were cited. Less significant reasons for respondents failing to persist were “lack of preparation” (n = 9, 16.7 percent) which included “grades not good enough” and “low GRE scores,” or “lack of confidence” (n = 4, 7.4 percent), “afraid I would fail a course.” These results are reported in Table 11.

**Likert Scale** Responses to 13 statements associated with failure to persist in science studies were recorded on a Likert Scale using the following points: (1) Strongly disagree (2) Disagree (3) Somewhat disagree (4) Somewhat agree (5) Agree (6) Strongly agree and (7) No opinion. Negatively worded items were recoded and responses of “no opinion” were removed prior to calculation of the mean.

Respondents agreed most strongly to the statement that their “grades were high enough to pursue further science studies” (X = 4.86), therefore, indicating that this was not the most important limitation for failure to persist in science studies. Respondents somewhat agreed to the statement that “jobs could be obtained without the need for further education” (X = 4.68). They were less inclined to agree with the statement that “money” was a limiting factor (X = 3.71). To approximately the same extent of agreement respondents indicated that “playing multiple roles” (X = 3.56) was a consideration for failure to persist.
Table 11. Categories of responses given to open-ended question related to failure to persist in science.

<table>
<thead>
<tr>
<th>Categories of responses</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money</td>
<td>37.0</td>
<td>20</td>
</tr>
<tr>
<td>Got job; job opportunities</td>
<td>35.2</td>
<td>19</td>
</tr>
<tr>
<td>Marriage, family, relationships, friends</td>
<td>33.3</td>
<td>18</td>
</tr>
<tr>
<td>Lack of information; unsure of what to study</td>
<td>29.6</td>
<td>16</td>
</tr>
<tr>
<td>Lack of motivation; tired of school</td>
<td>27.8</td>
<td>15</td>
</tr>
<tr>
<td>Lack of preparation; poor grades; poor scores</td>
<td>16.7</td>
<td>9</td>
</tr>
<tr>
<td>Graduate school characteristics (time, requirements, problems, not wanting academic route.)</td>
<td>13.0</td>
<td>7</td>
</tr>
<tr>
<td>Lack of confidence</td>
<td>7.4</td>
<td>4</td>
</tr>
<tr>
<td>Changed interest from science</td>
<td>7.4</td>
<td>4</td>
</tr>
<tr>
<td>Not interested in further education; baccalaureate degree is sufficient</td>
<td>7.4</td>
<td>4</td>
</tr>
<tr>
<td>Lack of support and encouragement</td>
<td>5.6</td>
<td>3</td>
</tr>
<tr>
<td>Location</td>
<td>5.6</td>
<td>3</td>
</tr>
<tr>
<td>Intend to pursue graduate school soon or in the future</td>
<td>5.6</td>
<td>3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5.6</td>
<td>3</td>
</tr>
<tr>
<td>Conflicted with other goals</td>
<td>3.7</td>
<td>2</td>
</tr>
</tbody>
</table>

* Percentages reflect the number who responded within each category.
Respondents disagreed somewhat that characteristics associated with graduate or professional school were limiting factors. For example, they stated that there was a "long time to degree completion" ($\bar{X} = 3.42$) and they cited "stress associated with school" ($\bar{X} = 3.29$). They were more inclined to disagree that they could not "compete with others" ($\bar{X} = 2.69$) or would "not have time to spend with family and friends" ($\bar{X} = 2.68$). Other areas in which respondents disagreed were "lack of encouragement from significant others" ($\bar{X} = 2.53$), "courses did not adequately prepare them" ($\bar{X} = 2.28$), and "loss in science interest by the senior year of college" ($\bar{X} = 2.21$). Stronger levels of disagreement were elicited to the statements that "experiences with a chilly classroom climate discouraged persistence" ($\bar{X} = 1.58$) and "graduate or professional school was mostly for males" ($\bar{X} = 1.56$). The extent of disagreement to the suggestion that a "chilly classroom climate" was discouraging was reinforced by respondents’ answers to survey question number 40. When asked "Did you ever consider changing from science to another major because of experiences with a "chilly classroom climate"?" 95 percent of respondents (both persisters and nonpersisters) answered no. These results are reported in Table 12.

**Influences of marriage and family life** The majority of respondents who failed to persist in science studies were not married at the end of their senior year of college ($n = 38, \ 73.1\ \text{percent}$). Of these, 24 (64.9 percent) indicated that the possibility of marriage did not affect their decision. When all respondents who were not married were asked to indicate their level of commitment to marriage and family life after graduation the most frequent response ($n = 12, \ 31.6\ \text{percent}$) was that they were "strongly committed." However, overall,
Table 12. Likert Scale responses to statements related to failure to persist in science.

<table>
<thead>
<tr>
<th>Survey number/item</th>
<th>Mean*</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>50. My courses did not adequately prepare me for grad/prof school.</td>
<td>2.28</td>
<td>.16</td>
</tr>
<tr>
<td>51. Grades in my science classes were high enough for grad/prof school.</td>
<td>4.86</td>
<td>1.26</td>
</tr>
<tr>
<td>52. I did not believe I could compete with students in grad/prof school and be successful.</td>
<td>2.69</td>
<td>1.32</td>
</tr>
<tr>
<td>53. My experiences with a &quot;chilly classroom climate&quot; discouraged me from considering grad/prof school.</td>
<td>1.58</td>
<td>.67</td>
</tr>
<tr>
<td>54. Lack of encouragement from significant people in my life discouraged my interest in grad/prof school.</td>
<td>2.53</td>
<td>1.41</td>
</tr>
<tr>
<td>55. I believed I could get a good job without attending grad/prof school.</td>
<td>4.68</td>
<td>1.13</td>
</tr>
<tr>
<td>56. I could not afford to go to grad/prof school.</td>
<td>3.71</td>
<td>1.66</td>
</tr>
<tr>
<td>57. I had lost some of my interest in science by my senior year of college.</td>
<td>2.21</td>
<td>1.26</td>
</tr>
<tr>
<td>58. I believed studying science in grad/prof school was mostly for males.</td>
<td>1.56</td>
<td>.78</td>
</tr>
<tr>
<td>59. I was discouraged from attending grad/prof school because of the long time needed for degree completion.</td>
<td>3.42</td>
<td>1.76</td>
</tr>
<tr>
<td>60. The time required for grad/prof school would not have detracted from time to spend with my family and friends.</td>
<td>2.68</td>
<td>1.49</td>
</tr>
<tr>
<td>61. I believed it would be too stressful to attend grad/prof school.</td>
<td>3.29</td>
<td>1.41</td>
</tr>
<tr>
<td>62. I believed I would have too many roles to juggle if I attended grad/prof school.</td>
<td>3.56</td>
<td>1.71</td>
</tr>
</tbody>
</table>

* Likert Scale Choices
(1) Strongly Disagree (2) Disagree (3) Somewhat Disagree (4) Somewhat Agree
(5) Agree (6) Strongly Agree (7) No opinion
only 47.4 percent (n = 16) were “somewhat committed,” “committed,” or “strongly committed.”

For those respondents who were married at the end of their senior year of college (n = 14, 26.9 percent) almost all (n = 11, 78.6 percent) stated that marriage affected their decision not to persist. By choosing all responses that applied from seven provided, the most common reason cited for how marriage affected their decision was “having children or desiring to have children” (n = 6, 54.5 percent). Only slightly less important were the factors “not enough time to devote to both marriage and school” (n = 5, 45.5 percent) and problems associated with the “financial aspects of further schooling” (n = 4, 36.4 percent). Three (27.3 percent) indicated that it was “not possible for both their spouses and themselves” to attend.

**Ways to attract more females to further science study**  
When nonpersisters were asked “Did you ever consider entering a science program of study in graduate or professional school?” a large number (n = 45, 86.5 percent) answered “yes, but I never attended.” Nonpersisters were then asked to indicate what could be done to attract more females to graduate or professional school. The most common response was “make it easier to attend school part-time” (n = 34, 66.7 percent). This was followed by “encouraging advisors to discuss with students the possibility of attending graduate or professional school” (n = 30, 58.8 percent). Other common responses were the need for “more financial assistance” (n = 28, 54.9 percent), “daycare” (n = 28, 54.9 percent), and the desire to have graduate courses available through “some type of video technology” (n = 27, 52.9 percent). Twenty one (41.2
percent) indicated the need to have “more work opportunities on campus.” Several respondents believed that the “time to degree completion should be shortened” (n = 18, 35.3 percent), “less research time should be required” (n = 13, 25.5 percent), and that the “number of female science professors should be increased” (n = 14, 27.5 percent). Only a very few believed that “entrance requirements” (n = 5, 9.8 percent) or “course requirements” (n = 5, 9.8 percent) should be decreased. These results are presented in Table 13.

**Persisters in science studies beyond the baccalaureate degree**

Graduates who entered professional programs of study or programs of advanced graduate studies were asked to respond to three types of questions: (1) an open-ended question asking what the three most influential factors were that helped them to enroll in further studies (2) an open-ended question asking for three reasons why they believe it is difficult for females to be successful in graduate or professional school and (3) a series of 17 statements asking for extent of agreement on participants’ experiences in graduate or professional school. This last area was measured on a Likert Scale with points identical to what was previously described.

**Most influential factors for persistence** Seventeen categories of responses were generated to this question. The most important factor for persistence was related to receiving “encouragement from others” (n = 45, 40.9 percent). Respondents predominantly indicated parents, family, and advisors as being sources of support. Almost as important as advisors were professors who “stimulated my interests & encouraged me to do grad. work.”
Table 13. Nonpersisters’ responses to changes that could be made to attract more females to study science in graduate or professional school.

<table>
<thead>
<tr>
<th>Response</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make it easier to attend school part-time.</td>
<td>66.7</td>
<td>34</td>
</tr>
<tr>
<td>Encourage advisors to discuss with students the possibility of attending graduate or professional school.</td>
<td>58.8</td>
<td>30</td>
</tr>
<tr>
<td>Offer more financial assistance.</td>
<td>54.9</td>
<td>28</td>
</tr>
<tr>
<td>Offer daycare at the graduate or professional school.</td>
<td>54.9</td>
<td>28</td>
</tr>
<tr>
<td>Make graduate courses available through some type of video technology to students who cannot attend campus classes.</td>
<td>52.9</td>
<td>27</td>
</tr>
<tr>
<td>Offer more work opportunities on campus.</td>
<td>41.2</td>
<td>21</td>
</tr>
<tr>
<td>Shorten the time to degree completion.</td>
<td>35.3</td>
<td>18</td>
</tr>
<tr>
<td>Increase the number of female professors.</td>
<td>27.5</td>
<td>14</td>
</tr>
<tr>
<td>Require less research time.</td>
<td>25.5</td>
<td>13</td>
</tr>
<tr>
<td>Lower academic entrance requirements.</td>
<td>9.8</td>
<td>5</td>
</tr>
<tr>
<td>Decrease the course requirements.</td>
<td>9.8</td>
<td>5</td>
</tr>
<tr>
<td>Other. Please specify ________</td>
<td>5.9</td>
<td>3</td>
</tr>
</tbody>
</table>

* Respondents chose all that applied, and therefore, percentages reflect the number who responded within each category.
Approximately one-third of the respondents cited a “love or interest of science” (n = 38, 34.5 percent). Most of these referred to their interest in medicine, the health sciences, human anatomy and physiology, or “classes concerning the human body.” Only three respondents cited research as their focus of interest. A similar number attributed persistence to their “choice of career” (n = 35, 31.8 percent) or “increased job opportunities” (n = 33, 30.0 percent) that would be available with further education. Specific careers were often cited: “desire to be a physician,” “have always desired to be a veterinarian,” and “desire to be a physical therapist.” Sixteen respondents specifically indicated that there were “very few job opportunities w/a B.S.” Others indirectly referred to the limitations of a bachelor’s degree: “felt I could do better if I had a higher degree,” and “career possibilities expanded.” Others expressed a desire for “more or a better education” (n = 25, 22.7 percent) as being important for persistence. Responses included “I wanted to become more specialized” and “I needed more out of my education.” “Personal motivation” was an important factor for 17 (15.5 percent) of the respondents. Some respondents were specific in why they were motivated: “desire to participate in a satisfying career,” and “my desire to be as successful as possible in a science career.” Others were more ambiguous in what motivated them: “I’ve just a gut instinct this is what I wanted to do. It makes me happy,” and “personal drive—I felt I had to go on.”

Less important factors for persistence were “influenced by others” (n = 16, 14.5 percent) and “past science experiences” (n = 16, 14.5 percent) or “successes” (n = 14, 12.7 percent). Influence came from a variety of individuals: “a history teacher gave me the
idea;" "my older brother and sister in grad/prof school--thus had been exposed to that option;" "interaction with graduate teaching assistants;" and "all my classmates were going to grad school." "Past science experiences" contributing to persistence included: being a research assistant; working with a specific type of individual (veterinarian); participating in high school science class enrichment programs, the "ISU Honors program," or a mentor program; and receiving internships. "Past science successes" were related to grades, "academic performance in undergrad," and confidence: "knew I could get PhD--had the ability;" and "I liked school and I was good at it."

Eight categories were cited by 10 percent or fewer respondents as factors related to persistence. Included in this group are "role models" (n = 6, 5.5 percent). These results are reported in Table 14.

**Difficulties in graduate or professional school** Twelve categories of responses were generated to this question. Two factors emerged as being the most significant contributors to experiencing difficulties in graduate or professional school. These were a "chilly classroom climate" cited by almost 50 percent of respondents (n = 50, 49.5 percent) and "family, marriage, children" (n = 44, 43.6 percent). Because the responses to a "chilly classroom climate" were somewhat diverse, the category was divided into 10 subtopics. Ranked from most frequently to least frequently cited these subtopics are: males respected more than females; sexism; male domination; science is a man’s world; intimidation; miscellaneous; discrimination; competition; higher expectations for females; and problems with male classmates. Examples of respondents’ comments within each subtopic follow.
Table 14. Categories of responses given to open-ended question related to persistence in science.

<table>
<thead>
<tr>
<th>Categories of responses</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouragement from others</td>
<td>40.9</td>
<td>45</td>
</tr>
<tr>
<td>Love, interest of science</td>
<td>34.5</td>
<td>38</td>
</tr>
<tr>
<td>Needed for career choice</td>
<td>31.8</td>
<td>35</td>
</tr>
<tr>
<td>Increased job opportunities</td>
<td>30.0</td>
<td>33</td>
</tr>
<tr>
<td>Wanted more education or a better education</td>
<td>22.7</td>
<td>25</td>
</tr>
<tr>
<td>Personal motivation; satisfaction</td>
<td>15.5</td>
<td>17</td>
</tr>
<tr>
<td>Influenced by others</td>
<td>14.5</td>
<td>16</td>
</tr>
<tr>
<td>Past science experiences</td>
<td>14.5</td>
<td>16</td>
</tr>
<tr>
<td>Past successes in science</td>
<td>12.7</td>
<td>14</td>
</tr>
<tr>
<td>Desire to help or work with others</td>
<td>10.0</td>
<td>11</td>
</tr>
<tr>
<td>Increased salary potential</td>
<td>9.1</td>
<td>10</td>
</tr>
<tr>
<td>Challenge; stimulation associated with college</td>
<td>8.2</td>
<td>9</td>
</tr>
<tr>
<td>Role models; mentors</td>
<td>5.5</td>
<td>6</td>
</tr>
<tr>
<td>Best option at the time</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>Money was offered</td>
<td>2.7</td>
<td>3</td>
</tr>
<tr>
<td>Female profession; high number of females</td>
<td>1.8</td>
<td>2</td>
</tr>
</tbody>
</table>

* Percentages reflect the number who responded within each category.
Males respected more than females  Comments include: “some females may feel they were a token, but not truly respected;” “not considered adept enough;” “getting less respect from the old (old school) professors and staff;” and “women not taken as seriously as men in the sciences.”

Sexism  Comments include: “sexist faculty;” “when in medical school, the men there seem to be much more sexist;” “I think there is much more sexism at this graduate level;” and “sexist remarks.”

Male domination  Comments include: “most of the professors are male;” “very few female classmates;” and “lack of female grad students (in some depts.).”

Science is a man’s world  Comments include: “females out of loop of male students and professor network;” “opportunities are provided to men more often;” “Science remains a man’s world. You have to be the best to succeed;” and “Lots of ‘boys club’ in the research world, could be hard for grants or fellowships.”

Intimidation  Comments include: “being intimidated too easily;” “male intimidation by a strong-willed, intelligent confident female;” and “there are male professors who intimidate and degrade females.”

Miscellaneous  A representative comment was “I’m often treated like a daughter by male advisor rather than a student.”

Discrimination  Comments include: “male professors of foreign ethnicity discriminate against females;” and “a few professors are biased against women-- you wouldn’t want them as a major professor.”
Competition  Comments include: “very competitive environment;” and “unhealthy attitude regarding competition.”

Higher expectations for females  Comments include: “you almost have to be twice as good as a male to be considered his equal;” and “female students more likely to be labelled incompetent than male with equal ability.”

Problems with male classmates  A representative comment was “fellow male students unable to accept or work with a female who might be as capable and intelligent as them.”

Responses to the difficulties associated with “family, marriage, and children” while in graduate or professional school were much more consistent in nature. These responses centered primarily around the issues of family and children. “Family commitments,” “desire to have children/family,” “family pressures (husbands, kids, etc.),” “balance of homelife (spouse & children) and long hours,” “its extremely difficult to start/take care of a family,” and “PhD level jobs require a commitment of time that makes it difficult to have a family--so why bother?” were typical responses. Less commonly cited was the specific problem of a husband’s job, however, a few respondents noted “for married women--pressure to follow husband to job.”

“Lack of encouragement and support” was ranked third (n = 22, 21.8 percent) regarding why it is difficult for females to be successful in graduate or professional school.
Typical responses included "may not have emotional support from family or friends," "there isn't alot of encouragement at this level," and "lack of spousal support."

Fewer respondents considered the "demands and difficulties of graduate or professional school" (n = 17, 16.8 percent), the "lack of female role models" (n = 16, 15.8 percent), and the "lack of money" (n = 15, 14.9 percent) to be difficulties associated with science persistence. Responses to the demands of further schooling included "time commitments" as being the most commonly cited. Only one respondent cited "difficult classes" and one referred to "safety issues regarding working late and long hours alone at school." The responses to "lack of female role models" were extremely consistent and for the most part were stated as such. "Financial support," "lack of scholarships available at graduate level," and "very low stipends or assistantships" were considered to be financial problems.

"Lack of confidence" (n = 8, 7.9 percent), "lack of information" (n = 7, 6.9 percent), and "lack of motivation" (n = 5, 5.0 percent) were cited by few respondents. These results are reported in Table 15.

**Likert scale** Respondents indicated their extent of agreement to 17 statements regarding their experiences in graduate or professional school. They agreed most strongly to the statement indicating that they "have been considered a valuable component of their research or study group" (X = 5.00). Other statements eliciting the strongest extent of agreement were related to: "respect shown between female students" (X = 4.78) and "between female and male students" (X = 4.72); "receiving adequate support from professors
Table 15. Categories of responses given to open-ended question related to why respondents believe it is difficult for females to be successful in graduate or professional school.

<table>
<thead>
<tr>
<th>Categories of responses</th>
<th>%*</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilly classroom climate; competition</td>
<td>49.5</td>
<td>50</td>
</tr>
<tr>
<td>Family, marriage, children</td>
<td>43.6</td>
<td>44</td>
</tr>
<tr>
<td>Lack of encouragement; support</td>
<td>21.8</td>
<td>22</td>
</tr>
<tr>
<td>Demands; difficulties of graduate/professional school</td>
<td>16.8</td>
<td>17</td>
</tr>
<tr>
<td>Lack of female role models</td>
<td>15.8</td>
<td>16</td>
</tr>
<tr>
<td>Lack of money; financial resources</td>
<td>14.9</td>
<td>15</td>
</tr>
<tr>
<td>No problems experienced</td>
<td>8.9</td>
<td>9</td>
</tr>
<tr>
<td>Lack of confidence</td>
<td>7.9</td>
<td>8</td>
</tr>
<tr>
<td>Lack of information</td>
<td>6.9</td>
<td>7</td>
</tr>
<tr>
<td>Lack of motivation</td>
<td>5.0</td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5.0</td>
<td>5</td>
</tr>
<tr>
<td>Lack of preparation</td>
<td>2.0</td>
<td>2</td>
</tr>
</tbody>
</table>

* Percentages reflect the number who responded within each category.

for research or academic efforts" (X = 4.66); having "professors who are accessible for helping students" (X = 4.58); and "students with research assistantships having an easier time finishing graduate school than students having teaching assistantships" (X = 4.55).

Agreement to the last statement indicates that respondents believe it is easier to finish graduate school if a research assistantship is given, compared to a teaching assistantship.
Respondents were slightly less inclined to agree with statements related to equality between females and males regarding: “receiving research assistantships” ($\bar{X} = 4.36$); “being included in matters affecting their departments of study” ($\bar{X} = 4.28$); “receiving respect from their male professors” ($\bar{X} = 4.16$); and “being included in attendance at regional or national professional meetings” ($\bar{X} = 4.05$).

Respondents somewhat disagreed with the statements that: “graduate financial aid was not adequate to help students maintain their college enrollment” ($\bar{X} = 3.66$); and “there is a camaraderie present between male professors and male students that is missing between male professors and female students” ($\bar{X} = 3.27$).

More disagreement from respondents was elicited to statements of: “being uncomfortable in social situations with male peers and professors” ($\bar{X} = 2.81$); receiving “unequal consideration, compared to males, for positions in research groups or other areas of study” ($\bar{X} = 2.78$); “not being respected for their research efforts” ($\bar{X} = 2.32$); and the “presence of a camaraderie present between female professors and male students that is missing between female professors and female students” ($\bar{X} = 2.26$).

The statement eliciting the strongest extent of disagreement was related to the belief that “female graduate students are more respected than males for their opinions in graduate or professional school” ($\bar{X} = 2.22$). The extent of disagreement indicates that the females of this study saw this as the biggest problem associated with graduate or professional school. These results are reported in Table 16.
Table 16. Likert Scale responses to statements related to experiences in graduate or professional school.

<table>
<thead>
<tr>
<th>Survey number/item</th>
<th>Mean*</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>71. I believe male students show respect for female students.</td>
<td>4.72</td>
<td>.98</td>
</tr>
<tr>
<td>72. I believe I have been considered a valuable component of my research or study group.</td>
<td>5.00</td>
<td>.96</td>
</tr>
<tr>
<td>73. I do not believe female students are respected for their research efforts in graduate or professional school.</td>
<td>2.32</td>
<td>1.00</td>
</tr>
<tr>
<td>74. I believe female graduate students are more respected than males for their opinions in graduate or professional school.</td>
<td>2.22</td>
<td>.80</td>
</tr>
<tr>
<td>75. I believe female and male students are included equally in matters affecting the departments in which they study.</td>
<td>4.28</td>
<td>1.10</td>
</tr>
<tr>
<td>76. I believe female and male students are treated equally in their inclusion at professional meetings at the regional or national level.</td>
<td>4.05</td>
<td>1.13</td>
</tr>
<tr>
<td>77. I believe female students show respect for female students.</td>
<td>4.78</td>
<td>.93</td>
</tr>
<tr>
<td>78. I believe I have been given adequate support from my professor for my research or other academic efforts.</td>
<td>4.66</td>
<td>1.27</td>
</tr>
<tr>
<td>79. I have not been made to feel comfortable in social situations with my male peers and professors.</td>
<td>2.81</td>
<td>1.32</td>
</tr>
<tr>
<td>80. Professors are accessible for helping students with their research or study efforts.</td>
<td>4.58</td>
<td>1.22</td>
</tr>
<tr>
<td>81. There is a camaraderie present between male professors and male students that is missing between male professors and female students.</td>
<td>3.27</td>
<td>1.47</td>
</tr>
<tr>
<td>82. The graduate financial aid given to students is not adequate to help students maintain their college enrollment.</td>
<td>3.66</td>
<td>1.65</td>
</tr>
</tbody>
</table>
Table 16. (continued)

<table>
<thead>
<tr>
<th>Survey number/item</th>
<th>Mean*</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>83. Students in graduate school with research assistantships have an easier time finishing graduate school than students with teaching assistantships.</td>
<td>4.55</td>
<td>1.21</td>
</tr>
<tr>
<td>84. Females and males equally receive research assistantships.</td>
<td>4.36</td>
<td>1.22</td>
</tr>
<tr>
<td>85. Females are not given the same consideration as males when being considered for positions in their research groups or other areas of study.</td>
<td>2.78</td>
<td>1.16</td>
</tr>
<tr>
<td>86. Females are given the same respect as males from their male professors.</td>
<td>4.16</td>
<td>1.11</td>
</tr>
<tr>
<td>87. There is a camaraderie present between female professors and male students that is missing between female professors and female students.</td>
<td>2.26</td>
<td>0.81</td>
</tr>
</tbody>
</table>

* Likert Scale Choices
(1) Strongly Disagree (2) Disagree (3) Somewhat Disagree (4) Somewhat Agree
(5) Agree (6) Strongly Agree (7) No opinion

Testing the Null Hypotheses

Thirteen null hypotheses were tested in this study. Hypotheses 1 through 6 were tested by two-way ANOVAs. Two independent variables were of interest: persistence of females for further science study after earning the baccalaureate degree, and cumulative GPA at the time of graduation. Each of these independent variables had two levels of interest chosen by the researcher. The two levels of one independent variable were persistence in further science study after earning the baccalaureate degree, or no persistence. The two
levels of the second independent variable were having graduated with distinction, or not having graduated with distinction. The six factors identified by factor analysis became the dependent variables.

**Two-way ANOVAs**

1a: There is no significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward the enjoyment of science as a discipline.

No significant difference (F = 1.583, p<.210) was found to be present between persisters in a science program of study and nonpersisters in a science program of study in the mean ratings of attitudes toward the enjoyment of science as a discipline. Therefore, the null hypothesis was not rejected.

1b: There is no significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward the enjoyment of science as a discipline.

No significant difference (F = 1.181, p<.279) was found to be present between students who graduated with distinction and students who did not graduate with distinction in the mean ratings of attitudes toward the enjoyment of science as a discipline. Therefore, the null hypothesis was not rejected.
1c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward the enjoyment of science as a discipline.

No significant interaction (F = .362, p<.548) was found to be present between persistence in science and GPA at time of graduation on attitudes toward the enjoyment of science as a discipline. Therefore, the null hypothesis was not rejected.

The results of this ANOVA are found in Appendix D.

2a: There is no significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward relationships with science professors.

No significant difference (F = .065, p< .799) was found to be present between persisters in a science program of study and nonpersisters in a science program of study in the mean ratings of attitudes toward relationships with science professors. Therefore, the null hypothesis was not rejected.

2b: There is no significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward relationships with science professors.

A significant difference (F = 10.544, p<.001) was found to be present between students who graduated with distinction and students who did not graduate with distinction in
the mean ratings of attitudes toward relationships with science professors. Therefore, the null hypothesis was rejected. Females who graduated with distinction had a significantly higher mean rating \((n = 73, \bar{X} = 4.07)\) than females who did not graduate with distinction \((n = 92, \bar{X} = 3.62)\). This indicates that females who graduated with distinction had a more positive attitude toward their science professors than females who did not graduate with distinction.

2c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward relationships with science professors.

No significant interaction \((F = .027, p<.870)\) was found to be present between persistence in science and GPA at time of graduation on attitudes toward relationships with science professors. Therefore, the null hypothesis was not rejected.

The results for this ANOVA are found in Table 17.

3a: There is no significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward self-confidence for science studies.

No significant difference \((F = 3.077, p<.081)\) was found to be present between persisters in a science program of study and nonpersisters in a science program of study in
Table 17. Two-way ANOVA for testing the factor attitude toward “relationships with science professors.”

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>.053</td>
<td>.053</td>
<td>.065</td>
<td>.799</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>8.541</td>
<td>8.541</td>
<td>10.544</td>
<td>.001</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>.022</td>
<td>.022</td>
<td>.027</td>
<td>.870</td>
</tr>
<tr>
<td>Residual</td>
<td>161</td>
<td>130.403</td>
<td>.810</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>139.037</td>
<td>.848</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

the mean ratings of attitudes toward self-confidence for science studies. Therefore, the null hypothesis was not rejected.

3b: There is no significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward self-confidence for science studies.

A significant difference (F = 21.227, p<.001) was found to be present between students who graduated with distinction and students who did not graduate with distinction in the mean ratings of attitudes toward self-confidence for science studies. Therefore, the null hypothesis was rejected. Females who graduated with distinction had a significantly higher mean rating (n = 72, $\bar{X} = 4.83$) than females who did not graduate with distinction (n = 92,
$X = 4.17$). This indicates that females who graduated with distinction were more confident regarding their science studies than females who did not graduate with distinction.

3c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward self-confidence for science studies.

No significant interaction ($F = .208, p < .649$) was found to be present between persistence in science and GPA at time of graduation on attitudes toward self-confidence for science studies. Therefore, the null hypothesis was not rejected.

The results of this ANOVA are found in Table 18.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>2.218</td>
<td>2.218</td>
<td>3.077</td>
<td>.081***</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>15.297</td>
<td>15.297</td>
<td>21.227</td>
<td>.000***</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>.150</td>
<td>.150</td>
<td>.208</td>
<td>.649</td>
</tr>
<tr>
<td>Residual</td>
<td>160</td>
<td>115.298</td>
<td>.721</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>135.422</td>
<td>.831</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** $p < .001$
4a: There is no significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward the sexist nature of the science classroom.

No significant difference ($F = .699, p<.404$) was found to be present between persisters in a science program of study and nonpersisters in a science program of study in the mean ratings of attitudes toward the sexist nature of the science classroom. Therefore, the null hypothesis was not rejected.

4b: There is no significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward the sexist nature of the science classroom.

No significant difference ($F = .000, p<.995$) was found to be present between students who graduated with distinction and students who did not graduate with distinction in the mean ratings of attitudes toward the sexist nature of the science classroom. Therefore, the null hypothesis was not rejected.

4c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward the sexist nature of the science classroom.

No significant interaction ($F = .553, p<.458$) was found to be present between
persistence in science and GPA at time of graduation on attitudes toward the sexist nature of
the science classroom. Therefore, the null hypothesis was not rejected.

The results of this ANOVA are found in Appendix D.

5a: There is no significant difference between the persisters and
nonpersisters in a science program of study on their attitudes toward the masculine
nature of the science classroom.

No significant difference ($F = 1.152, p<.285$) was found to be present between
persisters in a science program of study and nonpersisters in a science program of study in
the mean ratings of attitudes toward the masculine nature of the science classroom.
Therefore, the null hypothesis was not rejected.

5b: There is no significant difference between students who graduated with
distinction and students who did not graduate with distinction on their attitudes
toward the masculine nature of the science classroom.

No significant difference ($F = .069, p<.793$) was found to be present between
students who graduated with distinction and students who did not graduate with distinction in
the mean ratings of attitudes toward the masculine nature of the science classroom.
Therefore, the null hypothesis was not rejected.
5c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward the masculine nature of the science classroom.

No significant interaction \((F = 2.102, p<.149)\) was found to be present between persistence in science and GPA at time of graduation on attitudes toward the masculine nature of the science classroom. Therefore, the null hypothesis was not rejected.

The results of this ANOVA are found in Appendix D.

6a: There is no significant difference between the persisters and nonpersisters in a science program of study on their attitudes toward academic advising experiences.

No significant difference \((F = .773, p<.381)\) was found to be present between persisters in a science program of study and nonpersisters in a science program of study in the mean ratings of attitudes toward academic advising experiences. Therefore, the null hypothesis was not rejected.

6b: There is no significant difference between students who graduated with distinction and students who did not graduate with distinction on their attitudes toward academic advising experiences.

A significant difference \((F = 4.832, p<.029)\) was found to be present between students who graduated with distinction and students who did not graduate with distinction in
the mean ratings of attitudes toward academic advising experiences. Therefore, the null hypothesis was rejected. Females who graduated with distinction had a significantly higher mean rating (n = 73, X = 4.27) than females who did not graduate with distinction (n = 92, X = 3.75). This indicates that females who graduated with distinction were more positive toward their academic advising experiences than females who did not graduate with distinction.

6c: There is no significant interaction between persistence in science and GPA status at time of graduation on attitudes toward academic advising experiences.

No significant interaction (F = .006, p<.938) was found to be present between persistence in science and GPA at time of graduation on attitudes toward academic advising experiences. Therefore, the null hypothesis was not rejected.

The results of this ANOVA are found in Table 19.

**Table 19. Two-way ANOVA for testing the factor attitude toward “academic advising experiences.”**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>1.483</td>
<td>1.483</td>
<td>.773</td>
<td>.381</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>9.271</td>
<td>9.271</td>
<td>4.832</td>
<td>.029</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>.012</td>
<td>.012</td>
<td>.006</td>
<td>.938</td>
</tr>
<tr>
<td>Residual</td>
<td>161</td>
<td>308.866</td>
<td>1.918</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>321.231</td>
<td>1.959</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Multiple regression

Null hypothesis 7 was tested by Multiple Regression. The dependent variables used in the six ANOVAs were used as the independent or predictor variables. The dependent, or criterion variable was persistence for further science study after earning the baccalaureate degree.

7: There is no significant relationship between the mean ratings of females in science on their attitudes toward "enjoyment of science as a discipline," "relationships with science professors," "self-confidence for science studies," "sexist nature of the science classroom," "masculine nature of the science classroom," and "academic advising experiences," and their persistence to further science study after earning the baccalaureate degree.

The mean ratings of females in science on attitudes toward self-confidence for science studies and the masculine nature of the science classroom are predictors for persistence in science ($F = 5.4651, p<.0051$). However, these two factors explained only 5.19 percent of the variance. Results of the Multiple Regression are found in Appendix E.

T-test for independent means

The t-test for independent means was used to test null hypotheses 8 through 13. These tests were conducted to determine whether the two groups of persisters for further science study after earning the baccalaureate degree differed significantly from one another.
on the dependent variables used in the two-way ANOVAs. These two groups of persisters were those who continued on to advanced graduate studies and those who continued on to professional programs of study.

Before running each t-test an F-test was conducted to see if there was a significant difference between the variances of the two groups. If no significant difference is found between the variances the pooled variance estimate is used to determine the t-value. For all variances tested no significant differences were found to be present. Therefore, the pooled variance estimates were used to determine the t-values.

8: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the enjoyment of science as a discipline.

A significant difference \([t(106) = -2.84, p<.005]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in the mean ratings of attitudes toward the enjoyment of science as a discipline. Therefore, the null hypothesis was rejected. Graduates who pursued academic programs of study had a significantly higher mean rating (\(X = 4.6844\)) on attitudes toward the enjoyment of science as a discipline than did graduates who pursued professional programs of study (\(X = 4.2532\)). Because the survey questions for this
construct were related to the laboratory, these responses indicate that females who entered programs of advanced graduate studies enjoyed working in the laboratory to a greater extent than did females who entered professional programs of study.

The results of this t-test are found in Table 20.

Table 20. T-test results examining differences between two groups of science persisters on the factor attitude toward the “enjoyment of science as a discipline.”

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t-value</th>
<th>df</th>
<th>2-tail p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional program</td>
<td>63</td>
<td>4.2532</td>
<td>.765</td>
<td>-2.84</td>
<td>106</td>
<td>.005</td>
</tr>
<tr>
<td>Advanced graduate</td>
<td>45</td>
<td>4.6844</td>
<td>.796</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward relationships with science professors.

No significant difference \([t(106) = .62, p<.539]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward relationships with science professors. Therefore, the null hypothesis was not rejected.

The results of this t-test are found in Appendix F.
10: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward self-confidence for science studies.

No significant difference \([t(106) = .32, p<.751]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward self-confidence for science studies. Therefore, the null hypothesis was not rejected.

The results of this t-test are found in Appendix F.

11: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the sexist nature of the science classroom.

No significant difference \([t(105) = -.22, p<.823]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the sexist nature of the science classroom. Therefore, the null hypothesis was not rejected.

The results of this t-test are found in Appendix F.
12: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the masculine nature of the science classroom.

No significant difference \([t(106) = .23, p<.820]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward the masculine nature of the science classroom. Therefore, the null hypothesis was not rejected.

The results of this t-test are found in Appendix F.

13: There is no significant difference between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward academic advising experiences.

No significant difference \([t(106) = -1.00, p<.321]\) was found to be present between graduates who pursued advanced graduate studies in science and graduates who pursued professional programs of study in science in their mean rating of attitudes toward academic advising experiences. Therefore, the null hypothesis was not rejected.

The results of this t-test are found in Appendix F.
Summary

This chapter described how preliminary analysis of the data was undertaken and also stated the results of both descriptive analysis of the data and the testing of the null hypotheses. Inferential tests included two-way ANOVAs, multiple regression, and t-tests for independent means. Six two-way ANOVAs were tested. The two independent variables were persistence in science and cumulative GPA at the time of graduation with the bachelor's degree. The dependent variables emerged as a result of the factor analysis and became the following constructs: academic advising experiences; enjoyment of science as a discipline; relationships with science professors; self-confidence for science studies; masculine nature of the science classroom; and sexist nature of the science classroom. Three null hypotheses were rejected based upon these tests. Significant differences were found between females who graduated with distinction and those who did not graduate with distinction for the factors: relationships with science professors; self-confidence for science studies; and academic advising experiences. Females who graduated with distinction demonstrated more positive attitudes toward relationships with science professors and their academic advising experiences, and were more confident regarding their science studies. The six factors that emerged from the factor analysis also were used in a multiple regression equation to determine if they were predictors for persistence in science. The factors of attitudes toward self-confidence for science studies and the masculine nature of the science classroom entered the equation as predictors although they explained only a small percent of the variance. Six t-tests for independent means were also conducted to determine if females
who persisted in science to advanced graduate studies differed significantly on the six factors from females who persisted to professional programs of study. These two groups of females differed significantly on one of the six factors. Females who pursued advanced graduate studies enjoyed working in the laboratory to a greater extent than did females who pursued professional programs of study. The next chapter will discuss these findings.
CHAPTER V

SUMMARY AND DISCUSSION

Purpose and Organization of the Study

This chapter provides a brief review of the purpose and organization of the study. Research findings are then discussed and conclusions from these findings are stated. The chapter ends by listing contributions to the research, implications and recommendations, limitations of the study, and suggestions for further research.

The purpose of this research project was to clarify the significance of previously identified barriers to women's participation in science, to introduce a factor not previously studied in the type of student used for this research project, and to address some of the limitations of previous research projects. Although there have been many factors identified that are believed to be associated with the persistence of women in science, the research results at times are inconclusive and there appear to be some potentially important factors that have been overlooked. Also, as the literature review indicated there are few studies on females who persisted in science through the baccalaureate degree, but who failed to persist in science to graduate or professional school.

With these considerations in mind this research project was undertaken to accomplish these specific purposes, as previously stated in Chapter I: (1) To examine the importance of role models and significant others in the persistence of successful females in science in progress toward earning their undergraduate degrees; (2) To identify and characterize
reasons why successful females in science fail to persist in science beyond the baccalaureate degree; (3) To identify factors nonpersisters believe could help attract more females to persist in science beyond the baccalaureate degree; (4) To determine the extent to which successful females in science enroll in programs of further science study after earning the baccalaureate degree; (5) To identify factors that were most influential in helping successful females in science to persist in science studies beyond the baccalaureate degree; (6) To identify factors that persisters believe make it difficult for females to be successful in graduate or professional school; (7) To identify experiences in graduate or professional school in science that could hinder persistence of females in science while they are enrolled in these programs; (8) To determine if there are any significant differences between two groups of science graduates: persisters and nonpersisters, and those graduating with distinction or not graduating with distinction, on each of six factors related to undergraduate experiences, and to determine whether persistence and GPA have a combined effect on each of these six factors; (9) To determine if these six factors could be used to predict persistence in science; and (10) To determine if there are any differences between females who pursued advanced graduate studies and females who pursued professional programs of study on the six factors related to undergraduate experiences.

The research population for this study consisted of females who graduated from Iowa State University from 1986 through the summer of 1994 with undergraduate degrees in various biological and physical science majors from the College of Liberal Arts and Sciences. Specifically, these were females who were American educated in years prior to
entrance to college and who graduated with a 3.00 or higher cumulative GPA. Because of
the high GPA these graduates were considered to be “successful” females in science.

The research sample consisted of sampling the entire research population. A total of
219 females made up the sample. Of these, six mailings did not reach their destinations. A
total of 165/219 surveys were returned and deemed usable, therefore, constituting a return of
75 percent.

Data for this research project were collected through the use of a survey instrument.
Several factors associated with science persistence through the undergraduate college years
were studied. These factors included: “influences of others on science persistence”;
“academic advising experiences”; and “experiences in the science classroom.” “Experiences
in the science classroom” was divided into the factors of: “enjoyment of science as a
discipline”; “relationships with science professors”; “self-confidence for science studies”;
and “chilly classroom climate.” “Chilly classroom climate” was further divided into the two
factors of “nature of the science classroom” and “sex discrimination in the science
classroom.” The factor “enjoyment of science as a discipline” represented a new factor not
previously identified in the literature for the type of student studied in this research project.

All participants in the study were asked to respond to these areas of questioning.

The use of factor analysis resulted in two of the originally intended constructs or
factors being changed. The construct “sex discrimination in the science classroom” was
changed to the new construct “masculine nature of the science classroom” and a working
definition was developed for the new construct. The construct “nature of the science
classroom” was changed to the new construct “sexist nature of the science classroom” and another working definition was developed for this new construct.

One survey question was used to divide respondents into two groups. These groups consisted of females who failed to persist to graduate or professional school and those who did persist to graduate or professional school. After this division each group was studied separately. Females who did not persist were asked to cite the three most influential factors for their lack of persistence, to respond to 13 statements concerning their decision not to attend graduate or professional school, to respond to questions concerning their commitment to marriage and family, and to respond to statements associated with factors that could be changed to attract more females to study science in graduate or professional school. Females who had persisted were asked to identify the three most influential factors that helped them to make the decision to enroll in graduate or professional school, to identify three reasons they believed make it difficult for females to be successful in graduate or professional school, and to respond to 17 statements associated with their graduate or professional school experiences. Information was also gathered on the types of programs the persisters entered into in graduate or professional school.

All respondents in the study were asked to provide demographic information. Included in this survey area was a question which allowed for the respondents to be divided into two groups based upon their bachelor’s degree cumulative GPA. One group became those graduating with a 3.50 or higher GPA. These students are considered to have graduated “with distinction.” The other group included females who graduated with a GPA
of 3.00 to 3.49, and therefore, although considered to be “successful” females in science for this study had not graduated with distinction.

**Discussion**

The discussion section is organized according to the purposes of the study as stated in Chapter I. Each purpose is restated here and a discussion follows. Summaries are found at the end of some sections.

**Purpose 1: To examine the importance of role models and significant others in the persistence of successful females in science in progress toward earning their undergraduate degrees**

One factor believed to positively influence science persistence is exposure to various types of role models. For this study participants were provided with a definition of a role model and were asked to indicate which individuals were important for their persistence in science. The definition provided was “Individuals such as high school teachers or counselors, college professors, parents, relatives, friends, or others who have exhibited personality traits, behaviors, and attitudes that have been positive influences on your persistence in science.” The definition was framed in the context of participants’ exposure to role models up to and including their undergraduate college years.

There was a strong response to this area of questioning as almost every respondent (91 percent) believed they had been exposed to one or more role models. The overwhelming
choice for type of role model was high school teachers, where almost 71 percent of respondents chose this category. This was followed by college professors, chosen by 58 percent of respondents.

These types of choices by science graduates help to support a theme expressed by participants of a "Workshop on Diversity in Biological Research" ("Diversity in," 1991), and to support proposed interventions for increasing the number of women and minority students in science and engineering as stated in a recent report produced by a National Governors’ Association study ("Getting Women," 1994). This report recognized the importance of role models as it identified actions that could be undertaken by governors to increase the participation of women and minorities in science. One area cited for intervention was the high schools where lack of professional role models, specifically females and minorities, was seen as a barrier to science and engineering participation.

In July of 1991 a "Workshop on Diversity in Biological Research" was convened to provide answers to questions posed by the NSF ("Diversity in," 1991). Minority scientists who were participants of the workshops were charged with providing advice on how to increase the number of minorities in science and engineering. One recurrent theme expressed by participants was the significance of mentorship which was linked to the importance of role models. Specifically, these minority scientists focused on teachers at all levels in the educational process. Unfortunately, however, because mentorship requires both an expenditure of time and energy, participants noted that incentives to become an active mentor are often lost at the college level. They linked this to science faculty being driven by
the amount of grant dollars received, and the number of papers published, rather than investing time and energy into becoming effective mentors, and therefore, acting as role models for aspiring scientists.

Even if these barriers to faculty acting as role models could be diminished, another issue related to sex of the role model, emerges. Both Shapiro et al. (1978) and Berg and Ferber (1983) recognized the importance of same sex role models. Shapiro et al. (1978) believed that female role models act to facilitate the progress of women entering male dominated professions by helping aspiring women to resolve the issues of feminine self-concept and professional identity. Berg and Ferber (1983), studying male and female graduate students concluded that females are at a disadvantage in finding mentors or role models. This was related to their finding that students interact most comfortably with faculty of the same sex, but in all the science areas they studied the number of male faculty members was greater than the number of female faculty members.

Not surprisingly, the respondents of the present study indicated that they were exposed to more male than female role models who were high school teachers and college professors. This was true for females who reported being exposed to either female or male role models, but not both. In high school, approximately 39 percent of respondents reported being exposed to only male role models and 7 percent reported being exposed to only female role models. For college, differences also existed between sexes, with approximately 23 percent of respondents being exposed to only male role models and 4 percent being exposed to only female role models. However, although differential exposure to role models existed
for some participants of this study, these successful females chose to stay in science and earn undergraduate degrees. Therefore, it appears that for these females the sex of role models acting as educators is not seen as a barrier to completion of undergraduate science degrees, but because of the percentage who reported being exposed to these types of role models, their presence appears to be important for undergraduate science persistence.

Slightly over half of respondents also saw their parents as role models, with maternal influences (55 percent) being only slightly greater than paternal influences (53 percent). In a similar study to the present one, regarding the study of high achieving women, Fitzpatrick and Silverman (1989) demonstrated that fathers acting as role models and providing support were important for the selection of a daughter's engineering career, but they were less important for the selection of a science career. Also compared to the present study, a study by Sax (1992) of college freshmen demonstrated a difference between the influence of mothers and fathers on science persistence. Because Sax demonstrated that the engineering career of a father, but not a research scientist career of a mother predicted science persistence, Sax speculated that fathers acting as mentors or role models may influence science persistence. The present study, however, although not linking parents' careers to science persistence beyond the bachelor's degree demonstrated for slightly over one-half of the respondents an almost equal influence from mothers and fathers, who by acting as role models, facilitated science persistence through the undergraduate years.

Findings of the present study indicate that friends, fellow students, teaching assistants, and job supervisors were seen as role models by one-third or fewer respondents.
Even less important were male and female companions, high school guidance counselors, and spouses.

When participants were asked to indicate how role models were important to their persistence in science the most frequently selected response was "they were enthusiastic about the study of science" (79 percent). "Encouragement for science studies" (66 percent) and a "role model's success" (51 percent) followed next. For some respondents, being encouraged to "participate in science activities" (44 percent) or "working with role models" (39 percent) were important for science persistence. Role models, therefore, appear to be most important to females in the present study because of their expression of enthusiasm for their work. Encouragement for science studies and participation in science activities also appear to be important. Science educators of all levels are in a particularly important position to convey these messages to their students and to carry through on these messages by providing opportunities for their students to participate in science activities. Parents, because of the presumed close ties to their daughters are in a unique position to also convey these messages, but unless they themselves are in science careers, or can offer access to science opportunities, may need advice and guidance on how to best support their daughters' interests in science.

The findings of the present study regarding the issues of role models and mentors should be considered important contributions to our understanding of science persistence in women, at least through the undergraduate college years. As the 1991 "Women in Science and Engineering" report emphasized ("Women in Science," 1991), most research on
mentoring has been undertaken on disciplines other than science and engineering. Also, although many different professional societies and institutions assert the importance of mentoring, it is not known how important this actually is for science and engineering students. It appears that much of what is believed has not been substantiated through quantitative research, but mainly comes from anecdotal evidence. Therefore, the present study helps to provide supporting evidence for, perhaps, previously unsupported contentions.

Besides being interested in the influence of role models on science persistence the present study also gathered data to determine if "significant others" were important for science persistence during the undergraduate years. Almost three-fourths of respondents reported either being married or having a male or female companion at that time. For females of this study it may not have been as important for them to have their "significant others" also studying science as it was to receive support from them. While only 39 percent of "significant others" were also studying science in college, 90 percent of respondents believed that they had received either moderate or strong support from them for their science studies. Therefore, support from "significant others" appears to be a factor facilitating persistence in science for the successful females of this study, more so than having their spouses or companions also be science students.
**Purpose 2:** To identify and characterize reasons why successful females in science fail to persist in science beyond the baccalaureate degree

Of the 165 participants of this study, 53 (32 percent) failed to persist in science beyond the bachelor’s degree. In the open-ended question designed to solicit why these females failed to persist, 15 categories of responses could be distinguished from one another. Categories receiving the highest number of responses were related to “financial difficulties” (37 percent), “jobs” (35 percent), and “marriage, family, relationships, and friends” (33 percent).

Although the issue of financial aid is often cited as a barrier to science study beyond the bachelor’s degree (Ethington & Smart, 1986; Hornig, 1987; “Women in Science,” 1991), the literature review for this research project found that almost all studies assessing the impact that financial aid has on graduate school enrollment are performed on either current or former graduate students. The present study is important because it includes students who failed to persist in further science studies and, therefore, it allows these students’ perceptions of financial aid access to be studied. The findings of the present study concur with the one other study that also included nonpersisters. Ethington and Smart (1986), using longitudinal CIRP data from 1971 and 1980 found that financial aid was one of the two most important variables to impact graduate school enrollment. Therefore in the present study, as in the Ethington and Smart study, lack of money or financial aid was seen as the foremost barrier to science persistence.
The second ranked category, related to jobs, encompassed two types of responses. That is, females did not persist in science because they either were interested in obtaining employment or they already had found a job. The issue of job availability for science undergraduates has been given slight attention in past research studies. Two studies were found that addressed the issue of job opportunities for science students, but neither were in conjunction with science persistence beyond the bachelor’s degree. For females of this study, however, the issue of jobs ranked almost as high as financial aid and, therefore, should be considered one of the stronger barriers to science persistence. It is possible that this finding is linked to the issue of financial aid need although a possible link was not studied for this research project.

The factor of role conflicts as a barrier to science persistence emerged through respondents’ answers in the category of “marriage, family, relationships, and friends.” This category ranked third in significance for why there was failure to persist in science. Half of these responses were related to the issue that further education would interfere with raising a family.

In another part of the survey nonpersisters were questioned regarding their marital status, their commitment to marriage and family if not married, whether marriage affected their decision not to pursue further study, and if it did, how marriage affected their decision. Of the 27 percent who were married during the senior year of college almost 80 percent believed that marriage affected their failure to persist. When asked why, these individuals most frequently responded that “having children or desiring to have children” and “not
enough time to devote to both marriage and school” were barriers to persistence. These concerns were placed above the “financial aspects of further schooling” and “it was not possible for both spouse and myself to attend graduate or professional school.” Interestingly, for the majority who were not married (73 percent) 65 percent did not believe that the possibility of marriage influenced their failure to persist, although 47 percent reported being either strongly committed, committed, or somewhat committed to the possibility of marriage and family life at the time of their senior year in college.

These findings are important because they add to the body of knowledge regarding possible role conflicts between the factors of marriage and children, and science persistence. As noted earlier in this paper, most studies in this area are related to marriage rates, divorce rates, and stress in various types of students, in various majors, and at the graduate level. Fewer studies have been done on undergraduates addressing specifically what concerns might be present.

Kallio (1995) stated that institutions of higher education have downplayed the importance that students place on the need to factor into their career plans those of their spouse or partner. She considered a major finding of her study on students admitted to masters’ and doctoral programs to be the need and desire of students to factor in spouse or partners’ needs. Kallio believed that most institutions force students to solve such dilemmas themselves, rather than helping students to do so. Attention paid to the work plans of the spouse, Kallio stated, could help departments recruit graduate students.
Two studies have been found which are most related to the present one, although neither are related to science persistence beyond the bachelor’s degree. The Sax study (1992) on college freshmen demonstrated that placing a priority on raising a family as a life goal was negatively related to science persistence. Ware and Lee (1988), in a study of high ability college females found that concern for personal life and future family inhibited the choice of a science major. It is obvious that more research needs to be undertaken on college seniors to determine if the findings of the present study can be duplicated.

“Lack of information” as a reason for failure to persist was cited by 30 percent of respondents. In all cases the responses referred to problems related to not knowing what to study. This type of barrier to persistence should be remedied with proper intervention strategies. The most obvious disseminators of information on advanced study areas in science are college advisors and professors, although high school teachers and counselors could provide information earlier in the educational process. Past research provides mostly indirect evidence regarding guidance on pursuing advanced science studies. Kahle (1983) found that high school biology teachers were considered to be important sources of career information by their former biology students who were currently studying science in college. Unfortunately, high school guidance counselors were seen as less helpful than teachers, friends, and family members. Fitzpatrick and Silverman (1989) concluded that high school teachers exerted strong positive influences on the career choice of science majors, whereas Ware and Lee (1988) considered one of the most important findings of their study on college
females to be a negative association between choice of a science major and being influenced by high school staff regarding college plans.

Most closely related to the present study is one by Manis (1989). When college counseling was studied Manis found that females in science believed the counseling process was too impersonal and not helpful to the student for developing individual courses of study. The issue of advising will also be addressed in a later section.

One category not likely to be corrected by intervention strategies is “lack of motivation.” Respondents in this category (28 percent) were “tired of school, studying, and late hours.” As might be expected “lack of preparation” (17 percent), “lack of confidence” (7 percent), and “changed interest from science” (7 percent) were all chosen by a small number of respondents. It is also important to note that graduate school characteristics such as course requirements and time commitments were only perceived by 13 percent of respondents as being barriers to persistence. The “rigors of further education,” therefore, were seen by only a few as being a barrier to science persistence.

After the open-ended question nonpersisters were asked for their extent of agreement on 13 statements related to their failure to persist in science. Respondents agreed most strongly to the statement that their “grades were high enough to pursue further science studies” (X = 4.86), although their extent of agreement was not particularly strong according to this position on the Likert Scale. Associated with this was their failure to agree that “courses did not adequately prepare me” (X = 2.28) or that they could not “compete with others in graduate or professional school and be successful” (X = 2.69). These perceptions
of ability and academic preparation are important factors to consider for science persistence because as DeBoer hypothesized (1984), females develop beliefs about their science competency in high school and this sense of competency affects future decisions about participation in science.

The findings of the present study should be considered important because unlike most others it addresses the issue of whether females who have already earned undergraduate degrees in science believe they are capable of being successful in graduate or professional school. The majority of past research has either not focused on the college senior or has focused on sex differences in academic ability.

Two studies related to the present one indicate the importance of these findings. Berg and Ferber (1983) found that in graduate students females believed to a greater extent than males that “ability to handle the work” is an important factor when choosing a college major. In another study, impressive because of its size, over 27,000 college freshmen were studied in 1985 and followed up four years later (Astin & Astin, 1992). One of the most important findings of this study was that academic performance in college was closely associated to aspirations for advanced degrees.

In the present study, therefore, respondents by agreeing most strongly with the statement that their “grades were high enough,” and by disagreeing that they could not “compete with others,” and were not “adequately prepared for further study” have demonstrated that a sense of competency and academic preparation for science persistence exists in these successful females. Therefore, for these females, these factors do not appear
to be barriers to science persistence when interpreting these findings alone. However, the issue of self-confidence will be further addressed in a later section.

Responses to a few of the remaining statements measured on this Likert Scale followed to some extent the responses to the open-ended question asking why there was a failure to persist. However, the next two rankings were reversed in order of importance. The second most agreed to statement on the Likert Scale was that "jobs could be obtained without the need for further education" (X = 4.68). This ranked second in the open-ended question. However, the next highest ranked question falling in the area of "somewhat disagree" on the Likert Scale was that "money" was a limiting factor (X = 3.71). This ranked first in the open-ended question as a barrier to persistence. Although the open-ended question and Likert Scale responses varied in the ranking of barriers to persistence, this discrepancy does not appear to be significant because the issue of "jobs" and "financial difficulties" varied less than two percent, by frequency of response, in the open-ended question.

"Juggling multiple roles" ranked as the third most significant barrier to persistence in the open-ended question and ranked fourth in extent of agreement on the Likert Scale response (X = 3.56). The Likert Scale responses measuring graduate or professional school barriers (long time to degree completion, X = 3.42; and stress of school, X = 3.29) were ranked in the area of "somewhat disagree." Respondents disagreed to a greater extent that "not enough time to spend with family and friends" (X = 2.68), "lack of encouragement from significant others" (X = 2.53), and "loss in science interest by the senior year of college"
(X = 2.21) were barriers to science persistence.

The two statements eliciting the strongest level of disagreement were “experiences with a chilly classroom climate discouraged persistence (X = 1.58) and “graduate or professional school was mostly for males” (X = 1.56). For both of these respondents “strongly disagreed.” Earlier in the survey participants were provided with a definition of a “chilly classroom climate” and, therefore, by this point in the survey they were aware of how this was to be interpreted. The definition provided was “The climate that exists in the science classroom which causes a decrease in female student interest in science, leads to anxiety in females, is considered by females to be a form of sexism, or can cause females to consider changing majors, or to terminate their studies in college.” This definition was designed not only to take into account the issue of sexism, but to also include the factors associated with a competitive science classroom.

The extent of this level of disagreement becomes even more evident when these results are considered together with the results of another question about the “chilly classroom climate.” Although answered by both nonpersisters and persisters, participants, when asked if they had ever considered changing from science to another major because of “chilly classroom climate” experiences, overwhelmingly answered no. Ninety five percent of all respondents answered this way. It was not determined if the remaining five percent persisted in science or not.

Although several studies provide data to support the contention that the issue of sexism is an important issue in the science classroom it was unclear from the literature
review whether or not sexism has a significant enough effect on female college seniors to prevent their persistence in science. The findings of the present study, when using data from the open-ended question on reasons for failure to persist, the Likert Scale questions for nonpersisters, and the question for all participants specifically asking about persistence as it is related to a "chilly classroom climate" failed to demonstrate that a "chilly classroom climate" was a barrier to persistence during the undergraduate years, and for science persistence beyond the bachelor's degree. The extent of disagreement to the statement that "graduate or professional school was mostly for males" also demonstrates that this is not a barrier to persistence for the nonpersisters of the present study.

These findings of the present study conflict with some past research findings. McNamara and Scherrei (1982), in their study of college freshmen, found that to some extent movement through the science and engineering pipeline is somewhat restricted to the perception that science, mathematics, and engineering are masculine in nature. Kahle (1983), studying high school students, concluded that these areas are seen as being masculine in nature. Jackson (1989) and Brush (1991) discussed the damaging effects of a "chilly classroom climate" on science persistence. Recall that Tobias (1990), in her unusual approach to studying this factor concluded that the science classroom was an unfriendly and nonmotivating type of environment. Both the studies of Ware et al. (1985) who studied college freshmen, and Boisset (1989) who studied college students found that failure to find science courses enjoyable and interesting were obstacles to persistence for the undergraduate years. Frazier-Kouassi (1992), analyzing three studies at the University of Michigan stated
that females, in general, who were Honors mathematics students found a competitive atmosphere more harmful than did males. The Manis study (1989), however, comes closest to the present study for type of population studied. This study on college seniors found that more females than males found the science classroom unfriendly.

The findings of the present study are therefore, important, because by sampling only females who have earned undergraduate science degrees in selected majors data are yielded for a population seldom studied. For these successful females who are the ones most likely to persist in further science studies, but failed to do so, the "chilly classroom climate" issue was not found to be a barrier to their persistence in science.

In summary, the Likert Scale responses demonstrate some surprising findings. Two of these are related to the strong extent of disagreement to the "chilly classroom climate" statement and to the statement that advanced studies in science are mostly for males. When considered along with other findings it has been demonstrated that these factors are not seen as barriers to persistence for the nonpersisters of this study. The issue of the "nature of the science classroom," however, will be discussed in a later section of this paper. Another finding that is somewhat surprising is that self-confidence for advanced science studies is not higher in nonpersisters, considering their academic successes as undergraduates. Therefore it is difficult to understand, using this question alone, if nonpersisters have enough self-confidence for further science studies. The small number citing lack of confidence in the open-ended question, however, indicates that they do. This issue will be further clarified in a following section in light of another finding of the present study. Responses to "not enough
time to spend with family and friends," "lack of encouragement from significant others," and "loss of science interest" indicate that these are not seen as barriers to persistence for the respondents of this study. The perception that jobs could be obtained without advanced study can be seen as a barrier to persistence when this is interpreted with the findings in the open-ended question. As well, the same is true for financial considerations and multiple role playing. The rigors of advanced schooling should not be interpreted as a barrier to persistence if responses to the open-ended question are considered, along with responses discussed in the following section.

**Purpose 3: To identify factors nonpersisters believe could help attract more females to persist in science beyond the baccalaureate degree**

Nonpersisters were also asked "Did you ever consider entering a science program of study in graduate or professional school?" Eighty seven percent indicated "yes, but I never attended." When nonpersisters were asked what changes could be made to attract more females to study science in graduate or professional school it became evident that most did not believe academic standards should be changed. Only 10 percent believed that "entrance requirements" and "course requirements" should be lowered. Over half of the respondents, however, considered other issues associated with access to be important barriers to persistence. The item chosen most frequently was "make it easier to attend school part-time" (67 percent). This, as well as making course work available through "some type of video technology" (53 percent) indicate that other responsibilities make it difficult for these
females to consider attending graduate or professional school on a full-time basis. These responsibilities may include family and children because 55 percent of respondents believed that day care should be provided at school. The need to maintain a job, or balance work and school hours also appear to be important. Fifty five percent of respondents believed more financial assistance should be available and 41 percent indicated the need to have work opportunities available on campus.

Aspects of graduate or professional school that are somewhat less important to the nonpersisters, and are less likely to be reformed, involve characteristics of the advanced programs of study. Approximately one-third of the respondents believed that the length of the program of study should be shortened and approximately one-fourth believed that research time should be shortened. When reform in science education is discussed, however, changes at the graduate level are generally not considered. "The great preponderance of efforts," as Sheila Tobias stated (Tobias, 1992, p. 16), is at the undergraduate level where reform in science education is on teaching techniques and course materials with the intention of retaining students in science through the undergraduate years. Based on the literature it does not appear that anyone has asked, nor has listened to those students who have earned their undergraduate degrees in science, but failed to persist, and who, therefore, are the obvious candidates to consider advanced studies in science. The question becomes, then, "how much change is higher education willing to tolerate to bring these ‘lost’ students into advanced programs of study?"
Two types of responses were disturbing because they are capable of being reformed, but yet apparently were not in place for the nonpersisters of this study. Almost 60 percent of respondents believed that advisors should be encouraged to “discuss with students the possibility of attending graduate or professional school.” Again, as cited earlier, a lack of information has been demonstrated to be a weak link in the educational system for the females of this study. Also, 28 percent of respondents indicated that an increase in the number of female science professors would be helpful.

To summarize, nonpersisters indicated that the standards for entrance and the course requirements in graduate or professional school should remain high. However, they saw the need for reform at various levels: better dissemination of information on further study opportunities; easier course availability; more financial assistance; child care opportunities on campus; decreased time requirements for degree completion; and an increase in the number of female professors.

**Purpose 4: To determine the extent to which successful females in science enroll in programs of further science study after earning the baccalaureate degree**

Of the 165 participants of this study, 112 (68 percent) continued their education beyond the bachelor’s degree with none entering areas of study outside of science. Characteristics of these persisters include the following: 33 (30 percent) had earned or were currently studying to earn masters’ degrees; 71 (64 percent) had earned or were studying to earn degrees other than masters’ degrees; 2 (2 percent) quit doctoral programs of study
before earning any advanced degree (one will return to her program of study); and 6 (5 percent) pursued science, but not at an advanced level of study. These were second bachelors’ degrees. Of these 112 persisters, 63 (56 percent) had entered professional programs of study, which included the areas of veterinary medicine, medical school, dentistry, physical therapy, physicians assistant, pharmacy, medical technology, and nursing. The majority of this group of persisters (N = 32, 51 percent) entered the field of medicine. Forty five respondents (40 percent) pursued advanced graduate studies by entering either masters’ or doctoral programs of study or both. Of these, 26 pursued doctoral programs of study. For 4 respondents (4 percent) their programs of study could not be determined. Removing the six respondents who did not pursue advanced studies in either graduate or professional school, the total persistence rate can be adjusted to show that 106/165, or 64 percent, persisted in science at advanced levels of study.

These figures on persistence can be compared to figures obtained from other studies, although at best only indirect comparisons can be made. One way to consider the number of persisters in this research project is to reexamine the issue of the natural science and engineering pipeline as it was determined for high school sophomores in 1977. This has become the model upon which projections for persistence, and therefore, projections for the number of future scientists and engineers frequently have been made. Of 730,000 high school sophomores interested in science and engineering in 1977, 206,000 earned bachelors’ degrees in these areas by 1984, 61,000 were projected to enter graduate school in these areas, 46,000 were projected to earn masters’ degrees, and only 9700 were projected to earn PhDs
The persistence rate from the bachelor's degree to graduate school of 30 percent, and from the bachelor's degree to PhD of 5 percent. In comparison, for the present study when using the adjusted figures it can be determined that 45/165 participants entered programs of advanced graduate studies in science at the masters, PhD level, or both. This represents a lower retention rate to graduate school, 27 percent, than the pipeline projection. However, the pipeline model takes into account males and females and it has been demonstrated that males persist at a higher rate than do females. Also, students of various levels of academic achievement are included and the pipeline figures include majors not included in the present study such as mathematics, computers, and engineering. However, when only the number pursuing doctoral programs of study is considered, that is 26 females, the persistence rate from the bachelor's degree to PhD is 16 percent. This is over three times higher than what the pipeline model projects for persistence from the bachelor's degree to PhD.

Another means of comparison is offered by the findings of the longitudinal study by Astin and Astin (1992) on over 27,000 college freshmen, initially studied in 1985 and again in 1989. These researchers found that approximately 19 percent planned to attend either graduate or professional school. For the present study, again using the adjusted figures, 106/165, or 64 percent actually persisted to graduate or professional school.

Astin and Astin (1992) also found that students in the biological sciences are more likely than others to enter graduate school immediately after earning undergraduate degrees. In their study, 41 percent planned to do so. Their finding may partially explain the
persistence of females for the present study. That is, graduates with biology majors represented the most frequent type of persister, with 32 percent reporting this as a major.

Using figures of degree attainment for women as provided by the NSF (Matthews, 1990) the findings on persisters in the present study can be compared in yet another way. The NSF cited total science figures for women which included the areas of physical, computer, environmental, and life sciences, psychology, social sciences, and mathematics. If only the physical, environmental, and life sciences are considered the number of women earning bachelors’ degrees in 1988 totaled 30,872. In 1986, 4984 women earned masters’ degrees, and in 1988, 2390 women earned PhDs in these selected areas. Although these figures represent only attainment rates for selected years and not figures for a selected cohort of females who are followed from the bachelor’s degree to the PhD, it is likely that these figures relative to one another are similar to figures today. Therefore, considering the masters’ and PhD attainment figures together it might be projected that 7374/30,872 women, or 24 percent of those earning bachelors’ degrees in these areas persist to earn advanced degrees. Of course, this reasoning can only hold true if considerations are made for women entering these fields of study from other areas. As Astin and Astin (1992) discovered, however, 75 percent of graduate students in the biological and physical science areas come initially from these same areas. These figures and others obtained by these researchers led them to conclude that science is essentially a “one-way” street. That is, disciplinary boundaries are strong in the science, math, and engineering fields, and few students will enter graduate school in these areas from nonscience areas.
The number of females in the present study who entered professional programs of study should also be considered in light of other findings. Although 63 respondents could be identified as belonging to this category of persisters recall that 5 did not pursue professional programs of study at an advanced level (bachelor of nursing, n = 1; medical technology, n = 4), therefore, leaving 58 in the group intended to recognize only those who advanced in educational level beyond the bachelor’s degree. Most of these females entered medical school (n = 32). Once again, the number of females pursuing professional programs of study are likely attributed to the majority of respondents being undergraduate biology majors. Astin and Astin (1992) found that 1 in 10 biology majors aspired to medical degrees at the end of their undergraduate education, compared to only 1 in 100 for students in other majors. Also, they found that for students in the biological sciences who aspired to earn a PhD upon college entry, but who ultimately defected from this plan, the medical degree became the main goal. Another factor to consider, however, is the issue of how many students who enter college intend originally to study medicine and not earn a PhD. Astin and Astin found that 6 of 10 biology majors maintained their medical degree aspirations from the freshmen to senior year of college. If these figures hold true for the females of the present study it can be assumed that a certain number of these females who majored in science as undergraduates never intended to persist in the natural science and engineering pipeline beyond the bachelor’s degree.

In summary, depending upon how these findings on persisters are interpreted, the rate of persistence to PhD study for the females of the present study is high when compared to
other models or studies. This is expected, however, when successful females in science are
the basis from which comparisons are made. Astin and Astin concluded that large
universities “appear to have a negative impact on undergraduate students’ aspirations for
advanced degrees” (Astin & Astin, 1992, p.7-21). The findings of the present study on PhD
persistence, however, do not demonstrate this to be true for the successful science majors at
Iowa State University.

**Purpose 5:** To identify factors that were most influential in helping successful females
in science to persist in science studies beyond the baccalaureate degree

When both types of persisters were asked to cite the three most influential factors that
helped them to enroll in further studies 17 different categories could be constructed from
their responses. The most frequently cited factor for persistence was “encouragement from
others” (41 percent). The most frequently mentioned individuals providing this support and
encouragement were parents and family (including husband), followed by advisors, and
professors. Least cited individuals were friends, bosses, teaching assistants, and mentors.
The finding that encouragement from parents and family was significant to these females’
persistence is important because past research has focused mostly on high school students or
undergraduates, and not on science persisters beyond the bachelor’s degree.

In the present study persisters did not single out one parent or the other regarding
differential support, except in two cases. Therefore, it appears that these females considered
their parents as equals regarding sources of encouragement. This differs from the findings of
Berg and Ferber (1983) who studied graduate students in the biological and physical sciences. They found that 50 percent of females reported receiving paternal support and only 16 percent reported receiving maternal support for their studies. However, the present study supports the findings of Manis (1989) who found that 85 percent of senior science majors in college rejected the statement that "parents had not encouraged me to go into science."

The issue of advisor support is important for both persisters and nonpersisters. Recall that for the nonpersisters, 59 percent indicated that advisors should be encouraged to discuss with students the possibility of pursuing advanced studies. This was their second leading choice for ways to encourage more entry into further science study.

Females who persisted in science reported that support from their advisors was important to their persistence. The findings of the present study are important because they help to support previous research findings. Frazier-Kouassi (1992) specifically addressed the importance of encouragement for physics students and Honors mathematics students. Information obtained from focus groups on graduate students at the University of Michigan allowed her to conclude that having good relationships with advisors, being taken seriously by them and teachers, and being encouraged by faculty members, parents, and peers were important for both females and males during their undergraduate education for helping them persist to advanced degrees.

Other categories receiving the most responses related to reasons for persistence were "love or interest of science" (35 percent), "choice of career" (32 percent), and "increased job opportunities" (30 percent). Most responses in the first category were related to health, the
human body, or medicine and it is presumed that these came from respondents who entered medical programs of study. Only three respondents specifically alluded to research as their focus of interest. Most likely these respondents are part of the group that entered programs of advanced graduate studies. It is apparent that most participants in this study, both persisters and nonpersisters, became interested in science at an early age. Sixty seven percent indicated they first became interested in science in elementary, junior high, or middle school. Thirty percent discovered their science interest in high school and only four percent in college. Although not a part of this study it would be of interest to correlate the responses of the persisters and nonpersisters, for this category, with their time of recognition of science interest. Would the persisters be the group who indicated an early interest in science? As one persister noted “I decided on my profession when I was about 8 years old.” Also, did the nonpersisters develop an interest in science later, or did they miss opportunities to do so at an early age?

The two categories “choice of career” and “increased job opportunities” are related to some extent, but enough differences existed between these two categories to warrant a separation. Respondents citing “choice of career,” for the most part, referred to their persistence in science as being necessary to become doctors, veterinarians, or physical therapists, or to qualify for a career by attending graduate school. In the category “increased job opportunities” respondents often referred to limited job possibilities with only a bachelor’s degree. When compared to the responses of nonpersisters related to why they failed to persist, this is an interesting finding. The nonpersisters ranked as their second most
frequent reason for failing to persist that they did not need further education to obtain a job they wanted, or that they had already obtained a job. The persisters ranked as their fourth most important reason for persistence the lack of jobs with only bachelors' degrees. These differences likely indicate higher job aspirations in persisters and higher levels of motivation. Another possibility could be related to more financial security found in the persisters, therefore, allowing them the freedom to delay entering the job market.

Support for the contention that there are higher aspirations and more motivation in science persisters comes from two other categories of responses, although these categories were not as frequently cited as those already discussed. Approximately one-fourth of respondents wanted "more or a better education." This became expressed as simply a "desire to learn," or more specifically, as a "desire to perform basic research & teach." Sixteen percent of persisters indicated they were "personally motivated" to persist because of personal interests, motivation to succeed and be successful, or to contribute to their field of study or to society.

Cited by 15 percent or fewer respondents were the three categories "influenced by others" (15 percent), "past science experiences" (15 percent), and "past science successes" (13 percent). "Influenced by others" refers to individuals who came in contact with the persisters of this study and because of their actions or past accomplishments became influencing agents. For example, parents or siblings were cited as having advanced degrees. Also, friends and classmates were mentioned because they were "also going to graduate school." Only three respondents referred to teachers or teaching assistants as being
influencing agents. Because only 4 of the 16 respondents referred to peer influence this factor does not appear to be important for science persistence for the females of this study.

A finding most similar to that of the present study comes from a study by Fitzpatrick and Silverman (1989) of high achieving females studying science in college. These researchers found that peers were neutral influences on career choice. The finding of the present study, however, appears to dispute that of Astin and Astin (1992). They concluded that the peer environment influences students' aspirations for advanced degrees. This, they believed, happened when students affiliated for four years with peers who had high intellectual self-esteem, and therefore, were most likely to pursue advanced studies after earning the bachelor's degree. Astin and Astin concluded that peers, because of their interaction with others, may positively influence the preparedness for admission tests to graduate or professional schools. It is possible that this is also true for the persisters of the present study, however, this type of influence from peers could not be ascertained from the survey questions used in this study.

The relatively low number of persisters who cited “past science experiences” as being important to science persistence was an unexpected finding because when intervention programs to increase the number of women in science are discussed participation in science activities is frequently cited (Frazier-Kouassi, 1992; “Getting Women,” 1994; “Women in Science,” 1991). It is not known why few of the persisters of this study rated this factor relatively low. Two explanations appear to be most probable, however. One may be that the opportunities simply did not exist for most of the persisters. The other possibility is that
their motivation to persist was strong enough to overcome the lack of participation in science activities. In any case, participation in science activities was not demonstrated to be a strong facilitator to science persistence for the females of this study.

Another category receiving a low frequency of response was “past science successes” (13 percent). Also, cited by 10 percent or fewer respondents were the categories: “desire to help or work with others;” “increased salary potential;” “challenge, stimulation associated with college;” “role models, mentors;” “best option at the time;” “miscellaneous;” “money was offered;” and “female profession, high number of females.”

Considering the category of “role models” the low number citing this as an important factor for persistence (six percent) appears to contradict a finding discussed earlier on the significance of role models for undergraduate science persistence. Although role models were rated by a large number of respondents as being important for persistence up to and including the undergraduate years, as discussed earlier, they were not rated as highly for persistence to advanced graduate studies or professional school. Two factors may have contributed to this. To be included in this category the response had to specifically use the term role model. Parents and others who were considered to be role models in a previous question were now included in the category “encouragement from others” if they were not specifically cited as being role models. Second, there may be an actual difference in how respondents view role models when they are considering persistence in science after earning the bachelor’s degree.
In summary, the open-ended question allowed persisters to rank the most important factors related to their persistence in science beyond the bachelor’s degree. The most important factor was related to receiving encouragement, particularly from parents, advisors, and professors. Another factor considered to be most important was having an interest or love for a particular area of science. Sometimes this arose at a very early age. Two other factors that were most significant for science persisters were related to jobs. Persisters needed either to pursue further science studies based on a particular career path they had chosen or they saw a bachelor’s degree as being limiting, and therefore, felt the need for further education to widen their future job possibilities.

**Purpose 6: To identify factors that persisters believe make it difficult for females to be successful in graduate or professional school**

When persisters were asked in an open-ended question to identify three reasons why they believe it is difficult for females to be successful in graduate or professional school, 12 categories of responses were generated from their answers. Two factors emerged as being most important. The most frequently cited response was related to “chilly classroom climate” experiences (50 percent). The second most noted response was related to the issues of “family, marriage, and children” (44 percent).

A surprising finding on persisters was that a large number of them stated that “chilly classroom climate” experiences created difficulties for them in graduate or professional school. Recall that nonpersisters strongly disagreed with the statement that “my experiences
with a 'chilly classroom climate' (as an undergraduate) discouraged me from considering graduate or professional school.” Also, recall that bothpersisters and nonpersisters overwhelming stated that they had not considered changing from science to another major because of “chilly classroom climate” experiences. Based only upon these two previously discussed findings it would appear that the “chilly classroom climate” factor, as a barrier to persistence, did not exist for the females of the present study. Indeed, these findings indicate that this factor is not an issue for science persistence during the undergraduate years, nor is it important as a barrier when making the decision of whether or not to persist in science beyond the bachelor’s degree. However, for the persisters it ranked as the number one barrier to being successful in science studies after earning the bachelor’s degree.

The “chilly classroom climate” issue appears to have many subtopics associated with it, based upon a reading of the literature and the findings of the present study. A review of the literature indicates that included in this factor are the primary issues of the classroom itself, the classroom teacher, and experiences outside the classroom.

The findings of the present study required that subtopics of responses be developed. The original intent was not to do so, but after examining participants’ responses it became obvious that various types of concerns had been expressed. From most frequently cited to least frequently cited the subtopics became: males respected more than females; sexism; male domination; science is a man’s world; intimidation; miscellaneous; discrimination; competition; higher expectations for females; and problems with male classmates. Persisters expressed concerns about lack of respect, sexist remarks, lack of female faculty members and
peers, not being a part of the male network, being intimidated, not being treated as a student, experiencing discrimination from professors, competitive environments, higher expectations for females than males, and problems with their male peers.

The findings of the present study are important because as stated in the literature review, there are few studies involving college students who graduated with science degrees. Related studies to the present one include the older study by Holmstrom and Holmstrom (1974) who found that female graduate students were more likely to consider withdrawing from graduate school when they believed faculty did not take them seriously. The perception that faculty had negative attitudes toward these women was determined to contribute to their emotional stress and to decrease their commitment to remain in graduate school. Manis (1989), studying college seniors, found that some females believed that the science classroom was an unfriendly environment because of discriminatory behavior, not being taken seriously, and being made to feel less intellectual than men.

The present study, therefore, has demonstrated that a "chilly classroom climate" is perceived to exist for persisters and is seen as an important factor that makes it difficult for females to be successful in graduate or professional school.

Persisters to graduate or professional school ranked the factor of "family, marriage, and children" second as a reason why it is difficult for females to be successful in school beyond the bachelor's degree. Responses in this category were very consistent, with comments in reference to conflicts between balancing home life (especially children) and school. This finding follows one previously discussed. Earlier it was stated that the
nonpersisters of the present study ranked this factor third regarding why they did not enroll in graduate or professional school. Although both persisters and nonpersisters considered this to be an important factor associated with science persistence, it obviously was not as significant a personal factor for the persisters. One problem associated with interpretation of this finding is that it was difficult to determine from the responses whether or not these were personal issues for the respondents or whether they believed they were problems for persisters, in general. Reexamination of the responses indicated that both are likely to be true.

Previous research findings have demonstrated that the factor of role conflicts is important for students pursuing advanced studies, although few studies have been found for the area of science alone. Studies by Adler (1976) and Dublon (1983) found that female graduate students had lower family aspirations which were possibly related to the constraints of managing a family and school. Kaplan (1982), studying female graduate students over age 30 found that marital status was linked to field of study. That is, single or divorced women were likely to be in more masculine fields than were their married counterparts. Although the present study did not link marital status to experiences in graduate school, it would be of interest to do.

Persisters ranked “lack of encouragement and support” third (22 percent) in importance as a reason why it is difficult for females to be successful in graduate or professional school. Respondents mentioned lack of support from spouses, family, friends, and from society, in general. The factor of encouragement appears to be important to the
persisters of this study for two reasons. First, recall that they considered encouragement to be the most important factor related to their persistence in science. Second, they considered the lack of encouragement to be an explanation for why difficulties are experienced in advanced studies. Therefore, persisters consider encouragement to be a prominent factor related to science persistence.

Categories not considered to be as important were related to the difficulties associated with the demands of further schooling (17 percent), lack of female role models (16 percent), lack of money (15 percent), lack of confidence (8 percent), lack of information (7 percent), lack of motivation (5 percent), and lack of preparation (2 percent).

**Purpose 7: To identify experiences in graduate or professional school in science that could hinder persistence of females in science while they are enrolled in these programs**

Persisters were asked to respond to 17 statements concerning their experiences in graduate or professional school by indicating their extent of agreement to these statements on a Likert Scale. Responses indicated that the biggest problem these females experienced was that males were more respected for their opinions than were females when they “disagreed” that females are more respected than males for their opinions in graduate or professional school. This type of response should be expected, based upon the number who indicated experiencing problems with a “chilly classroom climate” in graduate or professional school. The issue of respect was also addressed in other statements that were designed to determine
if respect was present between fellow classmates, and between the students and professors, and to determine if females were respected for their research efforts.

Persisters of this study "somewhat agreed" that respect was shown between female students, and between female and male students, and to a lesser extent that they received the same respect as males from their male professors. Regarding their research efforts respondents "disagreed" that females are not respected for their research efforts in graduate or professional school. Responses to these statements are somewhat perplexing because the strength of the responses is not as great as what the comments on the "chilly classroom climate" discussed earlier, suggest. A possible explanation for this may be that the persisters of this study have met isolated and/or subtle instances of sexism and discrimination rather than experiencing ongoing forms of discrimination. This may have led these persisters to comment on selected instances in the open-ended question although they may not have experienced problems on a day to day or continual basis.

Rowe (1977) used the term "micro-inequities" to describe instances of sexism that for the most part are petty, but when considered together represent formidable barriers. Discriminatory acts that may be insignificant when applicable to a particular incident can collectively contribute to different academic experiences between men and women ("Women in Science," 1991). The data collected from persisters of this study suggest they have experienced "micro-inequities" as they reported numerous and varied instances in the open-ended question, but failed to respond more strongly to statements of discrimination in the Likert Scale.
Responses to other statements in this section of the survey help to support this contention. Females "agreed" that they have been considered to be a valuable component of their research or study group which would indicate peer support. Also, they "somewhat agreed" that professors provided them with adequate support for their research or other academic efforts; professors were accessible for helping students; females and males were included equally in matters affecting their departments of study; and females and males were treated equally in inclusion at various professional meetings. Persisters also "somewhat disagreed" that there is a camaraderie present between male professors and male students that is missing between male professors and female students, and to a greater extent "disagreed" about the presence of a camaraderie between female professors and male students that is missing between female professors and female students. They also "disagreed" that they felt uncomfortable in social situations with their male peers and professors, and that they received unequal consideration for positions in their research groups when compared to males.

Three questions were designed to obtain information concerning the financial aid experiences of the science persisters of this study. The literature review revealed that not only is financial aid the primary factor affecting access to graduate school (Hornig, 1987), but that the type of financial aid contributes to the quality of the graduate school experiences ("Graduate Education," 1982). Previous research has indicated that there is differential access between sexes in obtaining research assistantships (Solmon, 1976; Wong & Sanders, 1982) and that research assistantships have advantages over teaching assistantships.
Teaching assistantships have been seen as less desirable than research assistantships because they are associated with fewer hours available for student research (Hornig, 1987) and for lengthening time to degree completion (Wilson, 1965). The persisters of this study "somewhat disagreed" that graduate financial aid is not adequate to help students maintain their college enrollment and "somewhat agreed" that having research assistantships makes it easier to finish graduate school than having teaching assistantships. They also "somewhat agreed" that females and males equally receive research assistantships.

Interpretation of these findings is somewhat difficult because not only doctoral students responded to these questions, but also masters' degree students and those who have attended professional schools. As Hauptman (1983) noted, it is primarily the doctoral student who receives research assistantships. Therefore, it is possible that having studied only this type of student the mean responses to these questions may have been different.

In summary, the section on graduate or professional school experiences was designed to reveal perceptions concerning students' relationships with peers and professors, and to provide information on the issue of financial aid. In general, the persisters of this study appear to be somewhat satisfied regarding their relationships with peers and professors, and with their financial aid status. The strongest extent of disagreement was elicited from the statement that females are more respected for their opinions than are males. Clarification of the interpretation of these findings would be aided by separating the persisters into various groups, according to type of degree program, and comparing the group responses.
Purpose 8: To determine if there are any significant differences between two groups of science graduates: persisters and nonpersistence, and those graduating with distinction or not graduating with distinction, on each of six factors related to undergraduate experiences, and to determine whether persistence and GPA have a combined effect on each of these six factors.

A total of 18 null hypotheses were tested which represented the testing of three hypotheses for each of six two-way ANOVAs of interest to this researcher. As previously described, each of the two-way ANOVAs investigated the effects of two independent variables on one dependent variable. The independent variables were persistence in science beyond the bachelor’s degree and cumulative GPA at the time of undergraduate graduation. There were two levels for each independent variable. For persistence, the levels were persistence and nonpersistence. For GPA, the levels were graduation with distinction and without distinction. A discussion of the results of the testing of these six two-way ANOVAs follows.

Enjoyment of science as a discipline: Previous studies have attempted to measure the importance of enjoyment of science courses on science persistence, however, there appear to be two limitations associated with past studies. One limitation is related to the lack of study on the enjoyment of the laboratory component of science classes, or on independent laboratory research. It is likely that this is related to the many studies that have combined majors or disciplines that have a laboratory component with those that do not, such as mathematics. This researcher previously concluded in the summary of the literature review...
that this was a limitation of some studies examining the issue of science persistence because this researcher believed that the educational experiences of students majoring in biology and mathematics, for example, are different enough to warrant separation. The laboratory experience represents one important difference.

The second limitation is related to the year in school in which students have been studied. Few studies have been found that have actually examined the enjoyment of science as it relates to science persistence, and of those, they fail to study the college senior. Research by Ware et al. (1985), for example, studied enjoyment of science classes as a factor related to science persistence for college freshmen. Although studies such as this one are important, it is also important to understand if the college senior has maintained enough interest in the laboratory component of their area of study to persist in programs of advanced graduate studies beyond the bachelor's degree. The characteristic of laboratory interest is an important one for students to possess, particularly if they intend to pursue graduate school rather than professional school because laboratory work is a primary component of graduate work in science.

If it is assumed that undergraduates possess enough interest in the laboratory to decide on earning an undergraduate laboratory science major, then the question becomes whether or not this interest is high enough to become a factor related to science persistence beyond the bachelor's degree. The present study attempted to answer this question and to address the two limitations, just cited, found in previous studies.
The factor "enjoyment of science as a discipline" consisted of seven questions on the survey instrument, however, factor analysis resulted in the elimination of two of these questions. The items that remained solicited attitudes about laboratory sessions and data collection, experimentation, laboratory techniques, and the learning and application of scientific principles in the laboratory setting.

When the three null hypotheses were tested using the dependent variable "enjoyment of science as a discipline" none of the three could be rejected. That is, there was no significant difference found between the mean scores for "enjoyment of science as a discipline" for the persisters and nonpersisters, there was no significant difference found between the mean scores for the dependent variable for those graduating with distinction and without distinction, and there was no significant interaction effect between persistence and GPA.

These results demonstrate that the persisters and nonpersisters of this study did not differ in their enjoyment of the undergraduate laboratory component of their area of study, and that differences in undergraduate GPA did not affect their enjoyment. Also, persistence and GPA did not interact to affect this enjoyment. These results demonstrate that the various groups of respondents enjoyed their undergraduate laboratory experiences to the same extent. Although significant differences could not be found, the testing of these hypotheses adds to our body of knowledge because it yielded findings on a factor which has not been studied to a great extent on students who have earned undergraduate science degrees. For this
researcher this was an unexpected finding because it was anticipated that at least regarding persistence and nonpersistence, differences would be found.

**Relationships with science professors**  Six questions were used in the survey instrument to gather information about attitudes toward relationships with science professors, however, two of these became part of a new construct and two questions were added to the construct after factor analysis. This factor was of interest in the present study because part of the undergraduate science experience involves relationships with science professors, and therefore, these experiences may influence science persistence. Questions that remained a part of this construct solicited attitudes about the caring nature of science professors, the respect shown for students by science professors, the interest of science professors for teaching or their research, and the comfort level of seeking help from science professors outside of class. Questions that were added to the construct solicited attitudes about intimidation from male professors and feeling comfortable asking questions in science classes.

Two of the three null hypotheses for this two-way ANOVA were retained after testing and one was rejected. A significant difference was found to be present between students graduating with distinction and those not graduating with distinction on their attitudes toward relationships with science professors. There was no significant difference found between persisters and nonpersisters on their attitudes toward relationships with science professors, and also there was no significant interaction found between persistence and GPA. For the null hypothesis that was rejected, females who graduated with distinction
had a higher mean rating than those who did not graduate with distinction. Specifically, this indicates that females who graduated with distinction had a more positive attitude toward their science professors than did those with a lower GPA at the time of graduation.

It seem likely that there are several factors functioning which help to explain why a significant difference was found between the two groups of students graduating with different GPAs. One is that students at higher levels of academic achievement have better attitudes toward school in general, and toward their major area of study. This, then, becomes reflected in their attitudes toward their science professors. A second explanation is that students who are more academically successful are more personally involved with their studies, and therefore, with their science professors. A third explanation may be that science professors show more positive attitudes and are more helpful toward the better student, and therefore, the student has a more positive attitude toward their professors. Unfortunately, the current study does not allow testing of these hypotheses, however, it would be of interest in future studies to pursue this line of reasoning.

It would also be of interest to pursue whether differences exist for these types of students across different types of institutions. Astin and Astin (1992) stated that major universities such as the one in the present study, compared to liberal arts colleges, offer dramatic differences to science students regarding their science experiences. Specifically cited were the presence of larger classes in large universities, use of teaching assistants, strong faculty orientation toward research, and fewer opportunities for meaningful student contact with faculty. Would it also be true that differences could be found between students
with different GPAs who are attending small liberal arts colleges regarding attitudes toward
relationships with science professors?

**Self-confidence for science studies**  The factor of self-confidence for science
studies has been studied at various levels in the educational process, but it appears that few
studies have focused specifically on the college senior. For this reason, the present study
attempted to add to the body of knowledge regarding this type of student. Five questions
were originally intended to measure participants’ perceptions about their self-confidence for
science studies during their undergraduate years in college, however, factor analysis resulted
in the elimination of one of these questions and the movement of one question to a new
construct. The remaining questions assessed whether the females of this study believed they
were more capable, intellectually, than other students, whether they found it difficult to
compete with other students in the science classroom, and whether it was difficult for them
to be successful in science.

Testing of the null hypotheses for this factor of interest demonstrated that persistence
in science had no effect on self-confidence, however, a significant difference was found
between students graduating with distinction and those who did not graduate with distinction
on their self-confidence for science studies. Also, testing of the interaction effect between
persistence and GPA did not result in any significant interaction being found.

Testing of the main effect, GPA, on self-confidence for science studies demonstrated
that females who graduated with a 3.50 and higher cumulative GPA had a significantly
higher mean score for self-confidence than students who graduated with a 3.00-3.49
cumulative GPA. Therefore, students graduating with distinction were more self-confident about their science studies during their undergraduate years than students who graduated with lower GPAs.

Performance, therefore, appears to be linked more to self-confidence for science studies than does persistence. It is not possible, however, from the data gathered in this study to determine what factors could be related to higher performance. DeBoer (1984) concluded that students felt more competent when they had earned higher grades, and that the higher grades were related to having taken more science classes. It is possible that this may also be true for the females of this study, however, data were not collected to be able to determine this.

**Sexist nature of the science classroom**  Originally, this construct was named “nature of the science classroom” and was given the working definition “refers to respondents’ attitudes toward the friendliness of the science classroom and the ability of the science classroom to stimulate an interest in science.” In the survey instrument this was one of two constructs intended to measure experiences with and influences of a “chilly classroom climate” during the undergraduate college years. Six questions constituted the construct as answered by participants, however, the results of reliability measurement and factor analysis resulted in only three questions remaining, and the new construct “sexist nature of the science classroom” emerged. These three items assessed respondents’ attitudes toward male students in their science classes regarding the use of sexist remarks and the friendliness of male peers, and also toward their male science professors regarding their use of sexist
language in class. A working definition was developed for the new construct. This definition "refers to respondents' attitudes toward the presence of sexism in the science classroom either as a result of the actions of male peers or the actions of male professors."

None of the null hypotheses tested for this two-way ANOVA could be rejected. These hypotheses tested whether a significant difference was present between persisters and nonpersisters regarding their attitude toward the sexist nature of the science classroom, whether females with high GPAs and low GPAs differed in their attitude toward the sexist nature of the science classroom, and whether there was an interaction effect between persistence and GPA regarding this variable.

Because no significant differences were found results indicate that respondents reacted similarly to questions regarding their attitudes toward the sexist nature of their male peers and male science professors. Therefore, further insights into these results can be obtained by examining other findings of this study. Using data from Table 6 it can be seen that for question number 27, respondents "disagreed" that male students in science classes made sexist remarks to females. They also "agreed" for question number 38 that male professors did not use sexist language in class. For question number 28 respondents "agreed" that male students in their science classes made them feel welcome.

It appears then, that as undergraduates, the participants of this study have not experienced sexism in the science classroom from their male peers or professors. However, this seems to change once females enter graduate or professional school, as discussion in an earlier section indicated.
**Masculine nature of the science classroom**  This construct also represents one that differs from the originally intended construct. In the survey, respondents answered seven questions that were intended to measure attitudes toward “sex discrimination in the science classroom” during the undergraduate college years. The working definition referred to “respondents’ attitudes toward sex discrimination from their male science professors.” This was the second construct intended to measure experiences with and influences of a “chilly classroom climate” during the undergraduate college years. However, a test of reliability resulted in the elimination of one item and factor analysis resulted in a new grouping of questions. Therefore, the new construct “masculine nature of the science classroom” was developed which consisted of seven questions. These questions measured respondents’ attitudes toward the difficulty of science for females compared to males, preferences for more female science professors, feeling more comfortable with female science professors compared to male science professors, a science classroom biased toward males, failure of science classes to stimulate or help maintain an interest in science, preference for more female students in their science classes, and the perception that males were treated more fairly than females in science classes. A new working definition was developed that “refers to respondents’ attitudes toward the lack of female students and professors in the science classroom which can lead to a decrease in science interest.”

A testing of the three null hypotheses for this two-way ANOVA resulted in all three hypotheses being retained. That is, no significant difference was found to be present between persisters and nonpersisters regarding their attitude toward the masculine nature of
the science classroom, no significant difference was found to be present between females who graduated with distinction and those who did not, regarding this variable, and no significant interaction was found between persistence and GPA.

These findings are important primarily because they indicate that persistence in science is not related to experiences with a “chilly classroom climate” during the undergraduate years, at least regarding the masculine nature of the science classroom. When this finding is considered together with the findings of the construct “sexist nature of the science classroom” which also helped to define “chilly classroom climate” for the purposes of this study, it can be concluded that the persisters of this study do not differ from the nonpersisters regarding experiences with the “chilly classroom climate.”

The development of this construct is valuable to an understanding of the participation of females in science because it allows for an examination of some of the perceptions that successful females in science might have regarding experiences with a “chilly classroom climate.” However, its usefulness might be limited because as Frazier-Kouassi (1992) stated, although the term “chilly classroom climate” has become a buzzword around campuses, a definition of what constitutes this type of climate differs widely among administrators and researchers.

Therefore, it becomes necessary once again to state the definition of a “chilly classroom climate” as developed and used for the purposes of this study. This definition states that a “chilly classroom climate” is “The climate that exists in the science classroom which causes a decrease in female student interest in science, leads to anxiety in females, is
considered by females to be a form of sexism, or can cause females to consider changing majors, or to terminate their studies in college." If persons interested in this topic accept this definition and the results of this study, then it can be concluded that persisters and nonpersisters of this study do not differ significantly in their experiences with a "chilly classroom climate," and therefore, this factor is not related to persistence.

Although the review of the literature cited numerous studies in which females have found the science classroom to be an unfriendly place, the conclusion by this researcher was that it was unclear at this time whether the issue of sexism has a significant enough effect on females at the end of undergraduate studies to prevent their pursuit of advanced degrees. The results of the present study answer this question, at least for the participants of this study, and indicate that this is not true. Frazier-Kouassi (1992) stated that little is known about the short or long-term impact of "micro-inequities" on the goals of young women. The findings of the present study provide evidence that if they did exist for the females of this study, they were not serious enough to warrant nonpersistence to graduate or professional school, and therefore, they did not impact on this important decision.

**Academic advising experiences** One section of the survey instrument was designed to assess respondents’ attitudes toward their academic advising experiences. The original seven questions designed to solicit these attitudes were reduced to six after the use of factor analysis. The questions that were retained were in regard to determining perceptions about the helpfulness of advisors in answering questions about science majors, the interest shown by the advisor in the student, whether or not the advisor was a source of
encouragement for persistence in science and was a good source of information about job possibilities in science, whether advisors thought females should be in science, and whether or not advising sessions were helpful for gaining information about graduate school.

The testing of the three null hypotheses for this two-way ANOVA led to the retention of two of these. No interaction was found between GPA and persistence in science regarding attitudes toward advising experiences. Also, no significant difference was found between females who persisted in science and those who did not regarding this variable. However, a significant difference was found between females graduating with distinction and those who did not, and therefore, the null hypothesis was rejected. Examination of the mean scores for these two groups indicated that compared to females who did not graduate with distinction, females who graduated with distinction had a more positive attitude toward their academic advising experiences.

The issue of academic advising was previously discussed in this chapter. Recall that nonpersisters cited lack of information as the fourth most important reason why they failed to persist in science beyond the bachelor's degree. In all cases, this referred to not knowing what to study. It was then presumed that one important source of information should be the student's academic advisor. Also recall that persisters, out of 17 categories, ranked "encouragement from others" as the leading reason for their persistence in science. After family, advisors were most frequently cited as being sources of this encouragement. It is therefore, interesting, that a significant difference was not found between these two groups
of individuals, but that one was found between females with different levels of academic achievement.

Girves and Wemmerus (1988) stressed the importance of student-advisor relationships as being critical to a student's educational and professional development. Although their study involved graduate students, another study pertinent to the present one examined this relationship at the undergraduate level. Stansbury (1986) studied the relationship between science and engineering student environments and the student's level of self-confidence and assertiveness. Findings demonstrated a positive relationship between the quality of advisor relations and the levels of self-confidence and assertiveness for the females of the study. This led Stansbury to suggest that females are sensitive to the supportive features of the academic environment, and therefore, that the relationship between student and advisor should be improved.

Although the present study did not examine this same relationship, recall that not only did the females of the present study who graduated with distinction have a more positive attitude toward relationships with their academic advisors, but they also exhibited more self-confidence toward their science studies and demonstrated a more positive attitude toward relationships with their science professors compared to the females who did not graduate with distinction. These findings also suggest that a link might exist between self-confidence and the supportive features of the academic environment offered by the academic advisor and science faculty, for the highly successful females of this study. However, this
link does not appear to be present for those females who did not graduate with distinction, and therefore, are somewhat less academically successful than their counterparts.

The findings of the present study, therefore, lead to several speculations and questions. (1) Factors other than advisor relationships are functioning to affect persistence for the successful females of this study. However, if advisor relationships are studied prior to the senior year of college they may demonstrate to be important for persistence up to that point. (2) Some factor is present in females who graduate with distinction, compared to those who do not, regarding advisor relationships. Referring to the discussion on attitudes toward relationships with science professors it is of interest to raise similar questions. Do more academically successful females have a more favorable attitude toward their area of study or school in general, and therefore, toward their academic advisors? Are these females more motivated to seek closer contact with their academic advisors? Do academic advisors react more favorably to females who are more academically successful? (3) Are the supportive features of the academic environment most likely to be accepted by the more highly academically successful females in science, and is there a positive relationship to self-confidence as stated by Stansbury (1986)? Does this hold true for students outside of science? (4) Why do the nonpersisters of this study fail to have less positive attitudes toward their academic advisors than do the persisters, particularly when they cite “lack of information” as being a reason for failure to persist? Do they not perceive their advisors as being potential sources of this information, and therefore, fail to find fault with them? Answers to these questions are important and will need to be addressed in future studies.
Purpose 9: To determine if the six factors studied in the two-way ANOVAs can be used to predict persistence in science

A review of the literature indicated that many factors may function to affect persistence in science. The factors that were chosen for testing in the two-way ANOVAs were also chosen for testing of the hypothesis predicting persistence in science. The null hypothesis that was originally formulated was modified to reflect the two new constructs that emerged after factor analysis was performed on the data. This hypothesis became “There is no significant relationship between the mean ratings of females in science on their attitudes toward “enjoyment of science as a discipline,” “relationships with science professors,” “self-confidence for science studies,” “sexist nature of the science classroom,” “masculine nature of the science classroom,” and “academic advising experiences,” and their persistence to further science study after earning the baccalaureate degree. Testing of this hypothesis resulted in the finding that attitudes toward “self-confidence for science studies” and the “masculine nature of the science classroom” are predictors for persistence in science. Self-confidence for science studies became a positive predictor for persistence in science and the masculine nature of the science classroom became a negative predictor. However, these two factors only explained approximately five percent of the variance. This indicates that approximately five percent of the variance in the dependent variable, persistence in science, is attributable to the variance of the combined predictor variables. Because of this low percent it can be presumed that other variables not selected for inclusion in this hypothesis testing are functioning to predict persistence.
Several studies have addressed the factor of self-confidence for science studies, but unlike the present study they did not examine perceptions of the college senior regarding persistence to further science study. Because studies on students other than college seniors have demonstrated a link between self-confidence and persistence (Boisset, 1989; DeBoer, 1984; & Ware et al., 1985) it can be anticipated that this would be true for college seniors as well.

The second factor, masculine nature of the science classroom, correlated negatively to persistence in science. This indicates that females were less likely to persist in science if they: desired to have more female science professors; desired to have more female students in their science classes; felt more comfortable with female rather than male science professors; believed the science classroom was biased toward males; believed it was more difficult for females to be successful in science compared to males; and believed that the science classroom failed to stimulate or help maintain their interest in science.

**Purpose 10: To determine if there are any differences between females who pursued advanced graduate studies and females who pursued professional programs of study on the six factors related to undergraduate experiences**

The same six factors used in the two-way ANOVAs and the multiple regression hypothesis were also used in six t-tests for independent means to determine if females pursuing advanced graduate studies differed significantly from females attending professional schools of study. Five null hypotheses were retained when no significant
differences could be found between these females on their attitudes toward "relationships with science professors," "self-confidence for science studies," "the sexist nature of the science classroom," "the masculine nature of the science classroom," and their "academic advising experiences." The one null hypothesis that was rejected demonstrated that females who pursued advanced graduate studies differ significantly from females who pursued professional programs of study on their attitudes toward the enjoyment of science as a discipline.

The questions for this factor specifically solicited attitudes regarding the enjoyment of the laboratory component of an area of science study. The results indicate that females pursuing advanced graduate studies demonstrated a significantly higher mean rating toward their enjoyment of science as a discipline, compared to females attending professional schools of study. This is not a particularly surprising finding because the females who entered professional programs of study did not pursue areas of science study where laboratory research, in the form of a research project, was necessary to complete their academic goal. For example, females entering medical school or physical therapy would not be required to complete a research project in the laboratory in order to receive their intended degree. However, this finding is important if consideration is given to the question of why this difference exists or when this interest developed. When various findings of this research project are considered it makes it possible to argue that almost all persisters in science beyond the bachelor's degree developed an early interest in science and that a primary reason for their persistence was a love or interest in science. The data also indicate that past science
experiences, possibly in the form of laboratory work, are not a major factor contributing to this persistence. Responses to the open-ended question asking why there was persistence in science demonstrated that many persisters want to use their education to help others. Examples of these females include those who want to become physicians, physical therapists, or veterinarians. It is also likely that these persisters could not be swayed to study science that involves strenuous laboratory pursuit, as would be necessary for PhD obtainment. However, for other females who might ultimately study science and possibly persist beyond the bachelor's degree this evidence indicates that laboratory science interest should be initiated and cultivated early in the educational process.

Conclusions

This study of successful females who graduated from Iowa State University with bachelor's degrees in various biological and physical science fields provides important insights into their experiences as undergraduates and their persistence rates to and experiences in various graduate and professional schools. Since 1987, when the NSF produced a report projecting future shortages of natural scientists and engineers ("The Science and Engineering," 1987) various researchers have examined the issues associated with interest in science and the loss of this interest as students move through the natural science and engineering pipeline. In particular, studies have focused on females and minorities. Because females now constitute the majority of students attending college and because they are underrepresented in various science and engineering fields, it is logical to
consider their role in earning science and engineering degrees, and therefore, in helping to alleviate the projected shortage of scientists and engineers. It is with these assumptions that the present study was undertaken.

A major issue associated with science persistence has been the participation of females in science in graduate school, particularly at the doctoral level. The present study addressed this issue, and although the females of this study pursued advanced graduate studies at a slightly lower rate than projected by the science and engineering pipeline model, their persistence rate from the bachelor's degree to PhD level was over three times higher than predicted. Although this number might be considered commendable, other females entered programs of professional studies at a rate 1.4 times that of those entering masters' or doctoral programs of study. While the importance of those females entering professional programs of study should not be diminished, their loss from the science and engineering pipeline at advanced levels of graduate study does not help to alleviate the shortages of doctoral recipients in this decade and beyond. Of even more concern, and also contributing to this shortage, is the loss of slightly over one-third of the females who stopped their education after earning bachelors' degrees.

The present study, therefore, was not only concerned with persistence rates, but also with issues associated with persistence in the natural science and engineering pipeline during the undergraduate college years and beyond. Of particular interest were responses to questions regarding why nonpersisters left their studies after earning bachelors' degrees and why persisters continued in science studies beyond the bachelor's degree. Foremost among
the barriers regarding failure to persist in science were the issues related to financial
difficulties, jobs, and role conflicts.

Various studies have addressed the impact that financial aid has on graduate school enrollment, however, almost all have been performed on either current or former graduate students. The present study is important because it has documented the perceptions of females who failed, primarily because of financial reasons, to pursue advanced graduate studies or professional school. Although the present study did not allow for a determination of the specific reasons associated with this concern, it seems plausible to suggest that it is related to undergraduate debt load or lack of information concerning available financial aid in graduate or professional school. Nonpersisters, by citing present employment or the desire for future employment as the second most common reason for failure to persist in science studies may be indicating that their financial resources are inadequate. However, the factor of jobs also acts as a barrier to science persistence because these females agreed that jobs could be obtained without further education. In this respect, job prospects for these females seem positive.

Nonpersisters also saw role conflicts, either present or anticipated, in marriage, and with friends and family, as a barrier to science persistence. This finding is important because few studies have addressed this issue at the undergraduate level as it relates to science persistence beyond the bachelor’s degree. In a related finding not seen in other research on undergraduates, the marital status of the nonpersisters at the time of graduation was determined and although less than one-third were married at that time, over three-fourths
believed that marriage affected their failure to persist, either due to issues related to children or inadequate time for both school and family. It is apparent, therefore, that at least for these successful females, if marriage occurs before graduation the chance for persistence in science is reduced.

A barrier to persistence that should be considered serious, but amenable to change, is lack of information concerning what to study. It ranked fourth as a barrier to persistence in science. This finding should serve as an alert to professors and advisors who are most apt to provide information on further science study other than the student’s peers. It should not be assumed that students have adequate, accurate, or pertinent information on graduate school, or that they will be assertive enough to pursue this information.

Several findings on nonpersisters are surprising. First, although they generally believed they were adequately prepared, their grades were high enough, and they could compete with others in graduate or professional school, they did not exhibit a strong level of agreement on self-confidence for further science studies. Second, contrary to prediction, few females perceived the rigors of further education as being a barrier to persistence. Also, nonpersisters failed to agree that a “chilly classroom climate” was a barrier to science persistence. Although past researchers have demonstrated this to be a factor in failure to persist in science during the undergraduate years, the nonpersisters of the present study rejected the idea that this was a problem for them in the pursuit of further science education. Finally, although for various reasons these females failed to persist in science, almost 90 percent indicated they had at some time considered doing so.
What changes could be made, therefore, that would help attract more females to graduate or professional school? Nonpersisters were questioned regarding their beliefs on this subject and they once again rejected the idea that academic standards, in the form of decreased entrance and course requirements should be instituted. Nonpersisters were more inclined instead to believe that the time required for research and degree completion should be shortened. This finding, together with the factor of role conflicts, likely indicate that other commitments make it difficult to stay in a long program of study. Other issues of access, however, were of even more concern to nonpersisters. The primary change they believed should be made was to make it easier to attend school part-time. Also, they indicated that video technology should be used to make course work more available to them. Recent developments in communication technology should make this more feasible in the future. Nonpersisters once again expressed their concerns about inadequate financial aid. It will take great efforts and sacrifice, however, on the part of schools and the government to overcome this barrier. More scholarships and work opportunities are just two factors that should be examined in order to develop programs that could be used to entice more females to persist in science instead of pursuing immediate job opportunities.

The present study, because it surveyed both persisters and nonpersisters allows comparisons to be made between the two groups of females regarding why they chose the paths they did after earning their bachelors' degrees. Both open-ended questions and tests of two-way ANOVAs were used to determine if differences existed.
When persisters responded to an open-ended question asking why they persisted in science beyond the bachelor's degree, four factors emerged as being the most important facilitators for their persistence. Of these, the most frequently cited factor was having received encouragement from others, particularly from parents, family, advisors, and professors. The insight on parents and family is important because most other studies examining this factor have either focused on high school students or undergraduates, and not on those who have persisted in science beyond the bachelor's degree. Comments by these females also indicated that for the majority, differential support from one parent or the other did not occur, therefore, disputing a finding in one study on graduate students.

The issue of advisor support allows for an interesting comparison between the persisters and nonpersisters because both groups of females attended college under the same advising system. While some persisters recognized having received support and encouragement from advisors, nonpersisters believed lack of information was a factor in their failure to persist. Nonpersisters also strongly indicated that in order to encourage more females to persist in science advisors should be encouraged to discuss with students the possibility of pursuing advanced science studies. However, the results of the two-way ANOVA failed to find a significant difference between the persisters and nonpersisters regarding their academic advising experiences. This may be partly attributed to the fact that not all of the questions on academic advising experiences were in regard to graduate or professional school advice.
Three other factors that appeared to be most important as facilitators for science persistence beyond the bachelor's degree are: having a strong interest in science, particularly as it relates to some aspect of health, medicine, or the human body; needing an advanced degree because it is required for a career choice; and believing that an advanced degree will increase job opportunities. In this respect nonpersisters and persisters differ because the nonpersisters believed they could obtain the job they wanted, or they indicated they had already obtained a job. Of course as suggested earlier, nonpersisters may seek jobs because of financial constraints.

It is perplexing that past science experiences and successes were ranked relatively low as facilitators for persistence, particularly because participation in science activities has been cited as a way to increase participation in science. However, it may be that persisters simply did not have opportunities to participate in such activities, or to earn awards or accolades for their accomplishments. Until they do, it will not be possible to assess their importance to persistence beyond the bachelor's degree. Also, role models were not considered by persisters to be strong influencing agents for persistence after earning the bachelor's degree, but were considered to be important for undergraduate persistence. This finding may be due to interpretation of the open-ended question, as previously discussed, or it is possible that role models for persistence to advanced science studies did not exist for the persisters.

This study also asked persisters to identify factors that could hinder success in graduate or professional school. The two most significant factors cited were experiences
with a "chilly classroom climate" and role conflicts, while factors that were less significant were the demands of further schooling, lack of female role models, lack of money, lack of confidence, lack of information, lack of motivation, and lack of preparation. Once again, the lack of concern over finances is in sharp contrast to the nonpersisters who saw this as the foremost barrier to persistence.

One of the more surprising findings of the present study, and particularly disturbing, is the prevalence of a "chilly classroom climate" in professional schools and schools of advanced graduate studies. Although both persisters and nonpersisters overwhelmingly indicated that they had not considered changing from science to another major because of experiences with a "chilly classroom climate," and nonpersisters strongly disagreed that "chilly classroom climate" experiences as undergraduates discouraged them from persisting in science, persisters had different experiences. Fifty percent of persisters indicated that a variety of experiences in graduate or professional school created difficulties for them.

The experiences of the persisters concerning a "chilly classroom climate" were numerous and varied, and therefore, the experiences could be grouped into 10 categories. From most to least numerous these responses indicated that there is: less respect shown females than males, sexist remarks are made by faculty, there is a lack of female faculty and peers, females are not part of the male network, females have been intimidated, females are not treated as students, instances of discrimination from professors have occurred, competitive environments are present, there are higher expectations for females than males, and problems with male peers have occurred. This finding should be considered a serious
one for females who have persisted in science. Researchers have found, for example, that instances of certain “chilly classroom climate” experiences can lead to emotional stress in females and can decrease their commitment to remain in graduate school.

As predicted, role conflicts ranked high as a reason why females find it difficult to be successful in graduate or professional school. The comments in this category were the most consistent of any other difficulties cited. Persisters stated that it is difficult to balance school and home life, particularly if children are involved. Therefore, in this regard, persisters and nonpersisters are alike because nonpersisters ranked role conflicts third in importance regarding why they failed to persist in science. However, for various reasons persisters have either found ways to resolve such difficulties or they have persisted in spite of them, unlike the nonpersisters.

Persisters were also asked to respond to questions associated with difficulties experienced in graduate or professional school. Responses to these statements did not reveal any surprising findings, but rather reinforced other findings of this study. For example, persisters continued to maintain satisfaction with their financial aid status, and continued to disagree that they were more respected than males for their opinions in graduate or professional school. Their responses also indicated that they have experienced “micro-inequities” because they failed to demonstrate strong levels of agreement or disagreement to questions regarding sexism.

Undergraduate experiences were also examined to determine if persisters and nonpersisters differed on six factors associated with undergraduate studies, to determine if
females who graduated with distinction differed from females who did not graduate with distinction regarding these six factors, and to determine if there was an interaction between persistence and GPA for each of these six factors. These factors were also used to determine if differences existed between two types of persisters--those who persisted to advanced graduate studies and those who persisted to professional schools of study. The six factors were "enjoyment of science as a discipline," "relationships with science professors," "self-confidence for science studies," "sexist nature of the science classroom," "masculine nature of the science classroom," and "academic advising experiences."

A significant difference was found to be present between the two groups of persisters on only one of these six factors. Females who pursued advanced graduate studies had a more positive attitude toward the factor "enjoyment of science as a discipline" than did females who pursued professional programs of study. Because this factor assessed attitudes toward the laboratory component of science study it would be of interest to identify when and how this attitude developed. Insights into these questions would provide feedback on ways to enhance the laboratory experiences for females at various levels in the educational process.

Contrary to prediction, persisters and nonpersisters did not differ on their enjoyment of science as a discipline. This factor was tested because previous research has not examined it as a link to science persistence beyond the bachelor's degree either because the population studied did not allow it to be (for example, laboratory science and mathematics students have been included in the same study) or it has not been studied at the level of college seniors or graduates. This researcher believed that students who persisted in science would enjoy the
laboratory component of their field of study to a greater extent than females who did not, and therefore, this factor could be related to science persistence. However, this failed to be true. Also, contrary to prediction, persisters and nonpersisters did not differ significantly on the factors “sexist nature” and “masculine nature of the science classroom” which were used to assess experiences with a “chilly classroom climate” during the undergraduate years.

It should be recognized that not only do persisters and nonpersisters fail to differ on their perceptions of the presence of a “chilly classroom climate,” but also that they rejected the idea that one even existed during their undergraduate years. These are important findings because they contradict the findings of some researchers. Several explanations may be offered to understand them. First, the most desired explanation is simply that sexism, as a result of actions of male peers and professors does not exist in the science classroom, nor do students in science develop a decreased interest in science because of a lack of female students and professors. Second, because the participants of this study came from a large institution they may have had little direct contact with their science professors because of large classes or because they were taught by teaching assistants. Third, in some areas of study there may be more female than male students which can lead to decreased contact with male peers. Fourth, successful females in science are not sensitive to factors associated with the presence of a “chilly classroom climate.” Finally, the definition and means of assessment for this construct differ from other definitions or methods of assessment so that comparisons with other studies cannot be made.
Three null hypotheses were rejected when significant differences were found to be present between females who graduated with distinction and those who did not on the factors: "relationships with science professors," "self-confidence for science studies," and "academic advising experiences." To understand these findings recall that females who did not graduate with distinction were still academically successful because their GPAs at the time of graduation ranged from 3.00 to 3.49. What the present study did not determine, however, was why this difference in GPA existed. For example, if differences in GPA were related to differences in science GPA, then interpretation of the findings of the present study might be aided. Without this knowledge, however, only tentative explanations can be offered.

It seems likely that the females of the present study resemble the females studied by Stansbury (1986). Stansbury studied undergraduate females in science and engineering and found that there was a positive relationship between the quality of advisor relations and the levels of assertiveness and self-confidence in these females. This led Stansbury to suggest that females are sensitive to the supportive features of the academic environment. According to Stansbury, therefore, the student-advisor relationship should be improved. The findings of the present study also suggest a link between self-confidence for science studies and the supportive features of the academic environment. However, the present study adds another dimension to the understanding of females in science because it introduced an additional factor—relationships with science professors. For females of the present study, those who graduated with distinction exhibited significantly more positive attitudes toward their self-
confidence for science studies, their academic advising experiences, and relationships with their science professors, than did their counterparts.

These findings raise questions that go beyond the scope of this study. For example, what types of factors are associated with increased self-confidence for science studies? How are the factors of self-confidence, academic advising experiences, and relationships with science professors related?

A final purpose of this study was to determine if any of the six factors related to undergraduate experiences could be used to predict persistence in science. Although the results of multiple regression analysis indicated that self-confidence for science studies and the masculine nature of the science classroom were predictors, they explained only a small percent of the variance. Therefore, they should not be considered significant when predicting persistence in science.

This last finding helps to increase our understanding of successful females in science by providing insights on factors which are not related to persistence. Although it was expected that some factors would act as predictors, this did not occur. Instead, a better understanding of what divides these two groups of females developed through other types of data analysis. It is therefore, apparent, that further research will be required to fully understand what factors are associated with science persistence. Only at that time can progress be made toward increasing the participation of females in science beyond the bachelor’s degree.
Research Contributions

This study is important because it has contributed to our understanding of females in science in several ways. Listed below are the research contributions.

(1) Previous studies have focused primarily on undergraduate or graduate students in the sciences. Few studies have focused on females who have dropped out of science after earning bachelors’ degrees. The present study adds to the limited body of knowledge on these students by focusing on science graduates. It enhances our understanding of females at the time when the decision is made to pursue or not pursue graduate education.

(2) This study narrows the population from which females were drawn for study. In particular, it has eliminated the areas of mathematics and engineering and has focused on the laboratory-based sciences. This provides for a better understanding of females whose academic experiences differ from other females because of laboratory-based activities. By also focusing on successful females in science it enhances our understanding of females who are most likely to persist to graduate or professional schools of study.

(3) Some researchers have suggested that female and male attitudes and perceptions are different enough that the two sexes should be studied separately. Because the present study addressed only females in science, issues that are potentially important to them could be incorporated into the survey instrument. This allows for a clearer understanding of factors related to science persistence in females.
(4) Previous studies have yielded inconsistent results on whether mothers and fathers exert equal influence on females for persistence in science during the undergraduate years. Results of the present study indicate that differential support does not exist.

(5) The present study has documented differences in attitudes between females who graduated with distinction and those who did not on factors related to undergraduate science experiences. Females who graduated with distinction had significantly more positive attitudes toward their self-confidence for science studies, their academic advising experiences, and relationships with their science professors than did females who did not graduate with distinction. Other factors related to undergraduate science experiences were also examined. These factors were attitudes toward the enjoyment of science as a discipline, the sexist nature of the science classroom, and the masculine nature of the science classroom. No significant differences were found between females graduating with distinction or not, and persisters or nonpersisters on these three factors.

(6) The present study has documented the persistence rates for successful females in science who attended a large midwestern university.

(7) The present study has contributed to the body of knowledge regarding why successful females in science persist or fail to persist in studies beyond the bachelor’s degree. In particular, it has demonstrated that persisters believe encouragement from others is the most important factor for science persistence. For nonpersisters, the issue of financial constraints was the most important factor related to failure to persist. Although other studies
have examined these factors, most of them have failed to focus on their significance for the college senior.

(8) A review of the literature indicated that it is unclear to what extent the factor of self-confidence for science studies affects the female college senior in her decision to persist in science. Results of the present study demonstrated that there is no significant difference between persisters and nonpersisters on their attitudes toward self-confidence for science studies. However, findings of the present study demonstrated that regarding this factor there is a significant difference between females with lower GPAs (3.00 to 3.49) and higher GPAs (3.50 to 4.00).

(9) The majority of previous studies have failed to address an important facet of science study—that is, the laboratory component. Because this is a factor unique to the study of certain sciences it should be included in studies where it is appropriate for the research population. When the present study failed to demonstrate a difference between persisters and nonpersisters for this factor, it demonstrated that interest in the laboratory component of science is not a factor related to persistence. Inclusion of this factor in the present study also allowed for a test of significance between females attending graduate school and females attending professional schools of study. Results of this test found that females who attended schools of advanced graduate studies had significantly more positive attitudes toward the laboratory component of their undergraduate science studies than did females who attended professional schools of study.
(10) There has been an absence of data on whether the presence of a “chilly classroom climate” during the undergraduate years prevents females from pursuing advanced studies. The present study provides data indicating that this factor is not a barrier to persistence for successful females in science.

(11) The present study has contributed to the body of knowledge that seeks to understand if barriers exist for females who pursue studies beyond the bachelor’s degree. By asking persisters to respond to factors that make graduate or professional school difficult for them, barriers faced by these students in graduate or professional school have been documented.

(12) The present study demonstrated that the presence of a “chilly classroom climate” acts as an important barrier to being successful in graduate or professional school. This supports previous research documenting the presence of sexism at advanced levels of study.

(13) The factor of role conflicts as it relates to science persistence has been in need of further study for several reasons: many studies are outdated; many studies fail to focus specifically on science students; and most studies approach this factor from determining marital patterns, divorce patterns, and/or parenthood status rather than determining how the factor of role conflicts fits into the picture of science persistence. As recently as 1995, Kallio (1995) noted that previous studies have failed to examine this issue.
A recent review of the literature indicates that there has been a decrease in the number of studies in the last few years examining issues related to science persistence in females. Therefore, the present study provides current data on this topic.

Implications and Recommendations

(1) Because approximately two-thirds of all the participants in this study first became interested in science by middle school or junior high it appears that interest in science can develop early in the educational process. Therefore, individuals who are in the position of having influence over females at this time should be encouraged to identify and implement activities which are helpful for stimulating and helping to maintain an interest in science. They should also be made aware of personality characteristics that may or may not send messages of encouragement for science persistence.

(2) Almost all respondents indicated that they had been exposed to one or more role models who became important for their persistence in science during their undergraduate years. Because high school teachers and college professors were most often cited, it is apparent that influence over science persistence can also occur late in the educational process. Therefore, these individuals should be made aware of the influence they have over science persistence and should be encouraged and educated as stated in the recommendations above.

(3) Persistence rates in science at advanced levels of study should increase if more financial aid is made available to successful students. Schools should first identify, however,
why persisters and nonpersisters perceive financial aid differently. In this study nonpersisters considered financial aid to be the foremost barrier to science persistence while persisters did not consider this to be a problem. Schools should identify why these differences exist. For example, are persisters from wealthier families? Do students receive any counseling on types of financial aid packages available to graduate students? Do students have enough knowledge to determine if undergraduate and graduate school expenses can be reconciled into a plan that makes persistence a viable option? Because it is usually difficult to increase the amount of financial aid availability these questions should first be answered.

(4) Lack of information was considered by nonpersisters to be an important factor related to failure to persist in science. In every case nonpersisters stated that they did not know what to study if they persisted in science. Degree requirements should be examined for the majors studied in this research project to determine if pertinent information on graduate or professional schools is made available to students. For example, students earning degrees in zoology are required to take a course entitled Zoology Orientation early in their studies. Although this class examines areas of specialization and career opportunities in zoology, the department should question whether or not the class is effective during the freshmen year. Would it better serve the students if offered later in the curriculum? The biology curriculum, however, offers two courses pertinent to career information. The required freshmen course addresses professional opportunities in biology and the nonrequired senior course investigates graduate school and employment opportunities.
Should the senior level course be required? Is there enough emphasis on graduate school opportunities? Departments should evaluate whether their courses are properly placed in the curriculum, whether they should be required of all students, and whether they are providing a balance of information on job opportunities and graduate school opportunities.

(5) Nonpersisters believe that access to graduate and professional school should be improved. Schools offering programs of advanced science study should examine ways to make their programs easier to complete on a part-time basis. For example, over half of the nonpersisters indicated that they would like to see video technology used in advanced programs of study. This would be problematic, however, for classes that have traditionally low enrollments. Schools should also address the issue of child care and time management if they are serious about attracting more females to areas of advanced study. Both persisters and nonpersisters noted that issues related to marriage, children, and family are important obstacles to science persistence. How can females reconcile balancing both school and family responsibilities? As part of the undergraduate curriculum can courses addressing these issues be made available to females? Can nonacademic programs be offered to help females resolve these issues? Are females, as undergraduates, exposed to other females who can share their insights on how both school and family can be successfully managed? All of these suggestions are worth investigating.

(6) It is ironic that persisters believed encouragement from others was the most important factor related to their persistence in science, but that nonpersisters failed to recognize lack of encouragement as a factor in their nonpersistence. This finding indicates
that encouragement from others may help nonpersisters overcome other barriers to science persistence. Because parents, advisors, and professors were most frequently cited as sources of encouragement, programs need to be targeted to these individuals to increase their awareness of this issue.

(7) Few persisters cited past science experiences and successes as being important for their persistence in science. It is likely that this is related to the lack of opportunities, specifically directed to females. Opportunities for participation in science activities should be made available at an early age and should be ongoing during the educational process.

Limitations of Research

A review of the methodology used in this study indicates that there are three areas which act as limitations for interpretation of the data. One limitation is related to the number of items that made up a construct after the use of factor analysis. In some cases the number of items that made up the construct might be considered to be too small by some researchers.

A second limitation is related to the use of open-ended questions for gathering data. Although this type of data collection is valuable for understanding an area of study, the descriptive statistics it yields can be difficult to interpret. For example, in ranking items by the percentage of respondents choosing each one it becomes difficult to determine the cutoff point regarding what is most or least important.

A final limitation is related to having considered the two types of persisters as one group of females. A clearer interpretation of the data would have been achieved if the
Persisters had been divided into females pursuing advanced graduate studies and females pursuing professional programs of study.

Suggestions for Future Research

Although this research project has contributed to an increased understanding of the participation of females in science it also leads to suggestions for further research.

1. It is unclear from the results of this study whether or not exposure to role models is important for persistence beyond the bachelor’s degree. It is possible that the problem lies with interpretation of the data, however, clarification of this finding would be aided by further research.

2. Although other research has demonstrated that mothers and fathers are not seen equally as role models influencing science persistence, the findings of the present study do not support this. Further study is needed to determine if differences between parents exist.

3. This study has demonstrated that the issue of role conflicts acts as an important barrier to science persistence beyond the bachelor’s degree. While other studies have focused on this issue as it relates to graduate students, future research should study college seniors to determine if the findings of the present study can be duplicated.

4. It is clear from the findings of the present study that a “chilly classroom climate” is not perceived as being present during the undergraduate years, nor does it cause females to consider changing majors. However, it does act as an important barrier to being successful in graduate or professional school. Because other researchers have found this factor to be
important in undergraduates it would be of interest to determine if the findings of the present study can be duplicated. It would also be of interest to study females from both large and small institutions and from public and private ones.

(5) Future research should determine if there is a correlation between the time of first recognition of science interest and persistence in science beyond the bachelor’s degree. Do experiences early in life encourage study in science at both the undergraduate and graduate level?

(6) The results of this study demonstrated that females who graduated with distinction differ significantly from females who did not graduate with distinction regarding self-confidence for science studies, relationships with science professors, and academic advising experiences. Future research should attempt to duplicate these findings. If these findings can be duplicated it would be of interest to determine if these findings are related. If they are, it would also be of interest to determine their relationships.

(7) More studies should be performed on females who have studied in the sciences having a laboratory component. Past research has frequently combined laboratory and nonlaboratory-based areas of study. This separation should help to clarify research findings that appear to conflict with one another.

It has been the intent of this research project to contribute to the understanding of the participation of females in science. By focusing on successful females this study provides data on females who are most likely to persist in science beyond the undergraduate degree. Because it is anticipated that there will be an inadequate supply of scientists to fill technical
and academic positions in the years ahead, it is in the best interests of the country to understand what factors are functioning to affect science persistence. Since females currently constitute the majority of undergraduate students, but yet they are not on parity with males in graduate school, their potential talents and contributions to society are lost. A thorough understanding of factors that influence the female college senior to persist in science is needed. Only then, will proposed interventions for increasing their participation in science become effective.
REFERENCES


APPENDIX A: COVER LETTER
January 4, 1995

Dear FIELD(3):

In recent years science educators such as myself have become increasingly concerned about the lack of female participation in science in higher education. I am a science teacher and a graduate student at Iowa State University, and I am conducting a study that focuses on the experiences of women who have studied science at Iowa State University. Specifically, this study will examine the experiences, the perceptions, and the attitudes of successful women in science. I am particularly interested in obtaining your responses on the enclosed questionnaire because you were a successful science student at Iowa State University. Your experiences in higher education will contribute significantly toward the understanding of successful females in science. The questionnaire has been designed to require a minimum amount of your time. Through pilot tests it has been determined that it will take less than 15 minutes to complete.

Although your participation in this study is voluntary, it will be greatly appreciated if you can complete this questionnaire prior to January 23, 1995 and return it in the enclosed postage paid envelope. This research will not be able to be completed unless I obtain a completed questionnaire from you. Your responses will be kept in strictest confidence. There is a code number on your questionnaire, used only for follow-up purposes, that will be removed before any data are recorded. Therefore, the responses you have provided will only be treated as aggregate data.

I appreciate your time and welcome any comments that you have concerning this study. If you desire, I will be pleased to send you a summary of the study results. You may indicate your wish on the questionnaire. Thank you very much for your cooperation and assistance.

Sincerely,

Diane Doidge
Graduate Student
Department of Professional Studies
Iowa State University

Dr. Larry Ebbers
Professor in Higher Education
Department of Professional Studies
Iowa State University
APPENDIX B: SURVEY INSTRUMENT
Part I. In this section I am interested in understanding the extent to which you believe various individuals have influenced your persistence in science up to and including your undergraduate college years.

1. When did you first realize that you were interested in science? (Please circle the number by the appropriate response)
   (1) Elementary School
   (2) Junior High or Middle School
   (3) High School
   (4) College

For purposes of this study a "role model" is defined as:
"Individuals such as high school teachers or counselors, college professors, parents, relatives, friends, or others who have exhibited personality traits, behaviors, and attitudes that have been positive influences on your persistence in science."

2. Do you believe you were exposed to any role models prior to and including your undergraduate college years?
   (1) No, but that was okay.
   (2) No, but I wish I had been.
   (3) Yes...

3. Who were these individuals? (Please circle all responses that apply.)
   (1) Mother
   (2) Father
   (3) Male Companion
   (4) Female Companion
   3a. Circle all responses that apply. Also, indicate sex with a circle. (M = male, F = female, B = both male and female)
   (5) M F B Grandparents
   (6) M F B Other relatives
   (7) M F B Friends
   (8) M F B Fellow Students
   (9) M F B High School Teachers
   (10) M F B High School Guidance Counselors
   (11) M F B College Professors
   (12) M F B Teaching Assistants
   (13) M F B Spouse
   (14) M F B Job Supervisor
   (15) M F B Other. Specify ______________________

4. In what ways were these role models important for your persistence in science? (Please circle all responses that apply)
   (1) They were enthusiastic about the study of science.
   (2) They were successful in their work.
   (3) I could identify with their job.
   (4) They encouraged me to study science.
   (5) They encouraged me to participate in science activities.
   (6) They helped me with science projects.
   (7) They allowed me to watch them in their work.
   (8) They allowed me to work with them.
   (9) I admired their dedication to their work.

5. Were you married, or did you have a male or female companion, at any time, while earning your bachelor's degree?
   (1) No. I was not married, nor had a male or female companion while earning my bachelor's degree. (Please go to page #2)
   (2) Yes. I had a male companion.
   (3) Yes. I had a female companion.
   (4) Yes. I was married.

6. Was your husband, or male or female companion, studying science in college?
   (1) No.
   (2) Yes.

7. Was your husband, or male or female companion, supportive of your science studies while you were earning your bachelor's degree?
   (1) No.
   (2) No, but I wish I had received support.
   (3) Yes.......... How would you describe the amount of support you received?
   (1) Some support
   (2) Moderate support
   (3) Strong support
Part II. In this section I am interested in understanding about your experiences in the science classroom.

To what extent do you agree or disagree with the following statements concerning your experiences in the science classroom during your undergraduate years in college? (Please circle the appropriate number to the right of the statement)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. I sometimes felt frustrated in the laboratory because I did not understand the purpose of the laboratory experiments.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>10. My science professors did not care about me as a person.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>11. It was more difficult for females to be successful in science than it was for males.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
<td>6 7</td>
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<tr>
<td>12. Often times I believed laboratory experiments were long and tiresome.</td>
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<td>2</td>
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<td>5</td>
<td>6 7</td>
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<td>13. My science professors respected me as a student.</td>
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<td>2</td>
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<td>5</td>
<td>6 7</td>
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<tr>
<td>14. In my science classes I was more capable, intellectually, than most of the other students.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>15. In laboratory sessions I found it interesting to collect data and interpret that data.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>16. I would have liked to have had more female science professors as my instructors.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>17. Although I received good grades in my science classes I found it difficult to compete with other students in the science classroom.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>18. I enjoyed the challenges associated with carrying out a well designed experiment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>19. I felt more comfortable with female science professors than with male science professors.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
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<tr>
<td>20. There was not much competition in the science classroom.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>21. Performing laboratory experiments was the most interesting part of studying science.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>22. My science professors were more interested in teaching students than in their research.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>23. It was difficult for me to be successful in science.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>24. I enjoyed performing and learning new laboratory techniques and procedures.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>25. If I needed help I felt comfortable seeking my science professors outside of class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>26. I enjoyed learning about scientific principles and applying those principles in the laboratory setting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
</tbody>
</table>

Part III. In this section I am interested in your experiences with a "chilly classroom climate." For purposes of this study a "chilly classroom climate" is defined as:

"The climate that exists in the science classroom which causes a decrease in female student interest in science, leads to anxiety in females, is considered by females to be a form of sexism, or can cause females to consider changing majors, or to terminate their studies in college."

To what extent did you experience a "chilly classroom climate" during your undergraduate years? (Please circle the appropriate number to the right of the statement)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Male students in my science classes made sexist remarks other to me or to other female students.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>28. Male students made me feel welcome in my science classes.</td>
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<td>2</td>
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<td>6 7</td>
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<td>29. I believe that the science classroom is biased towards males.</td>
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<td>6 7</td>
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<tr>
<td>30. Sometimes my science classes failed to stimulate or help me maintain my interest in science.</td>
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<td>2</td>
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<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>31. During my senior year of college I was more interested in science than I had been in previous years.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
<tr>
<td>32. I would have liked to have had more female students in my science classes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6 7</td>
</tr>
</tbody>
</table>
Please consider only your male science professors during your undergraduate years in college when answering the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>33. I was sometimes intimidated by my male professors</td>
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<tr>
<td>34. I was comfortable asking questions in my science classes</td>
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<td>35. I believe males were treated more fairly in my science classes than were females</td>
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<td>36. Male professors appeared to like female students</td>
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<td>37. Male professors made remarks in class that degraded females</td>
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<tr>
<td>38. Male professors did not use sexist language in class</td>
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<td>39. Male professors enjoyed establishing a competitive environment in my science classes</td>
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</table>

40. Did you ever consider changing from science to another major because of experiences with a "chilly classroom climate?"
   (1) No.
   (2) Yes.

Part IV. In this section I am interested in gaining information about your academic advising experiences at Iowa State University during your undergraduate years.

To what extent do you agree or disagree with the following statements?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. My advisor was helpful in answering questions about my science major</td>
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<tr>
<td>42. My advisor was interested in me as a student</td>
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<tr>
<td>43. My advisor was not a source of encouragement for my persistence in science</td>
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<td>44. My advisor was a good source of information about job possibilities in science</td>
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<tr>
<td>45. My advisor thought females should be in science</td>
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<tr>
<td>46. Advising sessions with my advisor were not helpful for gaining information about graduate school</td>
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<tr>
<td>47. Iowa State advisors do not try to encourage the development of male scientists than female scientists</td>
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</table>

48. Are you currently or have you ever been enrolled in a science program of study in graduate or professional (For example, Medical School) school?
   (1) No. (Please go to question #49)
   (2) Yes. (Please go to question #69 - page 4, Part VI)

Part V. This section pertains to students who have never been enrolled in a science program of study in graduate or professional school.

Begin here only if you have never been enrolled in a science program of study in graduate or professional school.

49. Please describe briefly the three most influential factors that helped you to make the decision not to enroll in graduate or professional school.
   (1)
   (2)
   (3)

To what extent do you agree or disagree with the following statements concerning your decision to not attend graduate or professional school?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>50. My courses did not adequately prepare me for grad/prof school</td>
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<tr>
<td>51. Grades in my science classes were high enough for grad/prof school</td>
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<tr>
<td>52. I did not believe I could compete with students in grad/prof school and be successful</td>
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<tr>
<td>53. My experiences with a &quot;chilly classroom climate&quot; discouraged me from considering grad/prof school</td>
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<td>54. Lack of encouragement from significant people in my life discouraged my interest in grad/prof school</td>
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<td>55. I believed I could get a good job without attending grad/prof school</td>
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<td>56. I could not afford to go to grad/prof school</td>
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<tr>
<td>57. I had lost some of my interest in science by my senior year of college</td>
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</tr>
<tr>
<td>58. I believed studying science in grad/prof school was mostly for males</td>
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<tr>
<td>59. I was discouraged from attending grad/prof school because of the long time needed for degree completion</td>
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<tr>
<td>60. The time required for grad/prof school would not have detracted from time to spend with my family and friends</td>
<td></td>
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<tr>
<td>61. I believed it would be too stressful to attend grad/prof school</td>
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<tr>
<td>62. I believed I would have too many roles to juggle if I attended grad/prof school</td>
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</tr>
</tbody>
</table>
63. Did you ever consider entering a science program of study in graduate or professional school?
   (1) No.
   (2) No, but there have been times when I wish I had done so.
   (3) Yes, but I never attended.

64. Were you married at the end of your senior year in college?
   (1) No
   (2) Yes

65. Did the possibility of marriage affect your decision to not attend graduate school?
   (1) No
   (2) Yes

66. How committed were you to the possibility of marriage and family life at the end of your senior year in college?
   (1) Strongly uncommitted
   (2) Uncommitted
   (3) Somewhat uncommitted
   (4) Somewhat committed
   (5) Committed
   (6) Strongly committed
   (7) No opinion

67. Did marriage affect your decision to NOT attend graduate or professional school?
   (1) No
   (2) Yes...In what way? (Circle all responses that apply)
   (1) I did not believe it was financially possible to be married and attend graduate or professional school.
   (2) I did not believe that I would have enough time to devote to both marriage and graduate or professional school.
   (3) I did not believe my spouse would support my attendance in graduate or professional school.
   (4) My spouse was in school, and it was not possible for both of us to attend.
   (5) It was more important at the time for my spouse to pursue his interests than it was for me to attend graduate or professional school.
   (6) I had children or desired to have children in the near future and did not believe that this was compatible with graduate or professional school.
   (7) Other. Please specify: ____________________________

68. In your opinion, which of the following changes could be made to attract more females to study science in graduate or professional school? (Please circle all responses that apply)
   (1) Shorten the time to degree completion
   (2) Make it easier to attend school part-time
   (3) Offer daycare at the graduate or professional school
   (4) Offer more financial assistance
   (5) Require less research time
   (6) Offer more work opportunities on campus
   (7) Make graduate courses available through some type of video technology to students who cannot attend campus classes
   (8) Decrease the course requirements
   (9) Lower academic entrance requirements
   (10) Increase the number of female professors
   (11) Encourage advisors to discuss with students the possibility of attending graduate or professional school
   (12) Other. Please specify: ____________________________

Please go to question #90 - page 5.

Part VI. This section pertains to students who have at some time enrolled in a science program of study in graduate or professional school. Begin here if you have at some time been enrolled in a graduate or professional school in science.

69. Please describe briefly the three most influential factors that helped you to make the decision to enroll in graduate or professional school.
   (1) ____________________________
   (2) ____________________________
   (3) ____________________________
70. Please list three reasons that you believe make it difficult for females to be successful in graduate or professional school.

(1)  
(2)  
(3)  

To what extent do you agree or disagree with the following statements concerning your experiences in graduate or professional school? (Please circle the number to the right of the statement)

<table>
<thead>
<tr>
<th>Experiences</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>No Opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>71. I believe male students show respect for female students . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>72. I believe I have been considered a valuable component of my research or study group . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>73. I do not believe female students are respected for their research efforts in graduate or professional school . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>74. I believe female graduate students are more respected than males for their opinions in graduate or professional school . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>75. I believe female and male students are included equally in matters affecting the departments in which they study . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>76. I believe female and male students are treated equally in their inclusion at professional meetings at the regional or national level . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>77. I believe female students show respect for female students . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>78. I believe I have been given adequate support from my professors for my research or other academic efforts . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>79. I have not been made to feel comfortable in social situations with my male peers and professors . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>80. Professors are accessible for helping students with their research or study efforts . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>81. There is a camaraderie present between male professors and male students than is missing between male professors and female students . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>82. The graduate financial aid given to students is not adequate to help students maintain their college enrollment . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>83. Students in graduate school with research assistantships have an easier time finishing graduate school than students with teaching assistantships . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>84. Females and males equally receive research assistantships . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>85. Females are not given the same consideration as males when being considered for positions in their research groups or other areas of study . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>86. Females are given the same respect as males from their male professors . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>87. There is a camaraderie present between female professors and male students that is missing between female professors and female students . . .</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

88. Have you, or are you currently studying to earn a Master's Degree?
   (1) No.                                                                                       
   (2) Yes. I am currently studying to earn a Master's Degree...Field of Study                      
   (3) Yes. I have earned a Master's Degree...Field of Study                                      

89. Have you, or are you currently studying to earn a degree other than a Master's Degree?
   (1) No.                                                                                       
   (2) Yes. I am currently studying to earn a (Type of Degree) ...Field of Study                   
   (3) Yes. I have earned a (Type of Degree) ...Field of Study                                    

Part VII. In this section I am interested in obtaining important demographic information from all participants.

90. What is your age group?
   (1) 20-23                                                                                      
   (2) 24-27                                                                                      
   (3) 28-31                                                                                      
   (4) 32-35                                                                                      
   (5) Over 35                                                                                     

91. What is your country of birth?
   (1) United States
   (2) Other. Please specify __________________________
   __________

92. When did you come to the United States?
   (1) Before elementary school
   (2) During elementary school
   (3) During junior high or middle school
   (4) During high school
   (5) After high school

93. Please indicate your race.
   (1) Caucasian
   (2) African American
   (3) Asian American
   (4) Hispanic American
   (5) Native American
   (6) Other Please specify __________________________

94. In what area did you earn your bachelor's degree? If you earned a double-major, please indicate both degrees.
   (1) Biochemistry (7) Genetics
   (2) Biology (8) Meteorology
   (3) Biophysics (9) Microbiology
   (4) Botany (10) Physics
   (5) Chemistry (11) Zoology
   (6) Environmental Studies (12) Other __________________________

95. In what year did you graduate with your bachelor's degree?
   (1) 1986
   (2) 1987
   (3) 1988
   (4) 1989
   (5) 1990
   (6) 1991
   (7) 1992
   (8) 1993
   (9) 1994
   (10) Other. Please specify __________________________

96. Students at Iowa State who earn a cumulative G.P.A. of 3.5 or higher for their bachelor's degree study have graduated "with distinction." Did you graduate with this recognition?
   (1) No
   (2) Yes

97. What is the highest degree completed by your mother? __________________________

98. What is the highest degree completed by your father? __________________________

99. I am interested in gaining more in-depth data from some participants. This will be gathered in the form of a focus group. Please indicate whether you would be interested in participating in these efforts. This is designed to take a minimum amount of your time.
   (1) No. I am not interested.
   (2) Yes. I am interested. Please list a number where you may be reached. __________________________

100. Do you desire to receive a summary of the results of this study?
    (1) No
    (2) Yes

Thank you very much for participating in this study. Have you answered all questions? Please return the questionnaire in the postage-paid envelope that is provided. Your responses will be kept confidential.

Iowa State University
Attn: D. Doidge
ISU Mail Center
Ames, Iowa 50010-9901
APPENDIX C. CATEGORIES OF RESPONSES FOR QUESTIONS.

Table C.1 Categories of responses for survey questions numbers 49, 69, and 70.

#49 - Please describe briefly the three most influential factors that helped you to make the decision not to enroll in graduate or professional school.

Money
Marriage, family, relationships, friends
Lack of motivation; tired of school
Graduate school characteristics (time, requirements, problems, not wanting academic route)
Lack of confidence
Lack of support and encouragement
Got job; job opportunities
Lack of information; unsure of what to study
Lack of preparation; poor grades; poor scores
Location
Changed interest from science
Not interested in further education; baccalaureate degree is sufficient
Conflicted with other goals
Miscellaneous
Intend to pursue graduate school soon or in the future.

#69 - Please describe briefly the three most influential factors that helped you to make the decision to enroll in graduate or professional school.

Increased job opportunities
Love, interest of science
Encouragement from others
Needed for career choice
Increased salary potential
Past science experiences
Influenced by others
Table C.1 (continued)

#69 (continued)

Personal motivation; satisfaction
Wanted more education or a better education
Past successes in science
Desire to help or work with others
Challenge; stimulation associated with college
Role models; mentors
Best option at the time
Money was offered
Female profession; high number of females
Miscellaneous

#70 - Please list three reasons that you believe make it difficult for females to be successful in graduate or professional school.

Chilly classroom climate; competition
Family, marriage, children
Lack of money; financial resources
Lack of confidence
Lack of female role models
Demands, difficulties of graduate/professional school
Lack of information
Lack of motivation
Lack of encouragement; support
Lack of preparation
Miscellaneous
No problems experienced
Table C.2 Categories of responses for survey question number 89.

#89 - Have you, or are you currently studying to earn a degree other than a Master's Degree?

1 - No

2 - Yes - I am currently studying to earn a (Type of Degree) ______...Field of Study _____

3 - Yes - I have earned a (Type of Degree) ______...Field of Study _____

Category that was added:

4 - Went on for further study, but did not earn Master's, PhD, or "graduate level" degree.

Table C.3 Categories of responses for survey questions numbers 97 and 98.

#97 - What is the highest degree completed by your mother? ______

#98 - What is the highest degree completed by your father? ______

Less than high school

High School

2 or 3 year certificate or degree

Bachelor's degree

Master's degree

Graduate level degree other than Masters
Table C.4 Categories of study for females who persisted in science after earning the baccalaureate degree; survey question number 101.

Persisters entering a professional program of study entered these types of programs:

- Doctor of Veterinary Medicine, DVM
- Doctor of Osteopathic Medicine, D.O.
- Doctor of Dentistry, D.D.S.
- Doctor of Medicine, M.D.
- Physical Therapy
- Physicians Assistant
- Pharmacy
- Medical Technology
- Bachelor of Science degree in Nursing, B.S.N.

Persisters entering a program of advanced graduate studies entered these types of programs:

- Master’s degree in an academic area of study
- PhD in an academic area of study
APPENDIX D. TWO-WAY ANOVA TABLES

Table D.1  Two-way ANOVA for testing the factor attitude toward the “enjoyment of science as a discipline.”

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>1.058</td>
<td>1.058</td>
<td>1.583</td>
<td>.210</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>.789</td>
<td>.789</td>
<td>1.181</td>
<td>.279</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>.242</td>
<td>.242</td>
<td>.362</td>
<td>.548</td>
</tr>
<tr>
<td>Residual</td>
<td>161</td>
<td>107.569</td>
<td>.668</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>110.028</td>
<td>.671</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table D.2. Two-way ANOVA for testing the factor attitude toward the “sexist nature of the science classroom.”

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>.481</td>
<td>.481</td>
<td>6.99</td>
<td>.404</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>.000</td>
<td>.000</td>
<td>0.00</td>
<td>.995</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>.381</td>
<td>.381</td>
<td>5.53</td>
<td>.458</td>
</tr>
<tr>
<td>Residual</td>
<td>160</td>
<td>110.110</td>
<td>.688</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>110.987</td>
<td>.681</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D (continued)

TABLE D.3 Two-way ANOVA for testing the factor attitude toward the "masculine nature of the science classroom."

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>1</td>
<td>.981</td>
<td>.981</td>
<td>1.152</td>
<td>.285</td>
</tr>
<tr>
<td>GPA</td>
<td>1</td>
<td>.059</td>
<td>.059</td>
<td>.069</td>
<td>.793</td>
</tr>
<tr>
<td>Persistence X GPA</td>
<td>1</td>
<td>1.789</td>
<td>1.789</td>
<td>2.102</td>
<td>.149</td>
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<tr>
<td>Residual</td>
<td>161</td>
<td>137.065</td>
<td>.851</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>.853</td>
<td></td>
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</table>
APPENDIX E. MULTIPLE REGRESSION FOR PREDICTING THE PERSISTENCE OF FEMALES IN SCIENCE AFTER EARNING THE BACCALAUREATE DEGREE.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
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<td>2.280</td>
<td>1.140</td>
<td>5.465</td>
<td>.005</td>
</tr>
<tr>
<td>Residual</td>
<td>161</td>
<td>33.591</td>
<td>.209</td>
<td></td>
<td></td>
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</tbody>
</table>