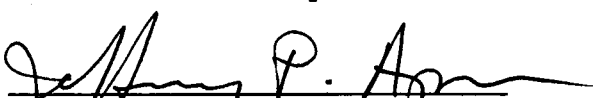
To the Graduate Council:

I am submitting herewith a dissertation written by Gail McDade Meyer entitled "The Influence of the Undergraduate Chemistry Department on Female Chemistry Majors." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Leadership Studies in Education.

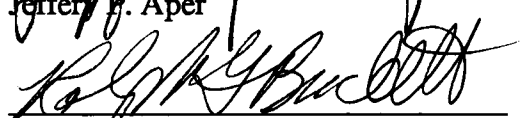


E. Grady Bogue, Major Professor

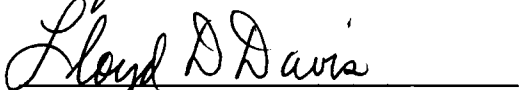
We have read this dissertation
and recommend its acceptance:



Jeffery P. Aper

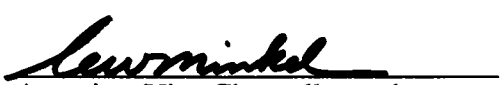


Ralph G. Brockett



Lloyd D. Davis

Accepted for the Council:



Associate Vice Chancellor and
Dean of The Graduate School

THE INFLUENCE OF THE UNDERGRADUATE CHEMISTRY DEPARTMENT ON FEMALE CHEMISTRY MAJORS

A Dissertation
Presented for the
Doctor of Education
Degree
The University of Tennessee, Knoxville

Gail McDade Meyer
December 1999

Copyright © Gail McDade Meyer, 1999

All rights reserved

DEDICATION

This dissertation is lovingly dedicated to my husband

Stephen Meyer

whose support, concern, and unfailing love

gave me the will to continue when the going got tough

ACKNOWLEDGMENTS

I have many people to whom I owe a debt of gratitude as this long road comes to an end. To my committee, Dr. Jeffery Aper, Dr. Ralph Brockett, Dr. Lloyd Davis, and especially my major professor, Dr. Grady Bogue, goes my heartfelt thanks for the support and encouragement throughout both my coursework and my dissertation preparation. I have gained much over the four years we have worked together.

I am also indebted to the members of the Chemistry Department at the University of Tennessee at Chattanooga for their continued encouragement, especially Ben Gross, Jim Narramore, and Tom Waddell, to the UC Foundation for its support of the sabbatical that allowed me to travel to my two case study sites, and to Mind Garden, Inc., for permission to reproduce the Mathematics Self-Efficacy Scale by Betz and Hackett.

One of the greatest benefits of being a student again was the opportunity to interact with my fellow students, many of whom I had never met even though we worked on the same campus. In particular, I am grateful that Ellen Neufeldt and I had those many trips to Knoxville together and that she continued to be an encouragement all during those lonely ABD months. Thanks go also to my good friend, Nancy Tolar, who carefully helped to transcribe many hours of interviews.

A special thanks is due my husband, Steve, and youngest son, Eric, who had to live with me during all the ups and downs of graduate school life. Thanks, guys.

ABSTRACT

Women continue to be underrepresented in the physical sciences, mathematics, and engineering. The problem for undergraduate departments in these areas is to identify factors under their control which may increase the number of women who select, and persist in, their majors.

The purpose of this study was to ascertain whether there is a difference in the environment of an undergraduate chemistry department which graduates a relatively high proportion of women to that of one which graduates a relatively low proportion of women. Case studies of two undergraduate chemistry departments at Carnegie Comprehensive I universities in the same state, one with a relatively high proportion of female graduates and one with a lower proportion, were conducted, and the data were analyzed for any positive or negative influence of the departmental environment on the women's selection of and persistence in the major.

Data were obtained from university and departmental documents, researcher observations, interviews, and the Mathematics Self-Efficacy Scale by Betz and Hackett (1993). A total of 12 faculty and 18 student interviews were conducted at the two schools.

Findings from the two departments may be summarized as follow:

1. Interview data from each department identified five critical aspects of the departmental environment.

2. Student interview data identified three categories of influence on the selection of and persistence in chemistry.

3. Analysis of data indicated that college factors are a critical link between school and major selection as well as pre-college and post-graduate plans. Some of these factors are within the school or department's control or influence while others are not.

4. Cross-case analysis found important similarities in the two departments which were relevant to the research. Nine relevant similarities were cited.

5. Cross-case analysis found important differences in the two departments which were relevant to the research. Eleven relevant differences were identified.

The two departments had common interests and problems representative of undergraduate chemistry departments in comprehensive universities. However, the differences in their environments, those factors over which they had control, appeared to have a significant impact on the selection of, and persistence in, chemistry.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION TO THE STUDY	1
Background to the Study	3
Statement of the Problem	5
Purpose of the Study	6
Research Questions	6
Significance of the Study	6
Research Design	8
Delimitations of the Study	12
Limitations of the Study	12
Assumptions of the Study	13
Definitions	13
Organization of the Study	14
II. LITERATURE REVIEW	16
Introduction	16
Historical Background	17
Overview of the Literature	18
Gender Studies on Self-concept, Self-efficacy, and Careers	19
Studies Focusing on the College Environment	22
Single-institution Studies	22
Multiple-institution Studies	26
Dissertation Abstracts	32
Summary	33

III. METHOD 34
Design of the Study 35
Population 38
Selection of Sites 38
Sample 40
Selection of Method and Instrumentation 40
Triangulation 43
Multiple-case Design 44
Procedures of Data Collection 45
Quantitative Data 45
Qualitative Data 47
Individual Interviews 47
Observations and Field Notes 49
Document Analysis 49
Researcher Bias 50
Human Subjects Protocol 51
Data Analysis 52
Quantitative Data 52
Documents and Field Notes 52
Interviews 52
IV. DATA ANALYSIS AND FINDINGS 55
Introduction 55
Part One: Helium University 56
Campus 56
Chemistry Department 57

Observations and Documents 57
Interview Data 60
Curriculum and Teaching 61
Research Expectations 65
Attitudes About Students 67
Recruitment 68
Gender and Personnel Issues 68
Selection of and Persistence in Chemistry 71
Pre-college Factors 71
College Factors 74
Within school/department control 74
Outside school/department control 77
Post-graduate Plans 78
Part One: Neon University 80
Campus 80
Chemistry Department 80
Observations and Documents 80
Interview Data 84
Curriculum and Teaching 85
Research Expectations 93
Attitudes About Students 95
Recruitment 97
Gender and Personnel Issues 99
Selection of and Persistence in Chemistry 100
Pre-college Factors 100

College Factors 102
Within school/department control 102
Outside school/department control 104
Post-graduate Plans 105
Part Two: Cross-Case Analysis 106
Research Question #1 106
Research Question #2 107
Curriculum and Teaching 107
Research Expectations 110
Attitudes About Students 111
Recruitment 112
Gender and Personnel 113
Research Question #3 113
Pre-college Factors 113
College Factors 114
Within school/department control 114
Outside school/department control 115
Post-graduate Plans 115
Conclusions 117
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 120
Summary 120
Conclusions 122
Research Question #1 123
Research Question #3 124
Research Question #2 125

Recommendations for Future Research 131

REFERENCES 133

APPENDICES 139

Appendix A 140

Appendix B 147

Appendix C 150

Appendix D 152

Appendix E 158

Appendix F 161

Appendix G 164

VITA 167

When I was in third grade, I had this elementary school teacher, and she thought I was just brilliant. Before then, I was just normal.

Helium University female chemistry major

CHAPTER I

INTRODUCTION TO THE STUDY

Historically, science and mathematics have been male-dominated disciplines in which few women participated and even fewer became role models. As women have entered professional fields in greater numbers, their representation in these disciplines has increased also, but not proportionally with the increased number of professional women overall. In 1994, women made up 46% of the US labor force, but held only 22% of the jobs in science, mathematics and engineering (SME) (Hanson, 1996).

The National Center for Education Statistics (NCES) collects, analyzes, and reports data relating to education in the United States. In its report, *The Condition of Education 1997*, it reports ratios of the percentage of females earning degrees in a specific field to the percentage of males earning degrees in the same field. A ratio of 1.0 would indicate identical percentages of males and females, while values greater than 1.0 would indicate that females are more likely than males to graduate in the field. A ratio of less than 1.0 would indicate that males are more likely to graduate in the field. Data for 1971, 1982, and 1994 are found in Table I-1.

As shown in Table I-1, the ratio of women completing bachelor's degrees in the physical sciences (including physics, chemistry, astronomy, and geology) **decreased** substantially between 1971 and 1994. This trend has not been explained. As the need for scientists and math-related professionals grows, it will be necessary to attract more women to these fields to meet the demands. As a result, researchers are very interested

Table I-1.
Female field concentration ratio of bachelor's degrees conferred: Academic years ending 1971, 1982, and 1994

Field of study	1971	1982	1994
Life sciences	0.54	0.82	0.88
Physical sciences	0.80	0.74	0.42
Mathematics	0.21	0.34	0.72
Engineering	0.01	0.13	0.15

Source: NCES, *Digest of Education Statistics* (based on IPEDS/HEGIS "Completion" survey) (as cited in NCES, 1997, p. 16).

in identifying factors which influence both the choice of major and the persistence in completing the degree for college women.

Background to the Study

As the barriers to women pursuing higher education decreased in the 1960s and 1970s, it might be assumed that equity among the various disciplines would be achieved. However, Astin in his 1993 study found that "stereotypic differences between men and women in behavior, personality, aspirations, and achievement" (p.406) widened during the undergraduate years, just as they did in his 1977 study. Removing the barriers to higher education itself did not address the problem of unequal distribution of women among disciplines, especially science, math, and engineering.

Of course, the education of males and females does not begin at the college level. The K-12 preparation of students is critical to their ability to succeed in a major in college. Farenga and Joyce (1999) found a strong gender effect on the selection of science courses by students as young as the fourth grade. Both girls and boys perceived physical science to be more appropriate for males. However, due in part to the increased number of math and science courses required by many high schools, the percentage of female students in 1994 taking science (except physics) and algebra II in high school was the same as that of the males (NCES, 1997). Ability differences between boys and girls in math and science are generally insignificant (except at the high end of math ability where males outnumber females 4:1 in scoring over 600 on the math SAT), and girls tend to have higher grades in math and science (Leslie, McClure, Oaxaca, 1998).

Boys, however, elect to take more upper level science and math courses and rate the usefulness of science and math higher than do females (Leslie et al., 1998). In addition, boys value science and mathematics more, and have a greater interest in and

more positive attitudes toward these fields (Betz & Hackett, 1983). These differences generally appear during adolescence, although the recent work of Farenga and Joyce (1999) indicates that the seeds are sown much earlier.

Studies have shown that even women who have equivalent abilities prior to entering college do not persist in the science fields at the same rate as their male counterparts (e.g., Seymour, 1995; Strenta, Elliott, Adair, Matier & Scott, 1994; Frazier & Frazier, 1992; Ware, Steckler, & Leserman, 1985). Theories to explain the attrition of women from science ranks abound but none have successfully explained all aspects of the problem. Some studies indicate that women have less confidence in their scientific ability (Seymour, 1995; Strenta et al., 1994; Frazier & Frazier, 1992; Ware, et al., 1985) and feel less comfortable in competitive classes than their male counterparts (e.g., Strenta et al., 1994; Manis, Thomas, Sloat & Davis, 1989). Ware and Lee (1988) propose that women who value a future homemaking role are less likely to major in science in college, while other studies focus on the self-efficacy of women for different careers (Lapan, Shaughnessy, & Boggs, 1996; Hackett, 1995, 1985; Farmer, Wardrop, Anderson, & Risinger, 1995; Smist & Owen, 1994; Smist, 1993; Lent, Lopez, & Bieschke, 1991; Brown, Lent, & Larkin, 1989; Lent, Larkin, & Brown, 1989; Marion, 1988; Lent, Brown, & Larkin, 1987, 1984; Betz & Hackett, 1983). The concept of self-efficacy, or the belief in one's own ability to be successful in a given endeavor, is generally credited to Bandura (1977) and has become one of the most cited factors in research in this area.

One of the most thorough studies of attrition and retention of both sexes was conducted by Seymour and Hewitt (1997). Their work consisted of a three-year ethnographic study at seven four-year institutions of different types and locations to discover what factors (present or absent) had a bearing on SME attrition and

persistence. The four public universities were large and offered large graduate programs as well. Although they interviewed both switchers and nonswitchers, and found more similarities than differences between them, they were concerned primarily with the factors which contributed to attrition. Rather than finding that the switchers were ill-prepared or academically inferior, they found a "high proportion of factors cited as significant in switching decisions which arise either from structural or cultural sources within institutions, or from students' concerns about their career prospects" (p. 32). Complaints about poor teaching were cited by both switchers and nonswitchers (90.2% of switchers and 73.7% of non-switchers), and 43% of switchers cited a loss of interest in SME majors.

It is evident that uncertainty exists about the reasons for the lower percentage of women who graduate with an SME major. However, most studies indicate that there are factors at the undergraduate level which can have an impact on the retention of women in these fields.

Statement of the Problem

The problem for undergraduate SME departments is to identify factors under their control which may increase the number of women who persist to graduation. It is not obvious why some undergraduate SME departments graduate a larger proportion of women than do others. According to the literature, success in math-related majors (e.g., chemistry) requires both mathematics ability and high mathematics self-efficacy. Therefore, incoming factors about the students themselves, as well as ongoing interactions between the students and the departments, may affect the final outcome: the completion of the degree.

Purpose of the Study

The purpose of this study was to ascertain whether there is a difference in the environment of an undergraduate chemistry department which graduates a relatively high proportion of women to that of one which graduates a relatively low proportion of women. Case studies of two undergraduate chemistry departments, one with a relatively high proportion of female graduates and one with a lower proportion, were conducted, and the data were analyzed for any positive or negative influence of the departmental environment on the women's selection of and persistence in the major. No previous study has attempted to determine why some departments graduate a higher proportion of women than others.

Research Questions

1) Do the departments that graduate a higher proportion of women enroll women with greater mathematics ability and self-efficacy expectations than those that graduate a lower proportion of women?

2) How do distinctive environmental characteristics found in chemistry departments affect the selection of, and persistence in, chemistry as a major by female students?

3) What factors influence the selection of and persistence in chemistry as a major for women, as perceived by female chemistry majors?

Significance of the Study

Studies have demonstrated that women do not choose, nor persist, in science, mathematics, and engineering disciplines at the same rate as men. Earlier studies have proposed pre-college factors (number of high school math/science courses; influence of high school teachers, family, friends), affective factors (confidence in math and/or science, comfort-level in SME classes, attitude about math or science, motivation,

enjoyment of SME classes, satisfaction, self-efficacy) and other factors (career considerations, grades in science, teacher interactions). Most studies have focused on why women leave the sciences rather than on why they persist. It is therefore difficult to say at the present time what might be done at any given institution to improve the retention of women in these fields.

However, what has not been addressed is the finding that some public universities are more successful in graduating women in the sciences than are others. Given that many of the factors under consideration are multidimensional and influenced by our society in general, it seems reasonable to ask what it is about certain schools that makes them more successful in attracting women to SME fields. Are the factors intrinsic to the school or department, or is the school located in a unique setting where there is better preparation, more support, or some other advantage for women in science?

Many of the earlier studies were performed at large research universities where undergraduate teaching may or may not be a high priority. Some studies pooled data from a sampling of universities, either in an attempt to obtain a range of types or to look at a particular type of student (as in highly selective schools). Only one study (Astin & Astin, 1992) appeared to assign any significance to the success or lack of success which the school or schools under study demonstrated in their graduation of science majors, and none focused on their success in graduating women in science, mathematics, or engineering.

Due to the large number of comprehensive public universities, increasing the number of females graduating in chemistry from these schools would have a large impact on the total number of women obtaining such degrees. Yet no study has specifically focused upon these schools, nor has any study recognized that some departments do a far better job than others in graduating female chemistry majors. This

study therefore addressed a void in the literature. In addition, its focus upon two departments from the same system, specifically chosen for their different proportions of female graduates, was unique. It has the potential to speak to undergraduate chemistry departments in a way in which no other study has.

Research Design

The study was performed using the case study method. According to Yin (1994), the case study method is useful when examining contemporary events in which direct observation and systematic interviewing can be conducted and documents and artifacts are available. The case study is particularly useful when "a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control" (p. 9). Although case studies cannot prove causality, descriptive case studies provide basic information upon which theories and comparisons can be built (Merriam, 1998).

A multiple-case design was employed, with each department serving as a separate case. Because each department was from a school with a different proportion of women graduating in chemistry, there was theoretical replication but not literal replication as would occur by using multiple sites with the same proportions. In addition, each case used an embedded design by surveying female students, conducting interviews with faculty and female students, consulting the records of the department, and taking field notes.

As Alexander Astin has discovered in his thirty years of studying college student development, students do not enter college as blank slates. Students enter college with certain characteristics, or what Astin refers to as *inputs*. Astin (1993) uses the input-environment-outcome (I-E-O) model "as a conceptual guide for studying college student development" (p. 7). The *environment* "refers to the various programs, policies,

faculty, peers, and educational experiences to which the student is exposed" (p. 7). In this study, the environment was limited to the undergraduate chemistry departments of two midwestern universities, although one could make an argument for other areas of the campuses as well. The *outcome* "refers to the student's characteristics *after* exposure to the environment" (p.7). The outcome of interest to this study was the selection of, and persistence in, chemistry as a major by female students. Although not actually a measure of a particular student's characteristics after exposure to the environment, it is a measure of the sum total of characteristics which lead women to graduate in chemistry.

The study's focus was on the effect which the environment of the undergraduate chemistry department can have on the proportion of female chemistry graduates. For this reason, two departments, with percentile ranks of 92nd percentile and 1st percentile in proportions of female majors, were chosen for conducting case studies. The researcher visited each department to make observations and conduct interviews, looking for departmental factors which could explain the proportion of female majors. These observations and interviews included factors such as faculty-student interaction, female role models, classroom climate, and research opportunities, all of which have been suggested in the literature as impacting the participation of women in science.

However, one cannot focus on the environment alone. Following Astin's model, it was possible that these two departments attract very different kinds of students and that it is the inputs that affect the outcomes, not the environments. In order to investigate this possibility, two measures of input were selected based upon the literature. Because there is considerable evidence to indicate that individuals must have both math ability and a belief in their ability to perform successfully in math-related majors, the average Math ACT was obtained for the female majors in each department and as many female

majors as possible were given the mathematics self-efficacy (MSES) instrument developed by Betz and Hackett (1983). The first measured the cognitive inputs of the students, while the second measured the affective inputs. These will serve as descriptors of the two samples in order to determine departmental effects on retention and graduation.

The MSES is a thirty-four item test composed of two subsections: Mathematics Task Self-Efficacy and Math-Related School Subjects Self-Efficacy (see Appendix A). The total score for the two subsections was used. In three separate studies, the internal consistency reliability values (alpha) for the total scale were .96, .92, and .94 (Betz & Hackett, 1993). Validity studies have compared MSES scores with math anxiety (conflicting results), educational and vocational behaviors (contributed significantly to the regression equation), and gender studies (Betz & Hackett, 1993).

The MSES was administered to female chemistry majors on a voluntary basis. The announcement and distribution took place in general chemistry classes as well as at least one upper level class, and anywhere the researcher had an opportunity to speak with female students. In addition, female chemistry majors were invited to participate in interviews to be scheduled with the researcher. The interview questions were open-ended, providing participants with an opportunity to add information other than that which was specifically requested (Weiss, 1994; see Appendix B).

The selection of the schools was performed by downloading the NCES data for chemistry for the years 1991-1995 into an Excel spreadsheet. The schools were then sorted by private or public, and public schools were retained. They were then sorted by Carnegie classification, and Carnegie Comprehensive I universities were selected due to the researcher's own interest in these schools and the lack of previous research on them in this area. In addition, due to their numbers and size, Carnegie Comprehensive I

universities are second only to Carnegie Research I universities in the actual number of chemistry undergraduates who go on to earn doctorates.

The decision was then made to eliminate all schools that had graduated fewer than fifty chemistry graduates during this time period (<10 per year) since their contribution to the total number was negligible. This left 72 schools that accounted for 5,357 chemistry graduates, 2,160 (40.3%) of whom were women.

It was not possible to calculate the female field concentration ratio in the exact same way that NCES does it, since they calculate the ratio of "females receiving degrees/female majors" to "males receiving degrees/male majors" and the number of majors was not available. Their calculation could be said to be a success ratio, and takes into account the total number of students who could possibly graduate with the degree.

To compensate for the inability to find the field concentration, several calculations were done. The first was a determination of the ratio of female chemistry graduates to all chemistry graduates for each school (chemF/chemA). This is an indication of the department's ability to graduate women. Next, a ratio of female chemistry graduates to all female graduates (chemF/AllF) was calculated for each school. This allowed some consideration to be made for the number of women on campus from whom the department could attract majors.

The two ratios for all schools were added, and the means and standard deviations for each ratio calculated. From this, z scores for each ratio for each school were found (indicating the number of standard deviations above and below the mean for each score). The z scores were made into transformed scores with a mean of 100 and a standard deviation of ten. The transformed scores for both ratios were added to give an

overall transformed score for each school. These were changed back into z scores and the schools sorted from high to low accordingly.

There were five schools from one state system which appeared on this list. They had total z scores of 1.34, -0.54, -0.59, -0.59, and -1.79. This gave a total range of 3.13 standard deviations. Their total transformed scores ranged from the 92nd percentile to the 1st percentile. The researcher selected the highest and the lowest schools on the list for the study (see Table A-2, Appendix C).

A description of each department (case study) was developed using the math ACT scores, MSES scores, interviews, observations, records, and field notes. These case studies were used to shed light on the interaction of undergraduate chemistry departments with their female students, and the effect which these interactions have on persistence to graduation.

Delimitations of the Study

The study was confined to the chemistry departments of two Carnegie Comprehensive I institutions in a midwestern state and students, faculty, staff, department heads, and records of these departments.

Limitations of the Study

It was possible that no discernible differences between the departments would emerge during the study, or that the differences would not be relevant to the differences in the proportion of graduating women. The schools were different in size, and one was more residential while the other was better described as a commuter campus . In addition, although both of the schools were located in the same state, they were not in the same city, and the perception of the city in which each was located may have impacted the number and gender of their majors.

There is always the possibility of researcher bias in a qualitative study, and this study was no exception. The researcher made every effort to consciously analyze and minimize any bias associated with the knowledge of which department was more successful in graduating female majors, and entered into each case study as open-minded and willing to learn as possible.

Although it is hoped that characteristics which were identified will be transferable, knowledge of factors such as the personal qualities of the faculty may be of limited use to other departments. In addition, pre-college factors and family issues are generally outside the realm of chemistry departments, and they may be powerless to overcome their effects.

Assumptions of the Study

In this study it was assumed that :

1. the criteria that were established for the selection of the campuses accurately reflect differences in the proportion of female chemistry graduates.

2. the investigator was able to recognize differing environmental characteristics of the departments through interviews, observations, and records.

3. those interviewed and surveyed were honest and introspective.

Definitions

1. Carnegie Classification - The Carnegie Foundation for the Advancement of Teaching classifies institutions of higher education into ten categories, depending upon the size of their baccalaureate and graduate programs, the amount of research support, and selectivity. This study focused on Carnegie Comprehensive (Master's) universities. These schools offer some master's degrees, and enroll at least 2,500 students.

2. environmental characteristics - For purpose of this study, these are factors which are under an individual department's control, such as course structure, class size, faculty-student interactions, funding for student research, and the degree to which the department welcomes students.

3. mathematics ability - In this study, mathematics ability was measured by mean mathematics ACT scores.

4. SME - Science, mathematics and engineering. In this study, science includes the physical sciences (e.g., chemistry, physics, geology) but not the life sciences (e.g., biology) nor the social sciences (e.g., psychology).

5. Self-efficacy expectations- According to Bandura (1977), self-efficacy expectations measure a person's beliefs concerning his/her ability to successfully perform a given task or behavior. For the purpose of this study, self-efficacy expectations were measured using Betz & Hackett's 1993 Mathematics Self-Efficacy instrument (MSES) and the total score used to compare the two samples of women.

6. WebCASPAR - the web site for the National Science Foundation's statistical database, found at http://caspar.qrc.com/cgi-bin/WebIC.exe?template=nsf/srs/webcasp/start.wi

Organization of the Study

The study is composed of five chapters. Chapter One consists of the introduction and background of the study, the statement of the problem and the specific research questions, the purpose and significance of the problem, research design, delimitations, limitations, assumptions, definitions, and the organization of the study. Chapter Two consists of a literature review of previous studies of factors impacting women in science majors. Chapter Three focuses on the research methodology, including the surveys and interview questions used for the individual case studies. Chapter Four provides an

analysis of the data. The final chapter, Chapter Five, summarizes the research and its conclusions, and provides suggestions for future research.

CHAPTER II

LITERATURE REVIEW

Introduction

The purpose of this study was to ascertain whether there is a difference in the environment of an undergraduate chemistry department which graduates a relatively high proportion of women to that of one which graduates a relatively low proportion of women. To address this issue, the following research questions were asked:

1) Do the departments that graduate a higher proportion of women enroll women with greater mathematics ability and self-efficacy expectations than those that graduate a lower proportion of women?

2) How do distinctive environmental characteristics found in chemistry departments affect the selection of, and persistence in, chemistry as a major by female students?

3) What factors influence the selection of and persistence in chemistry as a major for women, as perceived by female chemistry majors?

A literature search was conducted before designing the study to determine what factors have been determined to play a role in the selection of, and persistence in, science by female students. A thorough literature review took place during and after conducting the research as the two case studies were analyzed for potential impact upon their female students. The literature relevant to this study will be summarized in this chapter in two parts: 1) a brief historical perspective of women in science; and 2) an overview of studies focusing on the factors in the backgrounds and college experiences of students which affect their selection of science majors and careers.

Historical Background

Although women were earning doctorates in chemistry before the beginning of the twentieth century, the main employers and educators of females were the women's colleges (Roscher & Cavanaugh, 1987). During World War I, women were pressed into service in many previously male-dominated fields, and chemistry was no exception. However, following the war, discrimination against women increased as men in search of jobs recognized that women could be competitors for them.

> For example, the Illinois Steel Company announced in 1919 that: 'The women chemists of the Illinois Steel Company not only made good as chemists but showed their fine spirit by resigning in order to make places for the men returning from war work' (as cited in Rayner-Canham & Rayner-Canham, 1996, p. 204).

Women in the 1930s were more marginalized in the sciences than before. In 1929, 10% of chemistry PhD degrees were awarded to women, a figure which was not seen again consistently until 1972. In the United States there were fewer female medical doctors in 1930 than in 1910, and women in chemistry were more likely to be in the peripheral areas of chemistry: atomic science, biochemistry, and crystallography (Rayner-Canham & Rayner-Canham, 1996). The authors suggested that these areas were not as competitive as more traditional areas at the time. Further evidence of this concentration of women on the fringe of the field is obvious when one looks at a list of twelve of the women who have won either the American Chemical Society's Garvan Medal for Service to Chemistry or the Nobel prize. Of the twelve, ten were in the areas of biochemistry, radiation chemistry, or pharmacology/nutrition (Spector, 1995).

The picture in the United States for women in science, mathematics, and engineering has changed somewhat in the last twenty years. In 1995, young women were just as likely as young men to attend college, and just as likely to complete a bachelor's degree. However, while the gap between differences in the proportion of women and men earning degrees in life sciences, mathematics, computer science and

engineering has narrowed, the gap for the physical sciences has increased (NCES, 1997).

Just as women's colleges were critical to women's participation in academic chemistry early in this century, they have continued to play an important role. Between 1920 and 1980, more women who earned their doctorates in chemistry graduated from Mt. Holyoke (a women's liberal arts college in Massachusetts) than from any other college or university (Roscher & Cavanaugh, 1987). Over the last thirty years, liberal arts colleges in general have produced mathematics and science graduates at a rate over three times the national average. The 140 private Carnegie Liberal Arts I schools, with only 3% of the undergraduate enrollment, granted nearly 10% of the baccalaureate degrees in the natural sciences and mathematics (Narum, 1991). Public universities cannot turn themselves into small, private, liberal arts colleges. However, some public universities and undergraduate chemistry departments do a much better job of producing chemistry majors, especially women, than others. Is there something special about these schools and departments? Why do some women choose science and persist, while others do not?

Overview of the Literature

The relatively low number of undergraduates in the United States who choose a career in the physical sciences, mathematics, and engineering, has not gone unnoticed. A computer search of ERIC (Educational Resources Information Center) for 1982-1998 showed 1381 articles which included science and careers as keywords, 325 of which focused on women. However, articles focusing on women in chemistry are much fewer (96), and at the undergraduate level, even fewer (17). The metaphor of a "scientific pipeline" has been used to describe the passage of students through the K-12 educational system into college science, engineering, and math majors and eventually

careers. Both male and female students are lost throughout this pipeline, including the undergraduate years (Hilton & Lee, 1988; Matyas, 1992).

Research has identified both pre-college and college factors which contribute to this loss. Some studies focus on the initial selection of SME majors, while others are more concerned with retention. Studies range from those describing small samples at one institution at one point in time to large, longitudinal studies involving hundreds of institutions. Care must be taken in comparing data since some studies include not only the biological sciences, but even the social sciences, along with the physical sciences, drastically changing the results, especially when considering gender differences.

Gender Studies on Self-Concept, Self-Efficacy, and Careers

In 1977, Bandura posited that self-efficacy, or the belief in one's own ability to be successful in a given endeavor, is derived from four principal sources: performance accomplishment, vicarious experience, verbal persuasion, and physiological states. In 1982 Betz and Hackett presented a paper, which was later published (1983), in which they demonstrated a relationship between mathematics self-efficacy (as measured by their Mathematics Self-Efficacy Survey) and the selection of science-based majors in college. Males scored significantly higher than females on all three subscales, and the results seemed to support Bandura's claim that self-efficacy is crucial to the pursuit of that endeavor. Thus began a research focus to link self-efficacy (especially math self-efficacy) and math/science/engineering majors and careers.

Studies by Lent and others (Brown et al., 1989; Lent et al., 1984; Lent et al., 1987; Lent et al., 1989) found correlations between self-efficacy and the interest and persistence in science-related fields. Higher self-efficacy especially impacted the performance and persistence of students with lower aptitude. Other studies also found a direct relationship between math self-efficacy and the development of interests leading to

a choice of math-related majors (Bieschke & Lopez, 1991; Hackett, 1985; Lapan et al., 1996).

Using introductory psychology college students, Lent et al. (1991) determined that self-efficacy was a link in a pathway between past success and choice in a particular field. Success in a particular area increases one's self-efficacy for that area, thus promoting interest in the subject and a willingness to be exposed to it in the future. This increased exposure and interest provides the opportunity to choose that major or career.

Two studies which looked at minority participation in science (Grandy, 1998; Post, Stewart, & Smith, 1991) found that interest and commitment played a larger role than self-efficacy among females. However, if self-efficacy helps to determine interest, this is not a contradictory finding. In addition, Bandura (1977) stresses that strong self-efficacy can help one to overcome obstacles, thus increasing what would be perceived as commitment to an endeavor.

Chipman, Krantz, and Silver (1992) found a strong association between math attitudes and the willingness to consider a scientific career. Surveying over 1300 entering college freshman female students in a selective women's college over a three-year period, they found that math attitudes, especially math confidence, correlated positively with interest in science careers when quantitative SAT scores were held constant. The reverse, correlation of QSAT scores with science interest while holding attitudes constant, was not seen. In other words, ability without self-confidence does not support selection of a science major. They also found that a preference for working with things rather than with people correlated positively with choice of a scientific major.

House (1995) looked at achievement relative to attitude and years of high school math. House determined that initial attitudes of academic self-concept and achievement

expectancies were better predictors of achievement in introductory chemistry than were ACT scores or the number of years of high school math *for students who had the prerequisite math skills.* This reinforces the findings of Chipman et al. (1992) that, although ability and preparation are necessary for success, they alone are not enough if a positive attitude and confidence are not present. For females, self-ratings of mathematical ability entered the regression equation first, but self-ratings of overall academic ability was first for males (House, 1995). However, the overall regression equation for males explained 41.9 percent of the variance in chemistry grades, while it explained only 20.3 percent for females.

Smist and Owen (1994) attempted to explain the development of science self-efficacy among high school students. Although aptitude predicted science self-efficacy, other attributes and attitudes explained more of the variation in science self-efficacy found among students. Smist (1993) also looked specifically at self-efficacy in general chemistry at the college level. She found no significant change in self-efficacy toward chemistry as a result of the first-year course other than an increase in confidence in the laboratory, and no gender differences.

An excellent analysis of two national data sets (CIRP 1971 and 1980; National Longitudinal Survey of Youth, through 1993) by Leslie et al. (1998) found minimal ability difference between males and females in math and science, but a perception by males that math is more useful for them. This is supported by a recent study by Farenga and Joyce (1999) in which students in elementary grades were found to have strong stereotypical perceptions of physical science as a male domain. Leslie et al. reported that, whereas men tended to overestimate their abilities in math and science, females underestimated theirs, demonstrating a lower self-efficacy in the areas of math and science. As a result, they concluded that the effect of college grades was much greater

on women than on men. "For the physical sciences and engineering, the effect of having earned undergraduate grades of B or higher has almost twice the effect on achieving an undergraduate degree and almost a 50% greater effect on earning a masters degree for white women compared with white men (p. 259)."

In addition to self-concept/self-efficacy, other factors that emerged from the study (Leslie et al., 1998) were peer influence and goal commitment. The effect of peers was seen primarily prior to entering college, and women who were influenced to place a high value on attractiveness to men were less likely to select science or engineering fields. Plans for marriage by women were often a source of goal conflict and a test of commitment. Leslie et al. agree with Seymour and Hewitt (1992) that women's commitment to a career is often externally driven and is secondary to a commitment to family. However, they noted that success in introductory courses and personal contact with faculty can help increase the commitment to the field.

Studies Focusing on the College Environment

Single-institution studies

Many studies have been conducted at individual universities in an attempt to identify factors which influence selection and retention of an SME major among women. Ware et al. (1985) studied 300 freshmen at a large university. Their subjects were 150 male and 150 female students with equivalent mean SAT scores, high school preparation, and interest in science at the beginning of the year. At the end of the freshman year, only 50% of the women and 69% of the men who had expressed interest in a science career actually declared a science major (including life sciences). The authors used questionnaires and interviews to determine demographic information, choice of major, and plans for careers. Multiple regression analysis showed that different factors predicted selection of a science major for male and female students.

For women, predictors were: "1) having highly educated parents; 2) achieving outstanding mathematics scores on the SAT; 3) having a strong desire for control, prestige, and influence . . . ; 4) a desire for positive interaction with others" (Ware et al., 1985, p.75). For men, the predictors were: "1) having high grades in freshman-year science courses and 2) being certain about the choice of a major the summer before entering college" (p. 75). For both sexes, listing a science course as a favorite class during the freshman year was a significant predictor.

The one factor which predicted staying in science and which showed a strong difference by sex was enjoyment of the freshman science course. Men enjoyed the science course at a significantly higher level (49%) than did the women (31%). Although the women's science grades were actually slightly higher than the men's, they perceived that they were doing worse and blamed themselves for it. Men, on the other hand, blamed external factors for difficulties which they had in courses (Ware et al., 1985).

Boli, Allen, and Payne (1985) decided in a study of able students at Stanford that the disproportionately low number of women in SME was due to the lower mathematics ability of women when they entered the university (although the mean QSAT for these women was in the 97th percentile). The number of calculus courses in high school was not a factor in completion of the introductory chemistry course, but women had significantly lower grades and perceived the course to be more difficult. Boli et al. also found that, controlling for SAT scores, having a female mathematics teacher in high school lead to better performance in chemistry.

Boli et al. concluded that although gender had no direct effect on persistence, it had "large indirect effects on course performance [in general chemistry] through the SAT score and same-sex role models" (1985, p. 621). The authors also concluded that as

more women took more math courses, parity in SME would be obtained. Since the data were from freshmen entering in the fall of 1977, one wonders how long they thought it would take. This is particularly interesting in light of the fact that courses in high school mathematics did not have an effect on persistence in SME. Perhaps Stanford has a different profile than that of the rest of the country. Lovely (1987) also found gender differences in intentions to major in college science due mostly to relative differences in high school preparation, but did find greater attrition among less prepared women than men.

McDade (1988) interviewed men and women who had forsaken plans to major in chemistry and math, and found that the women had chosen chemistry initially for altruistic reasons, most commonly to enter medical or research programs which would help humankind. However, they left the major when they abandoned their idealized notions of professional life, began to consider themselves less competent and capable due to mediocre grades, or reacted negatively to external conditions in their departments.

Manis et al. (1989) surveyed 1210 senior students at the University of Michigan in 1987 to determine how their undergraduate years at the university had influenced their career plans, particularly with respect to scientific careers. For this study, science included the natural sciences, engineering and mathematics. When asked to identify the most important factor in selection of a major initially, students who persisted in the sciences were more influenced by career considerations and less influenced by enjoyment of the subject matter than students who selected non-science majors. The problems contributing to changing fields most frequently identified by the female students were lack of encouragement, poor teaching, and too much competition in the introductory science (chemistry was most frequently named) and mathematics courses. Some of these problems were exacerbated by a lack of preparation on the part of some

students, a lack of confidence about handling the work, and a lack of female role models.

The study (Manis et al., 1989) was difficult to interpret at times. It is quite long (43 pages including tables) and the text is filled with citations of percentages of this or that without indications of whether or not the differences were significant. Students were asked to agree or disagree with criticisms of science classes, rather than positive statements, and so may have been influenced negatively. At times the statements reported as most frequently cited in a portion of the questionnaire were cited by 50+% of the respondents, while at other times it was less than 20% of respondents, yet the conclusions were given equal weight in the text. Although the study included over 400 respondents, its applicability is limited due to some special factors common to a large public university. For example, one of the biggest complaints about entry-level chemistry classes was the poor teaching by graduate teaching assistants, most of whom spoke poor English and had a difficult time communicating with students. This would be especially detrimental to a struggling student or one who is lacking in self-confidence. At smaller undergraduate schools, however, this problem may be less likely to exist since there is less reliance on graduate students and adjunct faculty to teach introductory courses.

Frazier and Frazier (1992) looked at the factors affecting the mathematics dropout rate of honors mathematics students at the University of Michigan. They reported significant gender differences in areas of self-confidence. Female students responded more negatively to poor and alienating teaching and competitive situations. In addition, women sought more interaction with faculty, were more concerned about faculty expectations, and were more sensitive to faculty encouragement (or lack thereof). However, no data were given to support any of the claims, so the level of significance

was unknown. Also, the study was not longitudinal and did not address the impact of class and teacher interactions. Constantinople, Cornelius, and Gray (1988) did, however, attempt to describe patterns of interaction in the college classroom and for their university (Vassar), at least, determined that no inequities between males and females could be substantiated.

Donaldson and Dixon (1995) demonstrated that in at least one Canadian university, male and female students do not have identical experiences. "[W]omen students appear to be selecting courses differently because of pre-entry attributes and influences, the learning environment, use of university resources, varied behaviors during transitional periods, and perhaps most important, perceptions about their abilities to succeed within the academic environment although their final achievement scores are similar to those attained by male counterparts" (pp. 44-45). Women were less certain about career possibilities and more concerned about combining a career with family, yet they were more often working part-time than their male counterparts.

Multiple-institution studies

Other studies have looked at the persistence of women in SME at a range of institutions. Astin and Astin (1992) initiated a four-year longitudinal study in 1985 to identify factors that affected the interest of undergraduates in science majors and careers. Survey data were obtained from over 27,000 freshmen and their faculty at 388 four-year colleges and universities. They found that "[t]he strongest and most consistent predictor of changes in students' interest in science majors or careers is the students' entering level of mathematical and academic competency. Well-prepared students are more likely than other students both to persist in their initial choice of a science major or career and to be recruited into science majors and careers during the undergraduate years" (p. 2).

However, environmental factors at the respective institution did play a role in the selection of and persistence in a science major. "[T]he greater the proportion of a student's peers who are majoring in a particular SME field, the greater the likelihood that that student will end up choosing a career in the same field" (Astin & Astin, 1992, p. 3). In the physical sciences, the effect of number of majors was nonlinear; a critical mass was needed for a program to attract and retain majors. In addition, opportunities for interaction with peers, such as participation in honors programs or tutoring other students, were positive factors. Working off-campus and a lack of community on the campus negatively affected student satisfaction and interest in the major. Although independent research and participating in faculty research projects were positive factors in science selection and retention, faculty which were strongly research-oriented reduced persistence and negatively affected student satisfaction, as did attendance at a large institution.

A unique feature of this study by Astin and Astin (1992) was the addition of case-studies of five institutions which were "especially successful in encouraging retention and recruitment of students into SME majors and careers" (p. 7). Five common elements were observed on each of these campuses:

1) each placed an emphasis on teaching;

2) each offered research opportunities for undergraduates;

3) each demonstrated high levels of faculty-student interaction;

4) each had a supportive campus climate; and

5) each placed a high priority on undergraduate education.

An additional aspect of this study was an attempt to measure the self-concept of the students by asking them to rate themselves on math ability: lowest 10%, below average, average, above average, or highest 10%. Female science majors consistently

rated themselves lower than males, even when they were actually in the upper 10%. Both males and females of high ability showed lower percentages who defined themselves correctly after four years than in the freshman year. The decrease among women who initially described themselves as being in the top category was 50% by the end of the four years. This causes Astin and Astin (1992) to raise the question, which they do not answer: "Are declines in self-concept more frequently experienced in certain kinds of college environments" (p. 8-23)?

Another massive study (Ethington & Wolfle, 1988) used data from the 1980 sophomore cohort of High School and Beyond, a nationwide longitudinal study. Students were surveyed and tested in 1980, 1982, and 1984. It found that the number of mathematics and science courses taken in high school was the most influential variable in women's selection of quantitative fields of study in college. A study by Farmer et al. (1995) found similar results: the number of elective science courses in high school was the best predictor of persistence of women in science, math, and technology careers. Math self-efficacy also showed indirect effects. Ware and Lee (1988) also used the High School and Beyond data to show a negative relationship between women who placed a high priority upon family and their personal lives and their selection of science as a major.

Strenta et al. (1994) surveyed over 4800 students at four highly selective institutions to determine why highly capable women did not persist in SME majors at the same rate as men (48% female cf. 66% men). Their purpose was to test the "chilly climate" hypothesis which blames the classroom and departmental environment for the attrition of women in SME. The greatest attrition was in the areas of the physical sciences and mathematics where men were twice as likely to persist as females originally interested in the major. On the other hand, there was no gender difference in persistence

in biology, which was also the most attractive science to those students switching "into" an SME major.

When Strenta et al. (1994) performed logistic regression analyses of persistence on gender and grades in four majors, in chemistry and physics the difference in persistence for women was explained almost entirely by grades in science rather than gender or non-science grades. The authors discovered that women making the same grades in the introductory SME courses did in fact persist at the same rate. However, women's grades overall were lower in the SME courses (although higher in other courses) and the women were less confident and more depressed about their grades even when they were the same as that of the men. In fact, for the chemistry major, the only variable significant in predicting attrition in chemistry was that of grades in the science courses in the first two years. It is important to remember, however, that these students had an average SAT of 1310 and high school rank of 98th percentile.

Among the open-ended questions used by Strenta et al. (1994) were items asking for factors which influenced both the initial selection of a SME major and factors which led to a change in major. At a statistically significant level, women placed more emphasis than men on the influence of people (teachers, parents) in their choice of major. While both men and women who left SME majors named other fields as more interesting, women stated that they left science because the other field made better use of their talents (especially people talents) significantly more often than men. The authors concluded that although their study identified no obvious negative SME classroom climate, there was a greater sense of satisfaction found in other majors by those who left the SME major.

Seymour (1995) and Seymour and Hewitt (1997) also looked at the high undergraduate attrition rates of SME majors at seven different campuses. In their study,

they interviewed a total of 460 students to determine the different perceptions among males and females and "switchers" and "nonswitchers" in SME majors. The interview transcripts indicated that the "weed-out" course mentality of many introductory SME courses may not discourage the men as much as the women. Many women go through high school trying to please their teachers and valuing the praise of the teachers as much as the grades. When they reach the introductory SME courses where the competition for a few good grades is tough and the teacher does not appear to care who succeeds and who doesn't, these female students have no point of reference for their own success. Most male students, on the other hand, find the competitive atmosphere challenging and seem to feel that surviving the course will put them one step closer to being part of the SME fraternity. While the male students manage to avoid taking the faculty rejection of freshman initiates personally, most women do not and soon feel like they don't belong. This is interpreted as an inability to succeed in science, and a change in major is the natural consequence.

Seymour and Hewitt (1997) found the greatest difference between males and females was in selection of the major initially. Women were less clear about why they were majoring in SME, and felt a greater freedom to switch majors than did the men who felt greater familial pressure to remain. Disappointment with faculty as teachers was a key factor in failure to develop interest in the discipline for both males and females, but women needed a personal relationship with the teacher to maintain self-confidence and perform at their best. Even those women who initially expressed confidence in their ability to perform in SME were insecure after the initial college year and suffered diminished self-esteem and self-confidence in spite of good academic performance.

Seymour and Hewitt (1997), however, do not conclude that the climate of the SME classrooms is of no consequence. Rather, they argue that part of this phenomenon is due to the sudden position of women being in a negatively viewed minority in SME courses. Compared to high school classes, the number of women and women faculty in many SME courses is quite small. For white women in particular, Seymour and Hewitt propose that this is so unexpected and unfamiliar that it causes insecurity and a sense of isolation. Since there are relatively few female faculty in SME disciplines, the female students have few role models or counselors to whom to turn. However, African-American women were the exception in their study, showing independence and less need for discipline-related support. The authors offered no theories for this discrepancy.

Seymour (1995) argues that women have a more extrinsic sense of identity. She found that women: 1) more often seek to please others when choosing a major; 2) have a greater desire to form personal relationships with faculty; 3) suffer from large, impersonal classes; and 4) need encouragement to persist. She states that "persistence initiatives which do not take this into account simply will not be effective (p. 468)."

Strenta et al. (1994), Seymour (1995), and Seymour and Hewitt (1997) noted the importance of personal relationships for the female students and the need to identify the major with themselves and their talents. However, in an engineering study by Greenfield, Holloway, and Remus (1982), it was the men who were more influenced by family or friends to select their major while women were responding to recruitment. This study was conducted at one midwestern university, and may reflect a sample unique in some way. The women considered the first year a trial to see if the major was right for them and, as in Seymour's (1995) study, felt more free to "switch" majors than did the men.

In a meta-analysis of studies attempting to determine the factors affecting the choice of science as a major, Oakes (1990) determined that equally capable and prepared women defected from science areas at a greater rate than men. Many studies focused on one or more of the following factors: student choice of major, student persistence in a science major, student achievement in science and math at college and pre-college levels, student attitudes about science and science courses, and student self-confidence to perform well in science and math. As Oakes noted, the affective factors of attitude, motivation, and self-perception are conditional. Although positive affective factors are not enough to overcome poor preparation and opportunity, they are necessary if able women are to choose science and math and persist in them. In other words, both preparation and positive affective factors are needed.

Dissertation abstracts

With all of the interest being shown retention in science, and all of the unanswered questions, it is not surprising that a search of recent dissertation abstracts resulted in locating twenty-six dissertations on some aspect of women and science, and three specifically on the persistence of undergraduate women in science. Some of the factors identified in the abstracts were: 1) the factors influencing rural women to develop and maintain interest in an SME career (Daniels, 1997); 2) science self-concept (Carlin, 1997); 3) support networks and positive associations (Hyde, 1997); 4) academic involvement (Nguyen, 1996); 5) dissatisfaction (Lewis, 1994); and, 6) role of quality of instruction (Loftin, 1993). However, none of the abstracts reported a study that selected a particular school because it did or did not succeed in graduating women in science.

Summary

Research supports the premise that aptitude, self-efficacy, and the environment in which women find themselves all play a role in the selection of, and persistence in, science as a major in college. Some aspects of the equation (for example, number of math and science courses taken and much of the peer effects) occur before women ever reach higher education. However, many studies (especially Astin & Astin, 1992; Seymour, 1995; Seymour & Hewitt, 1997) point to particular environmental effects which influence the number of science majors. Seymour (1995) identifies key differences between male and female students which can lead to different outcomes for males and females in the same environment. These studies provide the basis for the research in this dissertation.

CHAPTER III

METHOD

This study focused on the environments of two undergraduate chemistry departments as described by students, faculty, records, and researcher observations. The purpose of this study was to ascertain whether there is a difference in the environment of an undergraduate chemistry department which graduates a relatively high proportion of women to that of one which graduates a relatively low proportion of women. Hopefully, it can then be hypothesized as to whether differences in the proportion of women who graduate with a chemistry major from different schools can be attributed to environmental effects of the chemistry departments. In order to address this problem, the following research questions framed the study:

1) Do the departments that graduate a higher proportion of women enroll women with greater mathematics ability and self-efficacy expectations than those that graduate a lower proportion of women?

2) How do distinctive environmental characteristics found in chemistry departments affect the selection of, and persistence in, chemistry as a major by female students?

3) What factors influence the selection of and persistence in chemistry as a major for women, as perceived by female chemistry majors?

This chapter describes the rationale for the design of the study, the population selected for the study, the method and instrumentation used, and the procedure used to collect and analyze the data needed to answer the research questions.

Design of the Study

Determining the factors that affect the number of women in science, mathematics, and engineering majors at the college level is a complex task. It is, in fact, only a sub-category of the impact that college has on students in general. Arguably the most cited study of college impact on student development, including the selection of a major, is that of Astin (1993). This landmark study, based upon data collected for the Cooperative Institutional Research Program (CIRP) from over 200 institutions, included data from over 20,000 students and 25,000 faculty.

To study college student development, Astin (1993) uses an input-environment-outcome (I-E-O) model. Astin describes this model as follows: "*Inputs* refer to the characteristics of the student at the time of initial entry to the institution; *environment* refers to the various programs, policies, faculty, peers, and educational experiences to which the student is exposed; and *outcomes* refers to the student's characteristics *after* exposure to the environment" (p. 7). In his study, Astin identified more than 140 entering student characteristics and more than 190 environmental characteristics. Add the possibility of interactions of any of these with gender, and the potential for influencing men and women differentially becomes enormous.

Astin (1993) has studied both cognitive (such as the ability to use reasoning and logic) and affective (such as attitudes and self-concept) outcomes using both psychological and behavioral data. Due to the large number of participants and the longitudinal nature of his work, descriptive data has of necessity been collected in a quantitative manner from pre- and post-tests and questionnaires. In addition, the final data collection and analysis must, due to the nature of the study, be completed *after* the student's completion of four years of college. However, in their 1992 report to the National Science Foundation, Astin and Astin selected five of the schools that they

determined to have strong positive effects on persistence and recruitment into the sciences and made site visits. These visits included surveys of and interviews with both faculty and students, and the qualitative data helped Astin and Astin (1992) identify five common elements of the selected schools: 1) an emphasis on teaching; 2) research opportunities for undergraduates; 3) high levels of faculty-student interaction; 4) a supportive campus climate; 5) a high priority on undergraduate education.

Therefore, it is evident that both *inputs* and *environment* can play a role in the selection of and persistence in science. In recognition of the importance of inputs on the impact of the college experience, this study sought to identify, on a much more modest scale, selected inputs that might influence the selection of or persistence in chemistry as a major. Because research has shown both math ability and math self-efficacy to be so critical to the selection of and persistence in physical science majors, these two areas were selected for comparison of the student inputs of the two departments. It was hoped that by identifying differences or similarities among the students in the two departments on these two inputs, input bias would be controlled to a degree which would "minimize the chances that your causal inferences will be wrong" (Astin, 1993, p. xvi). That is, a comparison of *environmental* effects would be more viable if *input* differences were identified.

The *environment* was generally limited to the departments of chemistry at each of the universities. The researcher did visit other areas on campus, and certain aspects of the campus as a whole (such as size and whether residential or commuter) were mentioned during the interviews. However, the impact of other areas of the university were outside the scope of this study and no attempt was made to investigate them.

The *outcome* of interest to this study was the selection of and persistence in chemistry as an undergraduate major. The outcome of persistence was not in question,

since the students selected were all chemistry majors. Instead, the selection of chemistry as a major was used to identify those individuals whose outcomes we wish to replicate, namely becoming and remaining a chemistry major, and to elicit from them their perceptions of why they made that selection.

In determining the most appropriate method for obtaining the information sought in the study, each research question was considered individually, resulting in both *quantitative* and *qualitative* methods being used. This "linkage" of qualitative and quantitative data is described by Miles and Huberman (1994) as a "very powerful mix" and can occur at three levels: 1) quantizing (or counting) qualitative information; 2) linkage between distinct data which provides confirmation via triangulation; and 3) overall study design, involving multimethod approaches. The illustrative design below demonstrates how the two methods have been interlinked in this study. According to Patton (1990), "The quantitative data identify areas of focus; the qualitative data give substance to those areas of focus" (p.132).

QUANT ----------> (selection of schools)	QUANT ----------> (student inputs)	QUAL ----------> (environment, interviews)	QUAL (analysis)

Although triangulation is an accepted means of combining data methods, another reason for the use of multiple methods is for developmental purposes, "wherein the first method is used sequentially to help inform the second method" (Creswell, 1994, p. 175). In this study, the quantitative data on the student inputs provided the researcher with important information on the students before analysis of the interviews. Similarly, the qualitative data provided personalities and individual experiences that "fleshed out"

the quantitative data. This combination of quantitative and qualitative methods has been used in other studies cited in this paper (Astin & Astin, 1992; McDade, 1988).

Population

Selection of Sites

The selection of the schools was performed by downloading on-line the National Center for Education Statistics (NCES) Survey Database for chemistry for the years 1991-1995 into an Excel spreadsheet (accessed through WebCASPAR at http: //caspar.nsf.gov/cgi-bin/WebIC.exe?template=nsf\srs\webcasp\main.wi). The schools were sorted by private or public, and public schools were retained. They were then sorted by Carnegie classification, and Carnegie Comprehensive I universities were selected due to the researcher's own interest in these schools and their infrequency in the literature. In addition, due to their numbers and size, Carnegie Comprehensive I universities are second only to Carnegie Research I universities in the actual number of chemistry undergraduates who eventually go on to earn doctorates.

The decision was then made to eliminate all schools that had graduated fewer than 50 chemistry graduates during this time period (<10 per year) since their contribution to the total number was negligible. This left 72 schools which accounted for 5,357 chemistry graduates, 2,160 (40.3%) of whom were women.

NCES calculates a "female field concentration ratio" by calculating the ratio of "females receiving degrees/female majors" to "males receiving degrees/male majors." Their calculation could be said to be a success ratio, and takes into account the total number of students who could possibly graduate with the degree. It was not possible to calculate the female field concentration ratio in this way because the number of majors for each school was not available.

To compensate for the inability to find the field concentration, several calculations were done. The first was a determination of the ratio of female chemistry graduates to all chemistry graduates for each school (chemF/chemA). This is an indication of the department's ability to graduate women. Next, a ratio of female chemistry graduates to all female graduates (chemF/AllF) was calculated for each school. This allowed some consideration to be made for the number of women on campus from whom the department could attract majors.

The two ratios for all schools were added, and the means and standard deviations for each ratio calculated. From this, z scores for each ratio for each school were found (indicating the number of standard deviations above and below the mean for each score). The z scores were made into transformed scores with a mean of 100 and a standard deviation of ten. The transformed scores for both ratios were added to give an overall transformed score for each school. These were changed back into z scores and the schools sorted from high to low accordingly.

There were five schools from one state system that appeared on this list (see Table A-2, Appendix C). This was of interest to the researcher because it offered an opportunity to limit the variables involved by focusing on schools in one state. These schools had total z scores of 1.34, -0.54, -0.59, -0.59, and -1.79. This gave a total range of 3.13 standard deviations. Their total transformed scores ranged from the 92nd percentile to the 1st percentile. All five schools were contacted to determine their willingness to participate in the study. When all agreed, the researcher selected the highest and the lowest schools on the list for the study. These schools were then given the pseudonyms of Helium University (highest) and Neon University (lowest) to maintain their anonymity.

Human subjects protocol was followed on all campuses. In addition to obtaining permission from the University of Tennessee, separate permission was obtained from each of the participating schools (see Appendix D). Letters were sent to the chemistry department head at both campuses (see Appendix E), and follow-up contact was made with the head and each faculty member by e-mail.

Sample

The two undergraduate chemistry departments selected for study were from schools given the pseudonyms of Helium University and Neon University. The Helium chemistry department had 94 chemistry majors, of whom 45 were female. Nine of these women were interviewed. The MSES was distributed to 37 female majors in various classes and labs, and 20 were returned. The department housed 14 faculty and academic staff at the time of the study, and seven were interviewed.

The Neon chemistry department had 63 chemistry majors, of whom 21 were female and nine were interviewed. The MSES was distributed to 17 female majors in various classes and labs, and 14 were returned. Of the 15 faculty and academic staff, five were interviewed.

All student interviewees were obtained by means of volunteers responding to announcements in various courses or labs. The researcher personally made these requests whenever possible. Faculty were selected to achieve a cross-section of males and females, tenured and untenured. In addition, the department chair and at least one of those teaching the introductory major course were selected at each school.

Selection of Method and Instrumentation

Research question #1: Do the departments that graduate a higher proportion of women enroll women with greater mathematics ability and self-efficacy expectations than those that graduate a lower proportion of women?

To measure the math ability *input,* mean math ACT scores were obtained for each department's female majors. Although self-reported data obtained during the interviews could have been used, math ACT scores do not suffer from response bias and are an accepted measure of math ability in the literature.

To measure math self-efficacy, the *Mathematics Self-Efficacy Scale* (MSES) was ordered from Mind Garden™, Inc., and permission to make and administer 100 copies of the test was purchased. Betz and Hackett (1983) developed this instrument to measure mathematics self-efficacy. The researchers used the MSES to determine that mathematics self-efficacy expectations, rather than mathematics ability, was a strong predictor of the selection of a math-related science major. This was confirmed in later studies (Lapan et al., 1996; Lent et al., 1991; Hackett, 1985) using the same or similar instruments. Although some of the interview data also relates to this topic, use of the instrument allowed for direct comparison between female students in the two departments.

The MSES is a 34-item test composed of two subsections: Mathematics Task Self-Efficacy and Math-Related School Subjects Self-Efficacy. The total score for the two subsections was used. In three separate studies, the internal consistency reliability values (alpha) for the total scale were .96, .92, and .94 (Betz & Hackett, 1993). Validity studies have compared MSES scores with math anxiety (conflicting results), educational and vocational behaviors (contributed significantly to the regression equation), and gender studies (Betz & Hackett, 1993). The authors of the test recommend using the Total Mathematics Self-Efficacy Scale score for comparison (Betz & Hackett, 1993). Results for each question and the total means for both schools can be found in Appendix A, Table A-1.

Research questions #2 and #3: How do distinctive environmental characteristics found in chemistry departments affect the selection of, and persistence in, chemistry as a major by female students? What factors influence the selection of and persistence in chemistry as a major for women, as perceived by female chemistry majors?

These questions could best be answered by using a qualitative approach. According to Merriam (1998), "[Q]ualitative research can reveal how all the parts work together to form a whole" (p. 6). In qualitative research, the phenomenon being studied is done so from the participants' perspectives with the researcher being the primary instrument for data collection and analysis. It usually involves fieldwork to obtain information first-hand, and uses an inductive research strategy. Sampling is "nonrandom, purposeful, and small" and the product is "richly descriptive" (p. 8).

Since the focus of the study was limited to the chemistry departments of two universities, a case study approach was used. According to Yin (1994), a case study "investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). In addition, case study research addresses "how" or "why" questions "asked about a contemporary set of events over which the investigator has little or no control" (p. 9). The case study approach was particularly appropriate to this study due to its special features (Merriam, 1998, pp. 29-30):

a. Particularistic - Case studies focus on a particular situation, event, program, or phenomenon. In this instance, the case studies are focusing on the environment of two undergraduate chemistry departments.

b. Descriptive - The end product of a case study is a rich, thick description of the phenomenon under study. In this instance, the researcher spent five days on each

campus using multiple approaches to describe, as fully as possible, the impact of the two departments upon their female majors.

c. Heuristic - Case studies illuminate the understanding of the phenomenon under study. In this instance, an analysis of the data from the two case studies provided insight into the process by which women chose and persisted in majors in those departments.

Data collection in case study research often involves three strategies: interviewing, observing, and analyzing documents (Merriam, 1998). All three strategies were employed in this study. Using multiple sources of evidence allows for "*converging lines of inquiry*" (Yin, 1994, p. 93).

Use of a combination of data types allowed for validation and a cross-check of the data. According to Patton (1990), this allows the researcher to "build on the strengths of each type of data collection while minimizing the weaknesses of any single approach" (p. 245). This triangulation increases both the validity and the reliability of the data.

In addition to describing the cases studied, all three types of data (interviews, observations, and documents) were analyzed and used to theorize about the phenomenon under investigation. This type of case study is said to be interpretive (or analytical), and is differentiated from purely descriptive case studies by "complexity, depth, and theoretical orientation" (Shaw, 1978, as cited in Merriam, 1998, p. 39).

Triangulation

Denzin (1978) has described four types of triangulation, all of which improve the credibility of a study. These involve the use of multiple and different sources, methods, investigators, and theories. This study makes use of three of these forms of triangulation.

1) Multiple and different sources: Multiple interviews were conducted on each site and many of the same questions were asked of different respondents. In addition, both faculty and students were interviewed. Researcher observations were made of the department and university, and document analysis was performed and compared to interview and observational data.

2) Method: Descriptive information on the two departments and their students was obtained quantitatively (through surveys and test data) and qualitatively (through interviews and observations).

3) Theories: Many different theories about the attraction to and retention of women in science helped to frame the design of the study and the interpretation of the data. Among the most critical to this study were those which focused on self-efficacy (Lapan et al., 1996; Hackett, 1995, 1985; Farmer et al., 1995; Smist & Owen, 1994; Smist, 1993; Lent et al., 1991; Brown et al., 1989; Lent et al., 1989; Marion, 1988; Lent et al., 1987, 1984; Betz & Hackett, 1983), ability (Leslie et al., 1998; Seymour, 1995; Strenta et al., 1994; Frazier & Frazier, 1992; Ware et al., 1985), confidence (Seymour, 1995; Strenta et al., 1994; Frazier & Frazier, 1992; Ware, et al., 1985), and environment (Seymour & Hewitt, 1997; Astin & Astin, 1992; Astin, 1993).

Multiple-case Design

This study employed a multiple-case design in which the two cases chosen were chosen for their contrasting proportions of women graduating as chemistry majors. This was then a theoretical, rather than a literal, replication. In theoretical replication, one selects cases which produce "contrasting results but for predictable reasons" (Yin, 1994). It was hoped that environmental factors within the departments could address the differences in their proportions of female chemistry majors.

The design in Figure III-1 for a multiple case study can be found in Yin (1994, p. 49), with some modifications. Although qualitative studies are generally not used to establish causality, both Patton (1990) and Miles and Huberman (1994) offer ways in which links between qualitative data describing the environment (cause) may be linked with its effects (outcomes). Patton reminds the researcher that speculations on causal relationships can be made, but they are *speculative* and should be so represented. Miles and Huberman state that qualitative analysis can identify mechanisms (not just associations) at a local level which are not limited to one time period. By cycling between variables and processes, causal theories can be developed. In this study, the researcher attempted to suggest a causal relationship between the environments of the two chemistry departments and their proportions of female graduates. However, as is true with most qualitative studies, the focus was to understand the two cases in depth, not to find out what is generally true of many departments. Therefore, generalizability is not one of the goals of the study.

Procedures of Data Collection

Quantitative Data

Mean math ACT scores were provided to the researcher by the departmental secretary at each school, and included all available scores for female chemistry majors. In each instance, some scores were unavailable due to missing data in the records.

The MSES was distributed to female majors in classes and in laboratories. The purpose of the study was explained, and both the MSES and the informed consent form (see Appendix F) were distributed. Students filled out the test on their own, and voluntarily returned it and the permission form to the researcher.

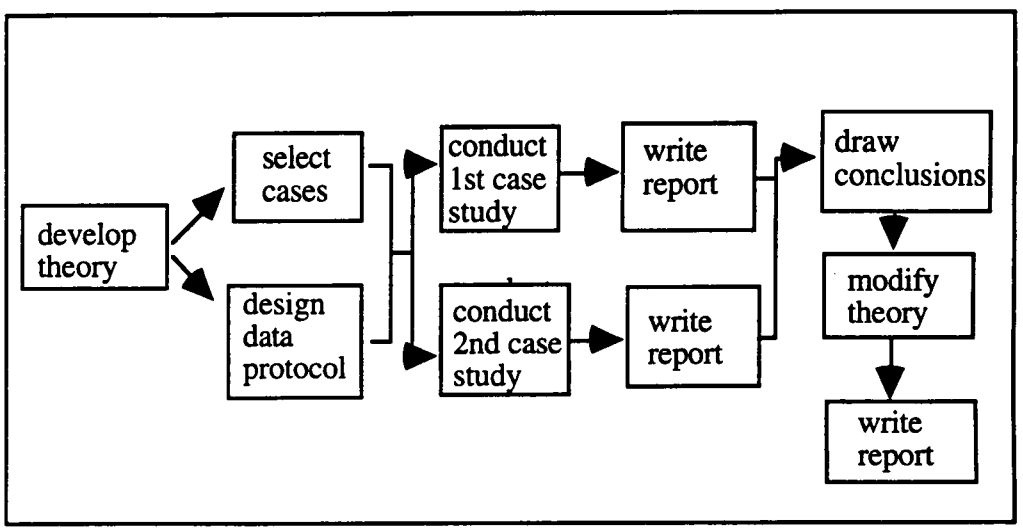


Figure III-1. Design For a Multiple Case Study
Adapted from Yin, 1994, p. 49

Qualitative Data

Individual interviews

The goal of interviewing in qualitative research is to allow each respondent to "define their world in unique ways" (Merriam, 1998, p. 74). This was accomplished by using a semistructured interview guide (see Appendix B) which allowed the interviewer to explore issues that arose in each interview as well as gain certain specific information from virtually all the respondents. The open-ended questions made it possible for respondents to describe the departmental environment and/or factors in their choice of a chemistry major in their own way and to develop their own categories of response (Patton, 1990). These questions developed from the literature, and were tested for clarity with several members of the researcher's home chemistry department before the research was undertaken.

Each campus was visited for five days. The researcher met some, but not all, of the faculty in each department and had both informal discussions and formal interviews with selected faculty on each campus. Faculty were selected for interviews in several ways. In each chemistry department, faculty most knowledgeable about the history and curriculum were selected, as well as those most involved in the introductory course. A cross-section was obtained by gender and tenure status, and faculty interest in being interviewed and availability were considered. Most interviews lasted from 30-45 minutes, although informal discussions allowed for follow-up in a few cases.

Interviews with students were conducted on a voluntary basis. However, a cross-section in academic class was obtained on each campus. Student interviews tended to be shorter, with 20-30 minutes being the average. Students at both schools seemed to be particularly busy and short on time, perhaps due to the time of the semester in which the interviews took place. At Helium, students placed their names on a sign-up sheet

centrally located in the department. At Neon, the location of the sign-up sheet was not centrally located and the researcher had to sign up students in classes in order to schedule the interviews. In each case, all students who signed up were interviewed (with the exception of two who failed to show). This provided a self-selected sample within the designated population of female chemistry majors.

Each interview took place in a designated location within the chemistry department of each school. The room was quiet and afforded privacy for the face-to-face interview. Before beginning each interview, the purpose of the study was discussed and the respondent signed the informed consent form (see Appendix F). Each respondent was given an opportunity to ask questions and was allowed to keep a second copy of the informed consent form. Respondents were asked if the interview could be tape-recorded, and all complied. Two recorders were used in each case for backup purposes.

One of the limitations of interviews for research purposes is the issue of respondent honesty during the interview process. The researcher attempted to develop a rapport during each interview by explaining the study and her role as a member of a chemistry department at another university. The respondents' body language and willingness to share information over and beyond that specifically called for by the question were noted. Since all of the respondents participated voluntarily, and most seemed eager to participate in a doctoral study, the researcher had confidence that the information obtained during the interviews represented the opinions of those being interviewed.

At the completion of the interview respondents were thanked, and if time allowed, the researcher made written or taped notes of anything of interest which might not be evident from listening to the tapes. Each tape was labeled with a code indicating whether the respondent was faculty or student, and the interview number. The tapes

were stored in a secured area except while being transcribed and were destroyed after the data analysis was complete. Three complete copies of the transcriptions were prepared. One was locked in a secure area while the other two were used for data analysis.

Observations and field notes

Classes were visited on both campuses, both to announce the study to students and to distribute the MSES, and also to observe the classrooms. Field notes were made during observations in classrooms, the department, and on the campus as a whole. The researcher walked around each campus, eating in the student dining facility, visiting the bookstore, and collecting university catalogs and newspapers.

Interactions between students in any departmental study areas, as well as informal interactions with faculty, were carefully noted. The presence of departmental student organizations and tutoring facilities were identified and investigated. On one campus, two individuals outside the department were suggested as being a source of information, and informal discussions were held with them.

Document analysis

In addition to the university catalog and newspaper mentioned above, each department was asked to provide data from their 1995-96, 1996-97, and 1997-98 American Chemical Society reports. This gave the researcher information on graduates for each year, by gender. Each department was also asked to provide any brochures which were prepared for distribution to potential students. Although both departments were asked about any retention studies they had done in which individual students were tracked, neither had done such a study on majors.

Of particular interest in the catalogs and brochures were the mission statements and the descriptors used to attract students to the campus and department. These were not

taken literally at face value, however. According to Merriam (1998), document authenticity and purpose must be assessed to determine bias in the documents. Since the researcher obtained the documents from the sources herself, authenticity was not in question. However, given that the purpose of the documents was both to inform and to recruit potential students, it was important not to use the documents in isolation but as only one source in the research process (Merriam).

Researcher bias

The researcher is a faculty member in a chemistry department at a Carnegie Comprehensive I university. As a result, she understood the type of departments and schools that she was visiting and was able to establish a rapport with most of the faculty and students quite readily. However, she brought with her sixteen years of teaching in one particular department, doing things in one particular way. It was necessary to be open-minded and non-judgmental about the methods used by each department visited. The researcher knew that one campus had much greater success in graduating female majors, and she worked diligently to be neutral in her outlook at each department. It was not the intent of the researcher to look for positives at one school and negatives at the other. For this reason, the researcher intentionally did not begin analysis of the data (other than that which is done subconsciously during the interviews themselves) from one school before visiting the second. Although most sources (e.g., Merriam, 1998; Miles and Huberman, 1994; Tesch, 1990) suggest that data analysis be done concurrently with data collection, the researcher felt that this would bias her second study and so chose not to begin analysis of the interviews until all had been collected at both sites. Since time was limited anyway, this was a prudent decision.

In addition, the researcher is female and was an undergraduate chemistry major in the department in which she now teaches. Although quite successful as an

undergraduate, she did not choose to complete the terminal degree in graduate school, for many of the same reasons which women cite today for not continuing in the sciences. Therefore, she is intimately familiar with the problems associated with being a woman in science. However, she did not wish to project her feelings onto those she interviewed and was careful to avoid anticipating responses.

Although Patton (1990) suggests that "reviewing the literature can present a quandary in qualitative inquiry because it may bias the researcher's thinking and reduce openness to whatever emerges in the field," he also states that a review of relevant literature can "help focus the study" (p. 163). The researcher chose to perform an extensive literature review both before and during the study. The literature helped to suggest the questions found in the interview protocol as well as to give guidance to the observations and document analysis. It also provided a rationale for selecting the two inputs which were used to describe the two student populations.

Human Subjects Protocol

Human subjects review protocol was followed in each step of the process. University of Tennessee approval was first obtained (see Appendix D). The researcher was in contact with the individual in charge of human subject review and approval at both Helium and Neon, and permission was obtained at each of those institutions as well (see Appendix D). An informed consent form was used for each respondent being interviewed, surveyed, or both. The one used at Helium was individualized to include the local director and protocol number, as requested. The informed consent forms are being kept in a secure location.

Interview tapes were kept in a secure location except while being transcribed by the researcher or transcriber. The transcribers agreed to strict confidentiality (see Appendix

G). All respondents were given pseudonyms in alphabetical order, and no identifying information was placed in the transcripts.

Data Analysis

Quantitative Data

The mean math ACT of female chemistry majors at Helium and Neon were acquired from the respective schools. These were compared to one another and to the 1999 mean math ACT for females obtained from the ACT Research Division.

The mean total scores on the MSES for both school were calculated. Although standard deviations for two sample populations were given in the *Manual for the Self-Efficacy Scale* (Betz & Hackett, 1993), these were scores from women in different majors. Since the mean Total MSES for both Helium and Neon were at the 90th percentile compared to these data sets, and the number of respondents at each school was small (20 and 14), a normal distribution was not assumed.

Documents and Field Notes

Documents and field notes were read for relevance to categories which emerged from the analysis of the interviews as well as used for descriptive purposes. The descriptions found therein, especially mission and recruitment statements, could be compared to both the perceptions of those interviewed and the observations of the researcher. These were then used to validate the interview and observation data when possible.

Interviews

A total of 30 interviews were conducted at the two schools. Each interview was tape recorded and later transcribed verbatim (with the exception of identifying information) by one of three individuals: the researcher or a transcriber. Proper names were omitted or pseudonyms substituted. Each interview transcript was coded for

school, faculty or student, sex, and the number of the interview. The final transcripts totaled 209 double-spaced pages for Helium University and 199 pages for Neon University. Three copies of the transcripts were made. One was stored in a secure location and the other two were used in data analysis.

Transcripts were analyzed in sets, first the faculty and then the students in one school, and then the faculty and the students in the other. One copy of the transcripts was used for reading and making notes in the margins about the type of information presented in the interview. These notes were the first step in developing categories into which the data fit. This process is known as coding (Tesch, 1990; Weiss, 1994; Merriam, 1998) and enabled the researcher to tell at a glance what type of information was contained on a page. It was also the beginning of data analysis as the researcher attempted to determine patterns. "The purpose of classifying qualitative data for content analysis is to facilitate the search for patterns and themes within a particular setting or across cases" (Patton, 1990, p.384).

The process used for developing categories was the constant comparative method. Although advocated by Glaser and Strauss for grounded theory development (Lincoln & Guba, 1985), the process of continually comparing data and placing it into categories can be used very readily in other qualitative studies as well. Merriam (1998) lists several guidelines for determining the efficacy of categories which were followed when analyzing the data from this study (pp. 183-184):

1) Categories should *reflect the purpose of the research*
2) Categories should be *exhaustive*
3) Categories should be *mutually exclusive*
4) Categories should be *sensitizing*
5) Categories should be *conceptually congruent*
(italics in original)

One copy of each transcript was read and cut into distinct data units (pieces of the interview ranging from a few words to paragraphs). These pieces were taped to index

cards. Each index card was coded on the back to identify the interviewee. Self-sticking pieces of note paper were arranged on a large white poster board, lying on a table, and labeled with the categories suggested by the initial coding. At the top of the poster board were placed the three research questions. The cards from one set of interviews (faculty or students from one school) were then sorted into stacks according to the categories. As sorting took place, categories were changed, added, or deleted. Reference was constantly made to the three research questions and the relevance of the categories to them.

Once sorting was completed, the cards were placed, one category at a time, on another large poster board with double-sided mounting tabs which enabled the cards to remain on the board with it standing vertically. At this time a descriptive analysis of each set of transcripts was written and a conceptual display of the data developed as suggested by Miles and Huberman (1994). This was repeated for each set of interviews for each school. Over 700 index cards were used and 42 pages of descriptive analysis were written.

The descriptive analyses were used to write the case study for each department. In addition to the interview data, observations and documents were used to interpret the effect of the environment of each department on its female majors. Finally, the two cases were compared and a composite conceptual map of the data was developed.

CHAPTER IV

DATA ANALYSIS AND FINDINGS

Introduction

The purpose of this study was to ascertain whether there is a difference in the environment of an undergraduate chemistry department which graduates a relatively high proportion of women to that of one which graduates a relatively low proportion of women. The results will be presented in this chapter.

The research questions which framed this study were:

1) Do the departments that graduate a higher proportion of women enroll women with greater mathematics ability and self-efficacy expectations than those that graduate a lower proportion of women?

2) How do distinctive environmental characteristics found in chemistry departments affect the selection of, and persistence in, chemistry as a major by female students?

3) What factors influence the selection of and persistence in chemistry as a major for women, as perceived by female chemistry majors?

Chemistry departments in two Carnegie Comprehensive I universities were selected for study based upon their relative proportion of female chemistry graduates. The two schools were given the pseudonyms of Helium University and Neon University for the purpose of this report. Scores from the math portion of the ACT exam and the Math Self-Efficacy Survey (Betz & Hackett, 1983) were used to describe the student inputs on the two measures specified in question one. University and departmental

documents, researcher observations and field notes, and faculty and student interviews provided the data for questions two and three.

The findings from the study will be presented in this chapter in two parts. In Part One, the case study of each department will be presented based upon all relevant data described above. Of particular interest to this study were environmental factors which had been identified in the literature as being relevant to selection and persistence in science, especially through their influence on self-confidence and self-efficacy: peer influence, the introductory course, grades, encouragement or the lack thereof, the emphasis on teaching, competition, faculty-student interaction, student research participation, and the general overall "climate" of the campus and department. In Part Two, a cross-case analysis of the two schools will identify differences and similarities and suggest possible relationships.

Part One

Helium University

Campus

Helium University is a mid-sized comprehensive state university of 5300 students (4800 undergraduates) in a city of about 10,800. Although in a quiet, rural area, it is also less than 30 miles from a large metropolitan area in a neighboring state. It began as a Normal School over 120 years ago, and when the original building was destroyed by fire near the turn of the century the community fought to keep the school in Helium (1997-1999 Undergraduate Catalog). The catalog also states that Helium "fosters excellence in teaching and learning" and "views the student as the major reason for its existence" (p. 5). Its first mission objective is to provide "an excellent environment for

learning, emphasizing the importance of faculty-student interaction in classrooms, laboratories, academic advising and co-curricular activities" (p. 5).

The Chancellor's message in the catalog states (p. 3):

> It has a tradition of informality and friendliness that it has retained from its beginning. There is a concern for the student as an individual and a dedication to excellence in teaching. It seeks to offer the means for each individual to develop talents and abilities to the fullest.

Although most students live on or near campus, many of them go home on weekends. Nearly 50% of the student body is from the neighboring state, whose reciprocity agreement with Helium's state system allows them to come for the price of in-state tuition. The campus offers a few master's degrees in select areas, mostly education. Textbooks are rented with the option to purchase at mid-semester. An active student paper publishes regularly. The campus is compact, and the cafeteria in the student center is small.

Chemistry Department

Observations and documents

There were 12 faculty and two academic staff on contract (one long-term) in the Chemistry Department during the fall of 1998. This did not include faculty on leave or recently retired who still participated in some activities. One faculty member was new for 1998, and a search was on for a faculty member to replace the short-term contract. Four of the 12 were women, as were both of the academic staff, so students walking the hall would have seen six women out of 14 occupied offices. Office doors were open more often than not, and office hours for each faculty member were posted.

The building which houses chemistry is over twenty years old but clean and open in its structure. The central stairwell is open, and a glassed-in area on the chemistry floor overlooking it (referred to as the fishbowl) serves as a student study area. The

chemistry department at the time of this visit had officially 94 majors, 45 of whom were women (48%). It offered the bachelor of science degree with several options, some of which are approved by the American Chemical Society (which stipulates certain courses and number of laboratory hours). The options available and the number of female majors in each are shown below:

Option	# of female majors
Regular chemistry	15
ACS-approved chemistry	12
Biochemistry	3
ACS-approved biochemistry	7
Secondary Education	4
ACS-approved polymer chemistry	1
	42 (3 unknown)

The non-ACS-approved options do not require calculus-based physics, and only secondary education requires advanced inorganic. Biochemistry options require two semesters of biochemistry and one of biochemistry lab. All require the same core courses, including 21 credit hours of chemistry, three semesters of calculus, and two semesters of physics (either calculus or non-calculus based). The department reports that approximately 50% of its graduates go to industry, 25% to graduate school, and 25% to professional schools (such as veterinary and medical schools).

Reports to the American Chemical Society for the three academic years 1995-1998 show the following breakdown in graduates:

Year	# of males	# of females	Total
1995-1996	9	6	15
1996-1997	6	15	21
1997-1998	9	7	16
	24	28 (54%)	52

Introductory general chemistry (approximately 400 during F98) was divided into five lecture sections with a maximum of 80 students per section. This lecture size is

considered large by the department, and was specifically mentioned by the department head in his interview. Each lecture met three days per week for 50 minutes. A fourth day of discussion divided each lecture into two groups, each of which met for one period with the lecture instructor. Therefore, each faculty member has five hours of contact for each lecture session. Labs have no more than 20 per session, and each has a faculty member as the instructor. Occasionally, a student assistant may also be available.

A departmental brochure states, "We emphasize personal interaction with students and we strive to keep lecture classes and laboratory sections small." It also lists major pieces of instrumentation owned by the department as well as its designation as the System Center of Excellence in Undergraduate Chemistry and Physics. The ACS Chemistry Club is noted for winning national awards as well.

In order to measure critical inputs of the students who enrolled as chemistry majors at Helium, the researcher requested the average math ACT of the female chemistry majors and administered the Math Self-Efficacy Survey (MSES) developed by Betz and Hackett (1983). Of the 45 female chemistry majors, math ACT scores were available for 40, and the mean math ACT for those students was 26. The MSES was distributed to 37 female chemistry majors (82%). Twenty (54%) were returned which resulted in a survey of 44% of the female majors. The students were asked to rate their level of confidence in accomplishing various math tasks (Part I) or completing certain college courses with an A or B (Part II) on a scale of 0 (no confidence at all) to 9 (complete confidence). The mean score for the female chemistry majors was 7.59 overall, with a range of 4.71-8.71 and a standard deviation of 1.03. This total score would place these women in the 90th percentile of all women taking the MSES according to Betz and Hackett (1993).

Interview data

Six faculty (three men and three women) and the long-term contract person were interviewed during the visit to Helium University in addition to nine female students. All students were traditional age, single and recently out of high school. There were four seniors, one junior, two sophomores, and two freshmen. Six began college as chemistry majors, five of them at Helium University. The sixth gave up a scholarship at another university to transfer to Helium. Of the three who began as other majors, one switched into chemistry from preveterinary medicine, while the other two chose chemistry in order to take classes with a friend who later dropped the science major. All but one came from a small town or rural area, and three had families who live on farms. Seven lived on campus, one lived in an apartment near campus, and the ninth lived nearby with relatives. Only one had a parent in math, science, or engineering, although there were other relatives in those fields. Two of their mothers were nurses. All respondents have been given pseudonyms for purpose of discussion.

One amazing fact to the researcher was that every student kept her interview appointment. Although students were encouraged to sign up whenever the researcher had an opportunity to speak with them in laboratories, classrooms, or in the hallway, each came and placed her own name on the interview list. Since the list was located on a door in a central location on the department's only hallway, students passed by it frequently. Nevertheless, even the faculty had a few cancellations or rescheduling, so the punctuality of the students was greatly appreciated and noted.

Faculty were asked about recruitment, retention, the interaction of faculty and students, and the best features of the department. Students were asked to describe their experiences in the department and if they would recommend it to a friend. The answers to these questions and subsequent conversations that followed form the basis of the

description of the environment of the chemistry department. Five categories of the environment pervaded the interviews: 1) curriculum and teaching; 2) research expectations; 3) attitudes about students; 4) recruitment; 5) gender and personnel issues.

Curriculum and teaching

The faculty spoke proudly about the chemistry program in general at Helium. Those who had been around in the late 80s when the designation as the system's Center of Excellence in Undergraduate Chemistry and Physics Teaching was awarded remembered applying for and winning that designation. They felt it was both a recognition of past excellence and a recruiting tool for the future. Although money was originally supposed to be a part of the designation, they received no funds, additional lines, or any other reward outside of the designation itself.

Faculty were proud that they teach all of the labs themselves, with only an occasional undergraduate assistant to help out. Most of the faculty offered help sessions outside of class time before exams, and there seemed to be a willingness on the part of the faculty to develop new programs and majors. In 1988 an interdisciplinary biotechnology major was developed. The department itself offered ACS-approved chemistry, biochemistry, and polymer options, in addition to regular Bachelor of Science options in chemistry, biochemistry, and secondary education. This required a great deal of flexibility on the part of the faculty and program, but there did not seem to be any resentment from the faculty.

They do not do any hard-sell recruitment among other majors, nor has there been any department-wide effort to change the introductory course to attract or keep more majors. There was some concern on the part of some faculty about retention, and a preparatory chemistry course is offered for those not yet ready to tackle the general introductory course. Faculty generally believed that all of those teaching the general

course tried to make it interesting, but each was allowed to teach the course in his or her own way.

One student who was involved in tutoring within the department described the department's attitude toward students who need help:

> And they're really trying to get the number of failures down, 'cause they feel it's a bad reflection on the chemistry department. It's hard on them in some ways 'cause they want to get the numbers down but yet they know some people just can't hack it . . . but they do offer, I mean, if you're willing to work hard and try to get back in it, they do offer the remedial chemistry and everything like that.

The department participated in a system-wide program on women in science a number of years ago, and the faculty were asked about that experience. The dean at that time had been very supportive, not only of the program but also of those faculty participating in it. There was an indication from one female faculty member that, when it came time for reappointment, the time spent working on redesigning courses and trying new teaching approaches was not a substitute for research in the area in which she had been hired with some members of the committee. However, the department's lack of a publication requirement for tenure made that less of an issue than it would be otherwise. When asked if there had been any long-lasting effects from participation in the program, faculty felt that there was more group activity being used both in classrooms and laboratories, and that even those who did not embrace changes initially had been affected.

The main approach to teaching as observed by the researcher could be called the "casual lecture" approach. Although still a didactic approach, there were pauses for questions and even an occasional question placed to a student. The fourth day of the general chemistry course, the discussion day, elicited the most attempts at group work and even some simulations. This day is reserved for review; no new material is presented. Each faculty member teaches two discussion sections for each lecture

section, thereby breaking up a lecture of approximately eighty into two discussion sections of approximately forty. There were comments that these were really getting too large, and the current department head felt that the faculty would support dividing the lectures into three discussion sections if rooms could be found. He did not believe they would see the additional hour of contact to be a problem.

Faculty mentioned assigning problems on web pages, assigning student journals, using molecular software on the internet, using group worksheets, and doing simulations as alternatives to straight lecturing. Students at the sophomore level are encouraged through the promise of extra credit to attend senior-level seminars, and told not to be discouraged if they don't understand them! Although there are no discussion days for the sophomore-level course, organic chemistry, it was evident from comments from at least one faculty member that help is available. Nancy, the most senior female faculty member, not only offers a help session before each exam, but she helps students to focus for the exam by telling them, in general, what will be on the exam. She also commented that she has postponed an exam when she felt the entire class was just not ready. Mary, who taught analytical chemistry, uses editorials from an analytical journal to help her students "see the broad scope of analytical chemistry and where they fit into that." She wanted them to connect future career choices with the course. Overall, there was an air of the courses being taught with the students in mind. Perhaps Jack summed it up best when he said, "You teach what the students need to know, not what you want to teach."

The administration had demanded increasing the numbers of students in lecture and laboratory over the years, and that was seen as a detriment. The two-credit organic lab for the majors was seen as a tremendous positive for the program: "It's got a reputation as the place to be. And that's taken us a long time to build that." General chemistry

"belongs" to anyone interested in it, not just physical and inorganic faculty as it had historically. Some faculty had as many as three different preparations per week. When asked, faculty in the large sections of general chemistry said they knew about 65-75% of their students by name.

One aspect of Helium's program became immediately apparent when talking with the students. Entering freshman chemistry majors are encouraged to sign up for one section of the general chemistry lab which is called the majors' section. Although designed for the chemistry majors, other science majors are free to enroll as well. There is also a special section for the second semester of general chemistry lab. In organic, the majors' section meets two days per week, three hours per day, instead of the one day like the regular section. These labs are intensive, but rewarding, experiences for the students.

> I really liked it. I'd never had a really intensive lab experience before . . . but I had a really great teacher for both semesters, and we just had a really great time and I learned an awful lot from them.
>
> And like in lab this year, I love it. I make a ton of mistakes, and [teacher] is just totally, she's like, that's what you're learning. That's why you're here. You learn from your mistakes.
>
> I liked the size of it, because you get a lot more personal information and you can get more interaction with the teacher. . . I hated my [regular] gen chem lab my first year here.
>
> . . . he always expects more of us, you know . . . But it's kind of nice, him expecting more too, 'cause then you put more effort into it and you learn a lot more.

A number of the students spoke of the relative ease of the introductory course, but most indicated that it served to give them confidence.

> It's kind of just repeated stuff that we learned two years ago. If there's something that comes up that I don't remember, I just look at my high school notes. Usually it just clicks right away.
>
> It was almost totally review first semester. I didn't study at all . . . this year organic is like, different. . . and I'm having to study more and get into the school.

> No, it's not a lot new, it's just a lot faster. Nothing that I haven't seen before. That's reassuring.

Although these opinions were shared by many of the students, there was another side to the story. One of the freshmen described the introductory course as "really intimidating at first" and said that she knew a lot of chemistry majors who were switching to other majors. This same student was having trouble finding time to study, and found that the discussion days helped her to "have this special time set aside that you work on your problems." Obviously, the women being interviewed for the most part were the ones for whom the first year course was not a deterrent to the major. When one of the freshmen was asked if she felt she was in competition with other students in the introductory course, she replied:

> No, and I'm very surprised at that 'cause I have a friend who's going to [another school in the same state], and she's going into dental school, so she's also in the chemistry program there, and there's major competition there. She's like, just totally stressed, and I don't feel any of that kind of stress, the competitive stress, here at all.

Research expectations

Oprah, the newest member of the faculty, was asked about the expectations of the department and whether or not she felt they had been expressed clearly. Not only did she indicate that they were, but the department's record of providing tenure to those it has hired indicates the same. If there had been a number of non-tenure decisions or non-reappointments it was not evident to the researcher. New faculty are encouraged to secure outside funding whenever possible. The school has a positive track record in securing NSF funding for equipment, and faculty are urged to seek grants for their own research as well.

Most of the major options in the chemistry department require that a student spend at least one semester doing research with a faculty member, and the department seems to

expect that faculty will be in the laboratory working with students. Although there is not a publication expectation for promotion and tenure, being involved with research with students is vital. The disadvantage of education grants, as one faculty member put it, is that they don't generally involve students. Oprah, in fact, chose to come to Helium specifically because she wanted an institution where the undergraduate educational experience was stressed, and teaching was not secondary to publishing. There is also an attempt to get the students to American Chemical Society meetings where they can participate in poster sessions.

The process of assigning students to research groups and finding topics for them to work on is very informal. Each year the department posts the research interests of the faculty and students usually just "show up at their doors" to ask to participate. Often, students in upper-level courses will be guided by faculty into projects in which the students appear to show interest. According to faculty interviewed, students are rarely if ever turned away from their first choice, and room is made for all. Students who are presenting their research in senior seminar are all provided training in Powerpoint presentations, and must give several practice talks before their seminar. Students in some upper level courses are also required to present their projects at a university-wide poster session. As one faculty member put it:

> But this really going into the lab with your majors is where you have an impact. They go back to their schools, tell their high school teachers of the experiences they have, and that's what builds a program. They go on and do well in graduate and professional schools or in work. And that's what the loop's about.

Undergraduate research is a required part of the curriculum for majors in the ACS-approved tracks. During the week spent observing, many students were seen working in the laboratories on their research projects. Therefore, the upper level students were asked about how they selected their research projects and how they felt about the research experience. Eileen gave a typical response.

> So I went in to talk to Dr. [advisor]. . . I said, 'Well, I'm going to take research.' She said, 'Well, what do you want to do research on?' [Student describes her interests.] The next day, she says, 'I've got a research project for you!' She talked to Dr. * and Dr. ** and Dr. * has this thing and he wants you to work with the IR, and I was like, OK. So I had a research thing in one day.

Cathy described the day when she finally got the product she had been trying to synthesize for an entire semester as "a really good day." Frances, who had done research both at Helium and during an internship at a large university over the summer, compared the two:

> Well, you have some part in the decision-making process [at Helium], but you're still learning so they're there with you in the lab to make sure that you're doing things right. I think now that I've done the internship and I'm more inclined to do things on my own, next semester I will be more independent in the lab, whereas before my advisor was there. He was answering questions for me. I wasn't actually getting into the library to do the library research.

Attitudes about students

The interest which the faculty have in their students was evident during the interviews. Karen felt that the greatest positive feature of the department is its one-on-one relationships between faculty and students. Faculty mentioned helping students during both official office hours and help sessions, as well as just walking into the student study area and offering assistance. Because Helium is located less than an hour from a neighboring state's flagship university, frequent comparisons were made between Helium and this larger school, and the in-state flagship university. As Lewis put it,

> You can do undergraduate research here that you'll never be able, that only the top 2 or 3 undergraduates will be able to do at [flagship]. You will know your faculty, your faculty will know you. We're all here. It's a much smaller environment, much friendlier environment, much easier for the majority of students. An 18-year-old student is generally not prepared to go to the University of *, or **, and take full advantage of everything that's there. Far more likely to just get lost in the shuffle.

Faculty in general at Helium were positive about their department, their students, and their profession. They felt that, although students worked more to support themselves and were thus harder to get involved in some activities, the quality of students had in general improved over the years. Faculty felt there was a reasonably good job market in the area for majors, and the department head had just recently been contacted by a temporary placement agency that specialized in chemistry placements. Overall, students seemed to get into graduate schools, professional schools, or industry, according to their preferences.

Recruitment

The faculty were almost apologetic about the lack of official recruitment on their part, other than the spring visit days for high school students. They believed the number of chemistry majors to be due to several factors:

a. a good reputation among high school teachers

b. a good reputation for placing pre-veterinary medicine majors

c. biochemistry and the biotechnology program

d. the friendly atmosphere that students find once in the program.

The current department chair proposed that there may be a self-selection process in terms of female students and where they go to school. He suggested that perhaps good male students in the physical sciences may be more self-confident and willing to go out on a limb to go to a bigger school, while the female students "may not be quite as sure of themselves and may go to a smaller school and so maybe we have better female students here."

Gender and personnel issues

Jack, the former department head, was asked if the department had ever made it a priority to hire or recruit women. He replied that, although the department has been

successful in hiring good female candidates, in every case the best applicant was hired for the position. He added that Nancy, the first female faculty member of the department (hired in 1977), wanted to see only good women hired since she believed they would have to be as good or better than anyone else, and "it doesn't do female students any good to see somebody failing at their job and everybody has to carry them." He also spoke of the importance for female faculty to keep their careers going during the family years.

Several of the faculty mentioned their own children, and their presence in the department through pictures and actual visits. There were both male and female faculty who brought their children to the department on a regular basis, and several of the faculty mentioned that they felt they were role models for female students considering a career in academe. The newest, and youngest, faculty member (Oprah) was female, and it was felt that women who wanted to know what it was really like in graduate school "right now" could get such information from her. When the researcher spoke with Oprah about this, she commented that being a graduate student was not always easy to balance with having a family, for men or for women. However, she had not been discouraged from pursuing her Ph.D. in biochemistry, and felt that Helium was very encouraging to females as well. She mentioned the fact that her biochemistry class is ninety percent female, and that the faculty is nearly 50-50. Therefore, she felt there were "lots of other women to ask things that you might be uncomfortable asking a man about."

Several of the female faculty commented that they urge their female advisees to think about what they want their lifestyles to be, to find out very specifically what a particular career or profession involves. However, they also encourage them to "go for it" and choose something they are truly interested in. No one seemed to feel there was

gender bias among the faculty in the department, either toward one another or students. Oprah, in particular, commented on how much better Helium was than the University where she did her post-doc.

However, two of the faculty, Jack and Lewis, specifically mentioned physics when asked about the equitable treatment of women campus-wide. Lewis felt that physics, being very unequal at least in numbers of male and female faculty, "is staring at extinction," while Jack told a story about the chemistry majors and the physics they are required to take. The students had created a tee-shirt to wear which stated "I hate physics" on it. Jack had confronted the physics department about their attitude toward chemistry majors, especially their tendency to challenge the students' choice of major, or to put them down because they were chemistry majors.

> I said, it might work for you guys to get up in front of a bunch of guys and say oh, you really blew it, you should have been a physicist, but I said you don't tell a bunch of women that . . . and I said that's why I'm talking to you, I don't expect it to happen again.

Jack felt that in many instances students were too uncertain of their career choices themselves to like being challenged in that way.

The faculty at Helium has lost six or seven faculty to retirement in the past five years, in addition to one who moved to another position. This was considered to have been a plus for the department in the long-term since it opens the door to a whole new generation of ideas. As Nancy put it, "We are more up-to-date, we are more willing to try new things, and we're more aggressive, and we're more active in research." One faculty member confided that there had been "curriculum wars" in years past which had left bodies scattered in the department. For one reason or another, however, those most dug-in on both sides of the issue were no longer around, and discussions could now go forth in a more civil manner.

Jack spoke of how difficult it is for senior faculty to bring in new faculty and give them the freedom to change things, but he stressed that it must be done. He and the new biochemist were team-teaching the laboratory, and had worked out a way to do so that pleased both of them. He felt that it was, after all, going to be their department in another ten to fifteen years, and they must be given an opportunity to plan its future.

Selection of and Persistence in Chemistry

During the interviews with the female students the researcher sought to ascertain why the students had chosen to major in chemistry in general, and why at Helium in particular. They were therefore asked about their experience in science, about influences in their lives, and about career plans. What they described were three categories of influence in the selection of and persistence in chemistry: 1) pre-college factors; 2) college factors; and 3) post-graduate plans. Under college factors, two subcategories emerged: 1) factors within the school or department's control or immediate influence and 2) factors outside the school or department's control or immediate influence.

Pre-college factors

When asked why they first chose chemistry, five of the nine women specifically mentioned a high school chemistry course and a teacher. An example is Irene, a freshman, who described her experience this way:

> Yeah, it was after my junior year in high school when I first had chemistry. I knew it was what I wanted to do. . . My teacher, she really just showed how everything connected to life, and I just thought it was just incredible. I just totally loved it. It was challenging, but it wasn't so difficult I couldn't do it . . .

Georgia also credited her good high school chemistry instructor for her interest in becoming a high school chemistry teacher herself. When asked what it was about him which made him a good teacher, she replied:

> Just the way he explained things. And if you didn't understand he didn't get upset. He'd go over it as many times as it took to get the point across. He was fairly entertaining. He made chemistry interesting with examples and stuff.

She had originally been a straight chemistry major, but had decided to stay for a fifth year to obtain her secondary teacher's certification, in part because she found chemists to be boring. At least, her uncle and some of the faculty she thought fit that description! In addition she did not see herself as a research chemist.

> And I didn't want to be in a lab the rest of my life . . . I didn't want to be out of touch with people. I don't know if that makes sense. But I didn't want to go into chemistry that I couldn't identify with everybody else in the world.

Other students had become interested in science, if not specifically chemistry, at an even earlier age. Helen traced her interest in chemistry to the summer after fourth or fifth grade.

> They just offered a really basic chemistry summer program. And she [the teacher] is one of, she won some award for chemistry teacher. She's just an amazing teacher and made it so interesting and so exciting. We made slime, and all the really cute little experiments we did.

Brenda, a sophomore, remembered loving science in middle school, and said that she "just loved lab instruments." Irene, too, remembered a microscope as her favorite childhood toy, but said it wasn't until her senior year in high school that she began thinking about a science career. She said, "Nobody ever said you can make a career out of science."

Cathy remembered from elementary school on that "sciences were a lot easier than any of the other stuff. Math was easy. I seemed to understand that better than like literature and all." Although a few students mentioned a dislike for physics, the students were, for the most part, strong in math and other sciences as well as chemistry.

One of the recurring themes at both the pre-college and college levels was that of confidence that came from having someone else believe in them. One of the students put it this way: "When I was in third grade, I had this elementary school teacher, and she thought I was just brilliant. Before then, I was just normal." Another student said:

> And then I had a science teacher in eighth [grade], and she was really enthusiastic about what she was doing, and she gave me encouragement. I think that was the point where I felt that I could probably do something bigger and better, but even then it wasn't until I came here, and was at least a year or a year and a half into the program, where I felt that I might have the potential to really make it . . . You get little things along the way that give you that extra boost, but I think you actually have to go out and do it and prove it to yourself.

This last student, Frances, is a senior and had spent the last summer in an internship at a large research university. She stressed that her confidence is still "an evolving process," and even though she had been successful in a very different environment, she still said, "I didn't want to let people down. That was a big thing. I'm still scared."

Some of the women remembered times when they had not been confident in their abilities. It was Georgia who remembered sometimes feeling less confident in high school.

> I guess the biggest thing in high school was that I sometimes felt that the men were favored by maybe some teachers and maybe made me feel a little less confident, as far as maybe, just offering answers in class, things like that, participation. But, personally, on tests or inward thinking, I still felt confident.

Eileen recalled making the same ACT score as a male friend in high school, and being surprised to think she was as smart as he was. She said of herself, "But I was kind of flaky in high school. I was always in the accelerated classes but I was cute and little. I think it kind of made him mad when I got those scores."

Overall, the women of Helium were an upbeat, confident group of young women. When one was asked how to produce more women like her, she replied, "I don't know. I never had the impression that girls shouldn't be in science." Another, when asked if there was ever a time when she had doubts in herself, replied, "No, everyone always told me I was smart!"

College factors

Within school or department's control or immediate influence

Among those factors mentioned which could be controlled by the school or department were the reputation of the chemistry department, especially its designation as the system's Center of Excellence in Chemistry and Physics and the "feel" of the school.

> I visited [two private schools], and it's just so much more welcoming here than it was at those two places.
>
> And they [chemistry department at Family Day] were just really welcome and inviting and they want you to be comfortable here. They want you to enjoy it. They're really excited about their program.
>
> Probably the fact that they are so good at chemistry, that they're rated so high.
>
> . . . I just heard about this one being designated the [system] for excellence in chemistry. And that kind of triggered that this was a good place to go.
>
> Just the program here's kind of like a family.
>
> I knew that class size was smaller, so you're able to see your professors more, get more help, more one to one. And just by that, it's nice. It's a smaller school.

Other departmental factors affected the confidence of the students. During each interview, students were asked to respond to the following: On a scale of 1-10 (with ten being highest), tell me how successful you feel you'll be in future chemistry courses. Helen, a freshman, was the only student who did not rate herself an 8 or higher. She was experiencing some difficulty in her first chemistry course.

> My first chem class is, like it's weird, 'cause in class I understand it, and it's no problem in class, but come test time, sometimes it's a little bit trickier. I'm getting 79% C, right now, so that's kind of disheartening, but I think I'll make it . . . This kind of stuff really came easy for me and now it's a little bit more studying. We're moving a lot quicker and so it's hard to make that switch. But I'm getting to make the switch now.

However, she assumed all the blame for her low grade. When asked what it would take for her to get an A or a B, she replied,

> Just definitely to put in more effort on my own part. It's not the teachers, it's not, and it's not that I can't do that, it's just to actually figure out that yes, you have to do this.

The students were also asked if, at any other time in their school careers, they had ever had more or less confidence in their future success. The students who gave themselves high scores indicated that, in addition to encouragement from others, success in courses was important in developing their confidence.

> Once I came here and started getting into programs it was like, oh, I've seen all this before. And the first semester was a real encouragement 'cause . . . everything my first semester I'd seen before in high school.

Georgia, a senior who had transferred to Helium her junior year, gave herself a score of eight. She stated, "I think partly due to my experiences in [first school] maybe make me feel a little less prepared, but since I've been here I feel that I'm becoming more and more prepared to handle things in other courses."

There were aspects of the departmental environment which played a role in retaining the students in chemistry once they were there. Often, these comments reflected back on some of the personal issues which were discussed in the selection of chemistry initially. The majors' lab and the introductory course specifically had a great effect on the students.

> I got to know a lot of the students that were chem majors and we got together a lot to work on assignments and we kind of formed our own support system, I guess.

> I developed a group within that lab and I'm taking all my classes with that group and I know that group really well and we're, that's where your feeling of a group and assimilation comes.

> It was fun. I love lab. There were a lot of fun people there, my friends.

One student, who as a premajor missed being in the lab, felt shortchanged: "But there's something lost there that I should have gotten. I should have just talked to an advisor but no one told me to."

Most of the students felt that the introductory course had given them confidence during their freshman year.

> It was kind of easy for me 'cause it was a lot of the stuff we had done in high school. . . It went pretty well, and second semester went fine for me too. I was pretty much encouraged throughout the whole year, so it gave me that extra boost I needed I guess to get through.

> It was like a full repeat of what I had in high school. I was just bored out of my mind. It was just really simple. . Probably encouraged me 'cause it came easier, so I understood it, and if I understand it I have an easier time doing it than if I get frustrated.

Alice, Cathy, and Eileen had not planned to be chemistry majors before attending Helium. Although they took the first chemistry course for a number of different reasons, they decided to remain chemistry majors. When asked why she remained in chemistry, Cathy replied: "I think the fact that I found it easy. It was pretty easy for me to do, and I understood it and it made sense."

Several of the students mentioned being involved in the chemistry demonstration club which performed for local high school students. There was also an active ACS student affiliates group which had movie night and other activities for students. One senior commented on the difficulties she had encountered in trying to get the freshmen more involved.

> I think they feel kind of intimidated. When I was a freshman and I went to the first chem club meeting, I'm like, oh, I don't want to be around the people. They were just too intimidating for me. . . I think it's more of making yourself accessible to them and making them see that you are a human being and they can talk to you.

The women who were interviewed did not seem particularly aware of the relatively high percentage of female students in the program. When asked to estimate the percentage of female majors, no one estimated as high as fifty percent. However, when told that the department actually had a high percentage of female majors, one student quickly provided a reason:

I think probably the welcoming thing. They make you feel so comfortable, so it's like, OK, you're here, let's go. Yeah, chemistry!

Students were also asked if they would recommend Helium University to a female friend interested in chemistry. In every case they said yes, although several qualified the endorsement by saying it would depend on whether or not she liked a small school. Another said she would recommend it only if her friend was in the majors' lab. Irene, a freshman, had visited other schools, and said:

> There's a lot more females. I think that's kind of nice. It's kind of hard when you don't have anybody that kind of thinks the same way, and kind of approaches things the same way as you.

Other reasons given were:

> They really try to challenge the students. . . They want you to do well and they're willing to help and stuff.

> I think you can work on the instruments more, which is really great. You get more one on one with the teachers. We know a lot of the teachers, and we'll go out and do social events with them.

> It's a nice atmosphere. You get to learn a lot. 'Course the professors are wonderful.

This last comment was echoed by several students when they were asked to name the one best thing about the department. In each case, faculty characteristics, particularly their "quality" and their caring attitude, were mentioned as the single most important characteristic of the department. Over and over, their willingness to help students in and out of class, and to invest time in finding research projects, graduate schools and internships was emphasized. Students believed in both the competency and the compassion of the faculty.

Outside the school or department's control or immediate influence

Although size of classes is one of the factors over which the school has some control, the size and location of the university itself are not easily controlled by the

school or the department. These factors also influence student decisions, as illustrated by the following comments:

> I'd always kind of been interested in [city] 'cause it's about the same size as my home town and I really like the size of the campus and I know that they are really good for chemistry, which really turned me on. And I looked at it once and I knew this is where I wanted to go.

> I guess location, and the school has a great science department; it's accredited. There's so many options, like I can go two different ways with biochemistry.

Some students had relatives who attended or had graduated from Helium, while others had had high school teachers from Helium. Official school recruiting did not seem to play much of a role.

Post-graduate plans

Several of the women planned to attend graduate school. Alice, a junior, was debating between graduate school and a job in a company based on her undergraduate biochemistry degree. She said, "In some ways it's the challenge to be the first to go through. Like grad school would be kind of fun, but I don't know." She also mentioned the challenge of chemistry, and thought the biochemistry option to be one of the most rigorous. In fact, of the nine students interviewed, four were either in the biochemistry option or considering it. Plans ranged from possible medical school to graduate school to industry.

Irene, one of the freshmen, was unsure about going to school for another four years after Helium. Her dream was to complete the biochemistry option and do medical research at a company she had read about. When asked about combining that career with a family, she replied:

> Not right away. I think you have to get settled first. I don't know, it'd be kind of hard cause I know that it's mostly males, and I think that if you got a job right away, and then all of a sudden you were raising a family, that would kind of, that a lot of companies would, you know, look down on you for that.

Helen, also one of the freshmen, was uncertain if she would remain in chemistry. However, she felt if she did that she would go on to graduate school, and had some ideas about how a chemistry career and family life would intersect.

> A science career is very demanding, and not necessarily the best hours probably if you're in research, like I kind of plan to be if I stick with it. Not the best hours, but hopefully by the time I decide to have a family I'll be past the grunt stage . . . It's kind of important to me to have the career in a good sight before I settle down 'cause I don't want someone else trying to change my mind on what I want to do.

Frances, a senior, had already visited some graduate schools. She commented on the ratio of men to women at the schools she had visited.

> Out of fifty men, one or two would be women. I was really wondering about that. A lot of the schools had me meet with at least one student who was a woman. So my mom would ask, and I would ask, and a lot of them felt that, if you are going to do this you've got to be willing to make it in a man's world essentially, 'cause there are going to be a lot of men there. But at the same time, they didn't feel really discouraged about it. You just have to be able to work in an atmosphere with lots of testosterone.

Georgia was the only one who expected to marry soon, and said that she would probably stay home with her children, at least until they were older. Although she had considered getting the chemistry degree and then, perhaps later, coming back for the teaching certification, she had decided against that option after seeing other nontraditional students at school.

> I see what it's like for them. They're trying to juggle their husbands, their kids. They work and just go crazy. I know it would be a lot harder. So I decided, I'm going to do it now, while I'm here.

Neon University

Campus

Neon University is a mid-sized comprehensive state university of 10,500 students (8800 undergraduates) in a city of about 57,000, only 90 miles from a major metropolitan area. It is considered both a major undergraduate and a regional graduate campus, offering master's degrees in thirteen areas. Although the chemistry department once offered a master's degree, and still co-lists its 400-level courses as graduate courses, it no longer offers the degree nor plans to do so again.

Neon University began as a Normal School over 120 years ago. Its vision now, as stated in the 1997-1999 Undergraduate Bulletin, is to "be an exemplary comprehensive University which serves and advances the educational interests of the region and beyond" (p. 8). It has as its first mission objective "to discover and disseminate knowledge and to extend the application of knowledge beyond the university for the betterment of society" (p. 9).

The majority of students are commuters, but there is housing on campus for over 3600 students (Undergraduate Bulletin, p. 287). However, most on-campus students go home or elsewhere on weekends. There is an active student newspaper, and the student center houses not only eating facilities but a bowling alley and other recreational activities.

Chemistry Department

Observations and documents

The department of Neon consisted of twelve tenure-track faculty (two of whom were women), including one professor emeritus whose office was used by the researcher as headquarters and the site of the interviews. There were three additional

females: one female PhD on continuing contract, and two female academic staff persons. One of the female faculty members was new that semester.

The building which houses the chemistry department is a four-story, L-shaped complex with a large auditorium classroom on the lower level. The chemistry department occupies the fourth floor of both legs, connected by an enclosed stairwell, thus physically dividing the department into two sections. The faculty offices were not on the main hallway with most of the laboratories and the classrooms, but rather opened onto another hallway which made a square on the side of each segment of the L. Although the researcher made frequent forays into the other segment, those faculty in the wing in which she was located were more easily accessible and therefore became more familiar to her.

The chemistry department at the time of this visit had officially 63 majors, of whom 21 were female (33%). It offered the bachelor of science degree with options for a professional emphasis or a liberal arts emphasis, and a bachelor of science in education for those wishing to teach in secondary education. On the list of majors, none of those listed under secondary education were women, and there was no distinction made in coding between the liberal arts and the professional emphases.

Within the Liberal Arts emphasis are four options: 1) chemistry, 2) biochemistry, 3) geochemistry, and 4) business. Interviews with faculty indicated very few students selected options 2-4. However, the department was making plans to offer an ACS-approved biochemistry option, and was adding additional biochemistry courses to the curriculum during the current academic year. Historically, the biochemistry had been designed more for medical technology students than for those wishing to study biochemistry further. The medical technology program, which is not part of the department, has approximately 50 majors, 75% of whom are women.

A departmental brochure describes the program as "one of the best in the state." It states that thirteen of the fifteen faculty hold doctorates and five have won awards for excellence in teaching. Students are said to consistently score "significantly above the average on national chemistry exams," and the importance of research is stressed. Approximately 60% of graduates go into industry, 35% to graduate and professional schools, and 5% into secondary teaching.

Reports to the American Chemical Society for the three academic years 1995-1998 show the following breakdown in graduates:

Year	# of males	# of females	Total
1995-1996	10	6	16
1996-1997	8	1	9
1997-1998	10	1	11
	28	8 (22%)	36

Introductory general chemistry was offered as one large lecture section of 150-180 in the fall. The off-sequence section in the spring was considerably smaller. During the semester of this research, the course was taught MWF at 8:00 am for one hour each day. In addition, students were divided into eight sections of discussion and laboratory of approximately twenty students each. A few of the lab sections were taught by the instructor who taught the lecture, but none of the discussions.

The general, organic, biochemistry (GOB) course for non-chemistry majors was divided into two large lectures of approximately 125 each. These were divided into twelve lab sections, many of which were taught by the same person who taught the lecture. There were no discussion sections. The two lecture sections had common exams given during the evenings or by arrangement during the day elsewhere on campus.

The department has developed a diagnostic examination which, although first used with at-risk students, is now administered to all students in the general chemistry

course at the beginning of the semester to ascertain whether or not they are prepared to take general chemistry. The exam is composed of 10 sections:

1) arithmetic problems
2) exponential numbers
3) logarithms
4) algebra
5) functional relationships
6) significant figures
7) dimensional analysis
8) verbal problems
9) reasoning skills
10) general chemical knowledge

The sections found to be most highly correlated to success in general chemistry are 1, 4, 5, and 7. Students who score below a certain score are encouraged to drop the course and take the GOB course and/or more mathematics. A workshop is also offered twice weekly for students in the general chemistry first-semester course. Although first designed to help at-risk students, it has been opened to anyone in the course. At the time of this visit, approximately half (60) of the students still enrolled in the course were enrolled in the workshop. Since it was offered in the evening from 5:30-7:30, it required a commitment on the part of these students whose lecture was at 8:00 am.

In order to obtain a picture of the type of women who enrolled as chemistry majors at Neon, the researcher requested the average math ACT of the female chemistry majors and administered the Math Self-Efficacy Survey (MSES) developed by Betz and Hackett (1983). Of the 21 female majors, ACT scores were available for 16, and the mean math ACT for those students was 24. The MSES was distributed to 17 female chemistry majors (81%). Fourteen (82%) were returned which resulted in a survey of 67% of the female majors. The students were asked to rate their level of confidence in accomplishing various math tasks (Part I) or completing certain college courses with an A or B (Part II) on a scale of 0 (no confidence at all) to 9 (complete confidence). The mean score for the female chemistry majors was 7.56 overall, with a range of 5.79-8.62