6-2004

Girls and Science: A Qualitative Study on Factors Related to Success and Failure in Science

Paula Denise Johnson
Western Michigan University

GIRLS AND SCIENCE: A QUALITATIVE STUDY ON FACTORS RELATED TO SUCCESS AND FAILURE IN SCIENCE

by

Paula Denise Johnson

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Department of Educational Studies

Western Michigan University
Kalamazoo, Michigan
June 2004

GIRLS AND SCIENCE: A QUALITATIVE STUDY ON FACTORS RELATED TO SUCCESS AND FAILURE IN SCIENCE

Paula Denise Johnson, Ph.D.

Western Michigan University, 2004

This qualitative study sought to determine how girls perceived factors that contribute to their success in science programs designed to maximize their achievement. The sample consisted of 20 students in 9th and 12th grades attending a school of choice. Respondents were interviewed using a structured interview protocol.

The National Council for Research on Women study (Thom, 2001) found that girls are more successful in math and science programs that incorporate a cooperative, hands-on approach than in programs that stress competition and individual learning. This finding was supported by this study among 20 high school girls in a school whose mission is to improve the access of girls who study and choose careers in STEM (science, technology, engineering, and mathematics) disciplines. Related studies on the subject of the underrepresentation of girls and women in science and related disciplines raise the question why so few girls choose STEM careers.

Qualitative inductive analysis was used to discover critical themes that emerged from the data. The initial results were presented within the context of the

following five themes: (1) learning styles, (2) long-term goals, (3) subject matter, (4) classroom climate/environment, and (5) evaluation. After further analysis, the researcher found that factors cited by the girls as contributing to their success in science programs specifically designed to maximize their achievement were: (a) cooperative learning, (b) a custom-tailored curriculum, and (c) positive influences of mentors.

UMI Number: 3130607

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

ACKNOWLEDGMENTS

Although only one name appears as the author of this dissertation, there were numerous people who helped to bring this project to completion, especially my *fairy gradmothers*: Dr. Sharon Anderson, Dr. Marianne Di Pierro, and Mrs. Gail Towns. Their encouragement, guidance, and source of confidence were priceless.

First and foremost I would like to thank God for always guiding me to where I needed to be and giving me what I needed to meet every challenge I faced. I owe my talents to Him, and I certainly could not have asked for a more rewarding life.

I would next like to thank my committee members individually and collectively. Dr. Jianping Shen who served as my dissertation committee chair and exhibited unwavering and untiring guidance and support during this process; Dr. William Cobern who was the project principle investigator for the grant which I served as doctoral research associate; and Dr. Donald Thompson who made this opportunity possible for me to serve as a doctoral research associate responsible for collecting data for the project because it was the grant which engendered the research that led to the dissertation. Collectively, I thank each committee member for his sincere dedication, precise judgment and profound wisdom.

Certainly I could not have completed this study without the help of my family: my mother, Gean for always being an inspiration and continuously lifting me up in prayer, and to two of my sisters, Dorothy and Gwendolyn for always being there for me whenever I needed a shoulder to lean on.

Finally, I would like to thank Dr. A. Celeste Shelton-Harris and Alice Sigfrids for being such good friends because friendship is unnecessary, like philosophy, like art…it has no survival value: rather it is one of those things that gives value to survival.

I would like to dedicate this dissertation to my father who is not here to witness the fruits of his labor and to all of those who participated in the interviews and informal conversations.

This study will have served its purpose if it succeeds in fostering a better understanding about how girls' self-perceptions and views with regard to science influence their success or failure in science programs designed specifically for them. Never be silent, either in word or in action, for it is only through impact that we can effect change.

"Success is getting
what you want.
Happiness is wanting
What you get."
—anonymous

Paula Denise Johnson

TABLE OF CONTENTS

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

Table of Contents—Continued

CHAPTER

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Overview

Education, business, industry, and science professionals have expressed major concerns about the underutilization of personnel, particularly females, in careers dependent on science expertise. Their concerns are twofold: First, there is a growing recognition that future economic prosperity and global competition depend on our scientific progress and our adaptability in the fields of science, technology, engineering and math (STEM). These fields are clearly linked to national-level growth and change and serve to drive and dominate social and economic trends (Sheriff & Svenne, 1993). Second, our society is currently experiencing a technological shift from a resource-intensive to a knowledge-intensive economy and it is critical that all citizens have the knowledge and skills to contribute positively to the continued prosperity of our country. As we progress toward the "information age," leading educators warn that society can no longer be complacent about the development of the learning potential of any of our students (Keating, 1996), and schools can no longer be indifferent about what kinds of living and working await their students when they make the transition to the adult world (Hargreaves & Fullan, 1998).

As a result of this transition, increasing attention has been drawn to the problems faced by women's participation rate in the STEM fields. However, to avoid generalizations which are difficult to substantiate, the researcher examined Science as a proxy for math, engineering, and technology because in order to be successful in the 21st century, girls need to possess the logical and creative problem-solving skills inherent in the disciplines of all four disciplines.

The Third International Mathematics and Science Study raised our national awareness of the country's vulnerability in competition with other nations. *The Trends in International Mathematics and Science Study* (TIMSS, formerly known as the Third International Mathematics and Science Study) resulted in part from the American education community's need for reliable and timely data on the mathematics and science achievement of our students compared to that of students in other countries. TIMSS is the most comprehensive and rigorous assessment of its kind ever undertaken. Offered in 1995, 1999, and 2003, TIMSS provided trend data on students' mathematics and science achievement from an international perspective. The 1999 Third International Mathematics and Science Study-Repeat (TIMSS-R) was a successor to the 1995 TIMSS and focused on the mathematics and science achievement of eighth-grade students in participating nations. It provided a second data point in a regular cycle of international assessments of mathematics and science that were planned to chart trends in achievement over time, much like the regular cycle of national assessments in this nation, such as the National Assessment of Educational Progress (NAEP) of the National Center for Educational Statistics (U.S. Department of Education, 2000).

TIMSS and TIMSS-R had the following science content areas in common: earth science, life science, physics, and chemistry. The 1995 TIMSS assessments revealed that U.S. 12th-graders scored below the international average and among the lowest of the TIMSS nations in mathematics and science general knowledge, as well as in physics and advanced mathematics. In 1999, the United States was one of 16 TIMSS-R nations in which U.S. eighth-grade boys outperformed U.S. eighth-grade girls in science, and U.S. eighth-grade students performed lower than their peers in 14 nations in science (U.S. Department of Education, 2000).

U.S. girls' performance in math, science, and related subjects may be rooted in many complex issues including gender-role stereotyping. At a time when these fields are suffering from a dearth of educated experts, evidence indicates that women face various forms of discrimination as aspiring students of these disciplines. Most recently, with restrictions on U.S. entry of foreign nationals for STEM positions, members of Congress have raised the low participation of women in STEM careers and jobs as a national work force and national security issue. For example, U.S. Senator Ron Wyden (D-Oregon) has challenged NASA to help triple the number of women graduating from college with degrees in science, math, and engineering by the year 2012 (Turkkan, Domske, & Josef, 2004).

According to the National Research Council (2002), young women studying STEM fields are pushed into traditional female roles such as teaching, while their male counterparts receive almost all the research fellowships that pay more completely for graduate school. "Given the challenges that lie ahead in national security, technology, and the global economy, we can not afford to leave half of our population behind," said Dr. Geraldine L. Richmond, a professor of chemistry at the University of Oregon, who runs a program dedicated to advancing the careers of women chemists. "We must recruit, educate, and promote a higher percentage of our women in technical fields." (U.S. Senate Hearing, 2002).

Many Americans have come to feel that excluding a large percentage of people in any group from prestigious, influential, and highly paid careers is unfair. However, beyond these considerations is the fact that, by limiting the number of women in STEM, we lose different perspectives that can enrich, expand, and revitalize these disciplines. It has been said that Representative Constance A. Morella (R-Maryland) was right when she explained that Congress had established the Commission on the Advancement of Women in Science, Engineering, and Technology Development "to help ensure that our labor force is ready for the information age and that our high-tech economy continues to flourish in the 21st century" (Campbell & Clewell, 1999). With STEM jobs often going unfilled for lack of skilled applicants, we have an opportunity to encourage girls and young women to enter these fields and succeed. If we expand opportunities for girls in STEM programs, we can open the doors to these careers for more women (Lee, 2001).

Background and Need

In response to the U.S. Department of Education reports, *A Nation at Risk* (1983) and *America 2000* (1991), the American Association of University Women

(AAUW) demonstrated its concern about preparing girls for the technological work force of the 21st century by commissioning research of public school education for girls. In 1992, the AAUW's report, *Shortchanging Girls, Shortchanging America* identified issues related to self-esteem, educational experiences, interest in math and science, and career aspirations of girls and boys ages 9–15. The study found that as girls reach adolescence, they experience a significantly greater drop in self-esteem than boys' experience. The report states that girls' self-esteem plunges dramatically from elementary school to high school. It concludes that 71% of the nation's adolescent girls are unhappy about themselves versus 54% of the boys. The study also confirms a growing body of research that indicates girls are systematically, if unintentionally, discouraged from a wide range of academic pursuits—particularly in math and science. This gap in self-esteem and drop in girls' interest in math and science have devastating consequences for the future of girls and the future of the nation.

Bias against girls in our schools has been extensively studied and reported by Myra and David Sadker (1994) in *Failing at Fairness: How Our Schools Cheat Girls*. As educators, the Sadkers have been examining gender equity in the classroom for some 30 years and with the help of some refined observation techniques have been able to track behavior that sends girls' self-esteem plummeting. The Sadkers used examples and statistics and cited over 400 books, reports, and articles to illustrate their claim that girls are systematically shortchanged by the educational system.

It is well documented that teachers favor boys by giving them more attention, encouragement, and feedback. The very structure of the classroom is biased toward boys, as girls tend to do better in cooperative learning settings where they can work in groups rather than working alone. The absence of women, role models and mentors from curriculum hurts girl's self-esteem and sense of inclusion and empowerment in the academic setting, and—by way of extension—society.

Using classroom videos, the Sadkers revealed teachers, even those who considered themselves sensitive to issues of gender—praising, challenging, and paying attention to boys far more than to girls. Boys excel in showmanship, waving hands wildly to get attention; girls retreat, becoming quieter, learning to hide intelligence and scholarly skills in order to be popular. Meanwhile, textbooks and standard visual displays, even those revised in the light of feminist pressure, still show few role models for girls. Interviews with students uncovered that boys would literally rather die than be girls, while girls find boys' lives attractive in many ways. This important study has been a timeless resource on gender bias in the classroom from elementary to graduate school.

Differential participation of girls and boys in science has been a matter of both national and international concern for some time. The result of research has indicated that boys generally have a more positive attitude towards science. However, there are gender differences between the different areas of science. For instance, trends show that girls are more inclined to have more positive attitudes towards science relating to human concerns, whereas boys tend to have more positive attitudes towards physical (Fleer & Hardy, 2001).

Sally Ride, the first American woman to go into space, was recently quoted in a newspaper article in *The Mercury News,* dated October 23, 2003, as saying:

> Statistics show that in elementary school boys and girls have equal interests and test scores in math and science. Yet, by the end of middle school girls perceive their abilities in these subjects to be inferior to boys' and have fewer aspirations to pursue scientific careers—even though they continue to have similar aptitude. The result? Women today make up 46 percent of the workforce, yet hold only 12 percent of the science and engineering jobs in business. (Ride & Stysek, 2003)

Fleer and Hardy (2001) identify that over the years there have been three distinct recommendations regarding girls and science:

> 1. Give girls more opportunities to study science—which looked at changing science to accommodate the girls rather than changing the girls to accommodate the science.
>
> 2. Make science more feminine—a gender sensitive science that took a real feminist approach to science such as stressing safety precautions rather than dangers, linking physical science to items that girls are familiar with such as prams, etc.
>
> 3. Allow girl students to participate in science learning in ways that assist them to make meaningful connections to their experience, their ways of understanding and their worldviews.

While the debate on gender and science/technology will be an ongoing one, it is evident that the student's prior school experiences influence how a child views science and technology. It is well established in social science research that adults treat boys and girls differently and that boys are encouraged to participate in physical activities and "rough" games whereas girls are encouraged to play with dolls and stay clean. This is not the case for every child, when girls are treated the same as boys who will be more inclined to participate in the more physical science. These girls are often referred to as "tomboys" and the reverse is evident for boys, as they tend to take a more passive approach to science and technology (Fleer & Hardy, 2001).

A young girl had this to say:

> As a teenager I started going to hobby astronomy courses, but I was put off in the end by the all male environment and the negligence of the tutor. I was ignored as he could not handle a girl being interested in it and joining the club. (Grant, 1995)

She moved on to attend a school of choice. At this school everyone was encouraged to share her voice. The school teaches in a collaborative style which facilitates the way a girl learns.

Research carried out by the American Association of University Women (AAUW) and others who have studied gender issues, shows boys and girls receive different kinds of education and that the girls' experiences in science differ from boys. An examination of a typical classroom scene serves to illustrate the issues and barriers to instruction; instructional support such as attention, encouragement, and constructive feedback; and classroom success for girls in science:

> Four sixteen, seventeen-year-old boys and girls, Margaret, Rachel, Mark, and Ralph, are doing experiments in electricity in small groups. What follows are descriptions of some aspects of their classroom conversations. Rachel is attaching a wire to a socket with a screwdriver. Mark watches impatiently, Rachel pulls the fastened wire—it is still loose. "Women and technology" Mark comments sighing, and as Rachel is trying again to fasten the wire, Mark demands: "Give it to me; just admit you are unable to do it the right way. Look at how you are holding the screwdriver."
>
> A few minutes later, the group is installing an ammeter in an electric circuit. Margaret opens the circuit for inserting the ammeter—Mark doesn't agree, takes the ammeter and connects it in parallel with the bulb. Short circuit—the teacher is asked to find the mistake—Margaret has her triumph:

> "I told you before, I was right, I am not as stupid as you always seem to believe." Going on to the next problem creating a circuit with bulbs in parallel and in series at the same time, Margaret shouts: "I don't know how to do it, I don't understand the task!"
>
> Mark and Ralph begin to connect wires and bulbs. Rachel tries to stop them and asks the boys: "Please, can you explain what you are going to do?"—"Wait and see!"—After they have finished they try out the circuit. One bulb doesn't glow, it is bridged. "Oh why doesn't it burn?" Mark and Ralph are helpless. Margaret, looking at the arrangement, has an idea: "You must take off these two wires. Mark and Ralph don't understand her idea. Rachel wants to do it, but Mark doesn't let her. "Don't touch my circuit!" He is probing here and there and explores if there is good electric contact. Meanwhile Ralph is looking for help, and as the teacher is just coming, Ralph asks the teacher. The teacher points to the bridging wires and let the group find out what's wrong with them. When the kids are alone again Margaret complains: "We had the right idea, why did you contact the teacher?"
>
> In the following session Margaret consults the teacher: "How do we connect the voltmeter—this way or the other way around—where is the positive pole?" Being very careful Margaret wanted to be sure not to ruin the instrument. The teacher hadn't really grasped her problem and called Mark: Show the girls how to use the instrument. Mark then behaves very much like the boss and organized the next sequence of experiments, leaving the girls no chance of handling the equipment when they wanted to change the arrangement for the next experiment. The girls were resigned to the passive role of note takers, wrote down the measurement data, the numbers the voltmeter needle pointed at, and sketched the corresponding circuit diagrams. (AAUW, 1998)

The group dynamics of the issues in the classroom scene including classroom instruction, instructional support, and the level of classroom success for girls supports the research findings on gender-sensitive issues in the science classrooms. Frequently, teachers themselves may not be aware of the different ways they treat boys and girls and the different expectations they have. In group lab projects, the girls frequently act as "gofers," getting the equipment to set up and as note-takers while the boys do the actual experiments. An aware teacher can make sure girls are directly involved in the experiment (Moncure, 1994). But as a result of such typical classroom scenes, several organizations—such as the National Assessment of Educational Progress (1988), National Coalition for Women and Girls in Education (1992), and the National Science Board (2002), began to discuss and research the current status of women in science and the findings served as a catalyst for change.

Other scholars such as Peggy McIntosh (1997), Elizabeth Fennema (1990), Peggy Orenstein (1994), and Kate Scantlebury (1994) conduct research on gender-sensitive issues in the science classroom and teach students who plan careers in secondary science education. In a classroom exercise, Kate Scantlebury assigns students the task of reflecting on their own experiences about gender differences in the classroom so that when they teach they will have a heightened awareness of how to make science education more effective and equitable for both sexes.

Statement of the Problem

Researchers, scientists, teachers, and the higher education institutions that prepare students and science, technology, engineering, and mathematics (STEM) professionals are grappling with the realities of too few scientists in the United States, too few women in the STEM disciplines, and too few resources dedicated to systematically and significantly improving the status quo.

Pejorative views that dismantle girls' academic and existential foundations—the ability to perceive themselves as technologically capable individuals who are welcomed as future contributors to the field of science—can be viewed as something systemic that has been going on for years. It is the attitude of others which reinforce this view—and, therefore, girls come to learn early on that they are not and never will be "scientists."

Girls' alienation from science and technology subjects begins early. Even from the age of 5, both girls and boys have definite views about what constitutes "men's work" and "women's work," according to research undertaken for the Engineering Council in 1991 ("Why Girls Turn Their Backs on a Science Education," 1996). With little variation across the social classes, girls and boys believe, for example, that car repairs and woodwork are the exclusive province of men while mending and washing clothes are the province of women (Engineering Council, 1991, as cited in "Why Girls Turn Their Backs," 1996). When children have been asked to assess jobs and activities according to those suitable for men, those suitable for women, and those suitable for both genders, children thought science was more of a man's pursuit than either firefighting or climbing mountains. This suggests that there is quite a psychological barrier to overcome if more girls are to be attracted to science subjects (Engineering Council, 1991, as cited in "Why Girls Turn Their Backs," 1996).

As one of the best known action research projects—Girls into Science and Technology (GIST), found in the early 1980s, by the time children start secondary school, attitudes which were already taking shape at 5, have become more complex but no less stereotyped (National Science Foundation [NSF], 2003). In one exercise, for example, in which 10- and 11-year-olds were asked to write up an imaginary interview about the life and work of a woman scientist, girls readily expressed their concerns about careers in science. Girls thought science was a difficult and demanding job which might take them away from family life and tended to describe the appearance of women scientists in unflattering terms, whereas boys had a more positive view of women in science. For instance, one boy wrote:

> She is famous, she made lots of people better with medication X. If it were not for medicine X, people would die. She is tall, brainy, clever, and saved people's lives. I think she should get a lot of money for doing experiments that succeeded. (NSF, 2003)

This statement both reinforces a stereotypical male view of the characteristics of a female and provides a positive view of a woman as a scientist. Unfortunately this boy's perspective is not widely shared.

Not surprisingly, these attitudes have a powerful impact on children's views of their own strengths and weaknesses. When, for example, a team of eight 10-year-old boys and girls were asked at a science investigation event organized by the Association of Science Education ("Why Girls Turn Their Backs," 1996) to mount an inquiry, the boys made off with the equipment to do the inquiry leaving the girls to make a poster for reporting the team's results. When questioned about their choice of tasks, the children said they were simply doing what each of them was "good at."

In the 1991 Engineering Council research ("Why Girls Turn Their Backs," 1996), primary teachers reported that while girls generally preferred painting, drawing and writing stories, boys preferred building and modeling with construction kits and being physically active. However, researchers found that teachers have a major role to play in challenging children's beliefs about what they can and cannot do. The problem of gender stereotyping is that people write themselves off from opportunities early and often unnecessarily. The Engineering Council study recommended that "Teachers need to be more aware of the extent and pervasiveness of gender stereotyping" among young children, and girls should be helped and encouraged to fully involve themselves in STEM curricula.

Committed and enthusiastic teachers who set high academic standards and show a personal interest in science and in the development of their pupils are more likely to encourage pupils to continue their education in science and engineering (*The Rising Tide*, 1994). This report, prepared by a team of top scientist examining women's roles in science, technology, engineering, and mathematics, concluded that there is a disproportionately greater impact on girls than boys when teachers show a personal interest in science and in their students development. "It is an effective way of encouraging them to develop and maintain an interest in these subjects."

Purpose of the Study

The most interesting and potentially insightful explanation of why girls tend to shy away from the sciences may lie in a better understanding of the perceptions that girls believe contribute to their individual success or failure in science programs. Therefore, the purpose of this study was to identify contributing factors that girls perceive are to their success in a program specifically designed to maximize girls' achievement in science. These "self-referential" factors were assumed to be different than the factors derived from other studies that may be defined as external referents.

In other words, this research sought to engage students in ways not previously explored.

Research, quoted in the February issue of *Labour Market Trends* ("What Happens to Women and Men With SET Degrees?," 2003), indicated that women actively choose not to enter STEM careers with the knowledge that they are likely to feel "cultural discomfort." It is argued that some women pay both personal and social costs when they cross the threshold into a "male domain" and that these costs continue to be paid until the number of women in the male dominated STEM professions reaches a critical mass. This is because, researchers say, young women in science and engineering, for example, find themselves working with values, systems, and performance criteria which have been set up by men for men and not for women. In a recent article in the journal *Scientific American*, Professor M. Holloway (1993) argued, for example, that women have a different management style from men. They organize their laboratories in a less hierarchical way than men and prefer to work collaboratively rather than in competition. They are also more likely to be interested in scientific problems if they have a social relevance or could produce a social benefit.

The design and delivery of science courses at the primary, secondary, and college levels may also affect young women's enthusiasm for STEM careers. Some educators, such as Allan Glatthorn (1994), Claudette Rasmussen (1997), and Mary Moffitt (1997) argue that modular science courses, incorporating a greater range of elective options, would be particularly attractive to women who appear less willing to concentrate exclusively on science subjects. And while an electrical engineering course that allowed students to study a foreign language or business management subject may appeal to some students, the professional institutions remain eager to protect the scientific and academic purity of traditional courses and not allow elective courses outside the major area of study.

Cultural barriers and the stereotyped attitudes of girls, boys, teachers, parents, employees, the media, and society at large have all featured heavily on girls' perspectives of the sciences, as have issues about the quality of careers, education and guidance, and the quality of science teaching and science courses in the classroom today. How we engage in future research and where we go from here is most critical. We have seen that change is possible, although complex. The current knowledge gained about factors and strategies that work for the involvement of women and girls in the sciences will enable them to thrive in the sciences; consequently, science will thrive because of the heightened participation.

Significance of the Study

One important reason for this study is that existing research tells us very little about the girls' perceptions and views of their success or failure to science and related topics in science programs specifically designed for females. Over the past decade, Pat McNees (2004), Jean Piirto (2000), and Ellen Spertus (1991), have made numerous observations on factors that have been identified to influence why so few girls choose science careers. These factors are located primarily within the realm of school and society. Girls' internal perceptions and views can clearly serve to influence their choices about careers as well as their perceptions of themselves among other factors. This study can provide information to the field about ways to possibly target funding and other resources in order to steer girls toward successful STEM careers, and for curriculum reform of the sciences to allow for the diverse ways in which girls learn. In addition to the diversity of learning styles, it may be shown that communications skills and strategies will have to be investigated and considered in classroom settings in order to construct a more ideal environment suited to the needs of girls.

The Research Question

This study attempts to answer the following question: What are the factors that girls identify as contributing to their success in a program specifically designed to maximize their achievement in science?

Definition of Terms

Achievement in science in this study means: the attainment of the academic outcomes outlined by the school as it relates to the girls' performance in the science curriculum as determined by the rating system.

Factors in this study means: the girls' assumptions, opinions, and views as determined by them through the interview process.

Perceptions in this study means: students' views toward science as a reflection of their individual characteristics, their learning experiences, and their limited exposure to applied science and science professionals individual characteristics, and situations which impact their insight and judgment.

Program specifically designed to maximize their success in science in this study means: a hands-on, experiential approach to science which targets girls and helps them gain an understanding of concepts and processes—such as chemical interactions, biological effects of chemicals, qualitative and quantitative analysis, and the difference between science and public policy.

Success in this study means: the relationship between the girls' identification of those elements that contributed to their favorable or desired outcome in obtaining a high performance or proficient rating in science class.

Student in this study means: girls who have attended the school for at least 3 years and would have been exposed to 3 years of different science curriculums in order to allow for comparative data of their overall exposure to science.

The Respondents' School and Background

The respondents' school, for the purposes of this study, is identified as a school of choice located in the United States. It is considered a "small school" defined by the size of its student body population. Admission is voluntary and the school is open city-wide. The student population is diverse and serves students of all backgrounds and abilities. The curriculum is integrated and inquiry-based.

The school's purpose is to ensure that girls are prepared for the 21st century workplace, a world where math, science, and technology skills are at a premium. The school's mission is to provide options to those who normally couldn't afford them by providing a high-quality, well-rounded, college preparatory education focusing on math, science, and technology, and dedicated to the development of leadership skills.

This school of choice was selected because of its unique characteristics, which are: (a) single-sex environment; (b) small in student population; (c) the school was created to help girls succeed in fields where women are underrepresented in order to help close the gap in the STEM fields; (d) a focus on academic achievement, career, and college preparation; (e) a focus on leadership development, personal, and social development; and (f) through mentoring and internships, the students have female role models in many accomplished fields in STEM careers.

The School's Science Curriculum

Extracted from materials provided by the school during the 2000/2001 academic school years, the following is an overview of the science curriculum.

> The science curriculum focuses on Nature of Science and Scientific Inquiry as unifying instructional themes. This is a unique and ambitious organizational scheme for science instruction, one that is not being currently adopted by any other school or school system. It is the school's strong belief, along with emerging research, that students' understanding of scientific inquiry and nature of science are fundamental to the development of scientific literacy.
>
> Science is a particular way of knowing about the world. In science, explanations are restricted to those that can be inferred from confirmable data—the results obtained through observations and experiments can be sustained by other scientists. Scientists never arrive at absolute truths about reality, but rather develop informed explanations inferred from empirical data. Inquiry based instruction allows students to engage in the practices of scientists and to construct their own scientific knowledge through investigations rather than memorizing factoids without meaningful context. When students engage in sustained reasoning about problems that interest

them and when they evaluate their own progress in solving these problems, they begin to practice the lifelong learning skills they will need to deal with scientific questions in the future.

Understanding the Nature of Science and Inquiry promotes critical reasoning processes and develops way of thinking that are unique to science. Developing students' understandings of the nature of science and scientific inquiry will serve as a guiding framework and context for the school's science program. Students experiencing such a curriculum focus will clearly realize why scientific knowledge is never absolute and is subject to change; while at the same time realize that current "tentative" explanations are truly based on significant data. These same students will learn to carefully analyze the sources of data and claims made by scientists as they attempt to make personal and societal decisions.

In short, it is expected that students who attend this school will be prepared to make reasoned/informed decisions that maximize the use of available information instead of relying totally on the opinions and biases of others. Having a deep understanding of not only scientific knowledge, but also the sources of this knowledge and its status relative to "truth," are outcomes that no K--12 science curriculum (let alone college curricula) can generally claim of its graduates.

The curriculum materials selected were considered to be with the identified program goals and offered the necessary content and concepts for the students as they enter and progress through the grades of the school. The plan was to intentionally infuse Scientific Inquiry and pedagogical principles that incorporate state of the art "best practices" for instructing girls about the Nature of Science into each of the high school science courses throughout the year. Each curriculum selection is subject to change based on the school's ongoing assessments of the programs in terms of specific criteria, student learning, and availability of newly developed curricula materials.

In addition to classroom-based activities/instruction, students work in teams each year on projects related to science topics of their own choosing. These projects are decided upon as a group, with the guidance of the teacher. The teachers' guidance focuses primarily on insuring that projects are developmentally appropriate for student groups and do not have inherent safety concerns.

This type of independent work is another aspect of the school science program that distinguishes it from mainstream science programs. More importantly, it is an excellent context for students to gain experience doing what scientist do and to gain an appreciation for the sources of scientific knowledge and the necessary qualifications that must accompany all knowledge claims,

It is not uncommon for students to participate in "hands-on" activities within science classes. However, in virtually all of these cases students are provided with a question to answer and procedures to follow. All too often students know the "answer" before they embark on the completion of such activities. The goal of the independent projects is to provide students with an experience more authentic to the daily activities of those who practice science as a profession.

The Conceptual Framework

The basic model examined in this study is presented below in diagrammatic form (see Figure 1). It illustrates the students' perceptions and views as they relate to their success and failure in science programs designed specifically for them.

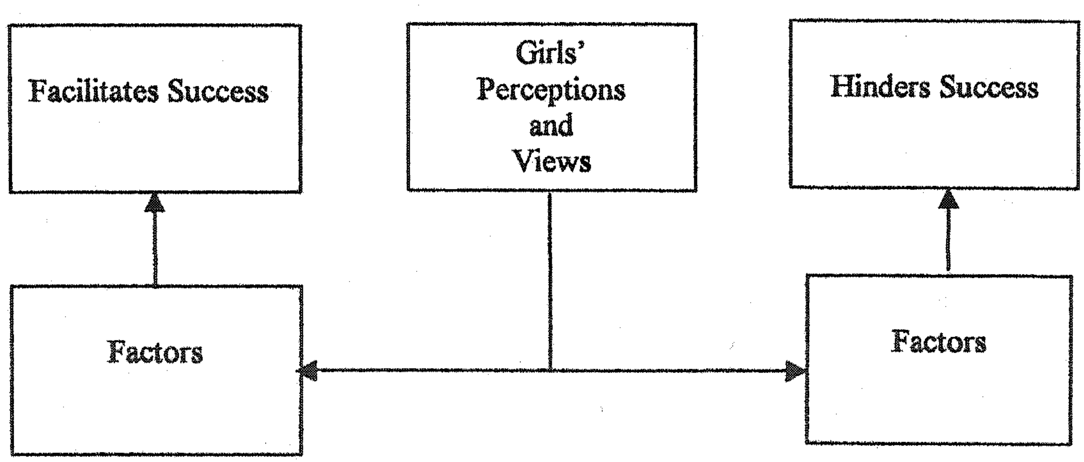

Figure 1. Conceptual Framework.

There are many different psychological theories that attempt to explain how success is defined and actualized. Hamilton and Ghatala (1994) talked about behavioral and cognitive theories from both perspectives. For example, behavioral theorists maintain that success can be described as actions that produce pleasing consequences in one's environment. From a behavioral perspective, a person can achieve success by increasing the frequency of those actions that bring about positive results. Cognitive theorists argue that success is related not to environmental standards but to experiences that match internal perceptions. Therefore, from a cognitive perspective, achieving success would entail increasing the frequency of experiences that match personal ideals.

A combination of these two theories known as social learning provides an image of achieving success that is determined through a combination of personal and social factors (Hamilton & Ghatala, 1994). Many educational researchers have built on psychological theories such as these in an attempt to measure which students meet their criteria for success, which do not, and what makes the difference. In student development, this theory is referred to as interactionism, which sees behavior as a result of personal attributes, environmental characteristics, and the effects of interactions between person and environment (Schroeder & Jackson, 1987). By drawing on elements of all of these theories, this study explored the different personal and environmental factors that could be involved in determining how success is defined and achieved.

Beginning at a young age, many girls and boys receive different messages from parents, peers, teachers, and the media. Young girls are taught to be nurturing, while boys are encouraged to play with toys they can tinker with or manipulate, such as construction sets, LEGOS, building blocks, and tool kits. Playing with these toys provides opportunities to develop problem-solving and independent-thinking skills inherent to success in science and math. Girls who lack these skill-building experiences often enter science and math classes feeling insecure about their abilities.

Self-perceptions play an important role in science and math achievement, especially for girls. Research shows that self-esteem and academic achievement among girls begin to decline during middle school (Backes, 1994) and that girls often exhibit a loss of self-confidence by age 12 (Orenstein, 1994). This lack of self-confidence is also reflected in the fact that boys are more likely to attribute personal success to effort, whereas girls tend to attribute it to luck. As a result, many girls underachieve in science and math simply because they choose to participate in activities in which success is almost assured. "The typical explanation for female underachievement in science and underrepresentation in scientific professions is that girls choose not to take physics, chemistry, and calculus" (Lee & Burkam, 1995). For example, about 25% fewer female students took the AP test in chemistry than male students in 1998, 55,156 female test takers compared to 25,662 male test takers, and about 12% fewer female students took the AP test in calculus than male students in 1998, 19,275 female test takers compared to 25,662 male test takers (The College Board, 1998).

Attitudes also contribute to the underachievement of girls in science and math. Although middle school girls take more high-ability courses than boys and make comparable or higher grades, their attitudes toward science and math are less positive, and they are less likely to participate in related extracurricular activities.

Unfortunately, research shows that social attitudes tend to become fixed during middle school and early in high school (Heller & Martin, 1992). So girls who develop negative attitudes toward science and math during this period of development are unlikely to acquire the academic background necessary for careers in science, math, or engineering. As a result, by grade 12, more girls than boys say they chose not to take more science or math courses because they either disliked the subject matter or didn't do well in those subjects (U.S. Department of Education, 1997).

In essence, girls' and boys' abilities are the same; their self-perceptions and attitudes are different. Even girls who have course backgrounds and achievement levels similar to those of boys have less confidence in their abilities and less interest in studying science and math. Consequently, girls are less likely than boys to pursue related careers (U.S. Department of Education, 1997). Finally, some girls underachieve in science and math because they are discouraged from studying these subjects. One study shows that higher percentages of girls than boys are advised not to take senior science or math (National Science Foundation, 1994).

Limitations/Delimitations

Limitations

An assumption in this study was that all participants answered interview questions about their perceptions truthfully, freely, and frankly. It was assumed that the interviews provided a complete and useful database of information upon which interpretations and conclusions can be drawn. Ethnicity was not a factor that was examined in this study.

A possible limitation of the study may include the lack of generalizability of findings beyond the specific research setting. The transferability of the research findings to another situation have not been validated, although providing sufficient information might make findings applicable to a new situation depending on the degree of similarity (Lincoln & Guba, 1985).

An additional limitation of the study could have been related to the objectivity of the researcher. In such cases Patton (1980) recommended "empathic neutrality" (p. 55). He stated that empathy "is a stance toward the people one encounters, while neutrality is a stance toward the findings" (p. 58). He also stated that the neutral researcher needs to be nonjudgmental while trying to report what is found in a balanced way. While as the researcher I found the topic compelling, I identified with the girls and the issues; yet I believe that I was able to maintain empathic neutrality, objectivity, and balance in reporting the findings.

Delimitations

This study confined itself to interviewing those students from the school of choice who have attended the school for at least 3 years. The study focused on the respondents' perceptions of factors that they could identify as contributing to their success or failure in programs specifically designed to maximize their achievement in science.

Organization of the Remainder of the Study

The remaining chapters of the study have been organized as follows. Chapter II reviews the related literature and research relevant to the current investigation. The methodology and procedures used to gather data for the study are presented in Chapter III. The results of the data analyses and findings that emerged from the study are contained in Chapter IV. Chapter V contains a summary of the study and findings, conclusions drawn from the findings, discussion, and recommendations for further study.

CHAPTER II

LITERATURE REVIEW

The purpose of the literature review is to synthesize the literature on women and girls in STEM fields and establish justification for the study. The review of the literature focused on three aspects important to the study:

Section I: Factors that hinder women's success in STEM and factors that promote or encourage women's success in STEM.

Section II: Girls' perceptions of their status within the STEM fields; an exploration of the direct and logical connections and strategies that may help lead overcome negative perceptions. Also of interest was the discovery of pedagogical strategies currently used by alternative schools as a means to retain girls within science and overcome girls' negative perceptions of their "place" within science.

Section III. A review of critical studies that address the success or failure of these pedagogical approaches that are centered in retaining girls in science programs; the outcomes of these approaches, and literature that discusses whether and how well these strategies work.

Education, in general, and science, technology, engineering, and mathematics (STEM), in particular, is perhaps the most critical factor in this information age. It's very clear that our nation's economic future depends on the ability of our workers to be proficient in STEM careers. Over the next 10 years, the United States will need to train and educate an additional 1.9 million workers in the sciences (National Science Board [NSB], 2002). Recent enrollment trends indicate that increased involvement of underrepresented groups is essential in meeting this demand (NSB, 2002). Currently, all along the educational pipeline, students are being lost in STEM fields. Moreover, the participation and persistence rates of women in these fields are dramatically lower than those of the general student population (Chang, 2002).

STEM careers offer abundant opportunities today, yet women and girls continue to be a minority in these fields. While the percentage of women in STEM has increased significantly in the past 30 years, research indicates that we still have a long way to go, and in some areas we are even losing our gains (Lee, 2001).

Female students have a lower level of interest in the sciences (NSB, 2002), although an increased participation of women is essential in meeting the projected need for STEM workers and in furthering the nation's production of STEM research. Numerous conferences and hearings have been convened and numerous articles have been written to discuss the current status of women in STEM fields. The review of the literature includes factors that facilitate or hinder women's success in STEM fields, alternative schools with STEM emphasis—with a focus on the factors they theorize have positive and negative impacts on students' success, and various STEM curricula and theories concerning their success or failure.

Section I

Factors That Hinder Women's Success in STEM

The current status of women scientific fields can be described as low—women are largely "underrepresented" in the sciences; however, their numbers are growing slowly. The "harder," or more mathematical-oriented the science, the fewer women there are. The percentages of women in physics and engineering are far lower than the percentages of women in biology and even further behind the percentages of women in social sciences like psychology. The percentage of doctorates awarded to women in 1989 was biology, 37%; chemistry, 24%; math, 18%; computer science, 16%; physical science, 11%; and engineering, 8%. Also, the higher up in rank or prestige of the STEM discipline, the fewer women there are. In physics, 15% of bachelor's degrees and 11% of Ph.D.s go to women, yet only 3% of tenured/tenure-track faculty are women. Overall, between 13 and 16% of all employed scientists are women (Grant, 1995).

There has been an increase, though not a substantial increase, in these numbers over the last decade. The percentage of doctorates going to women in 1999 was biology, 41%; physical science (includes physics, chemistry, and astronomy), 23%; math, 26%; computer science, 18%; and engineering, 15%. Yet, the hard fact remains that women scientists still make up only 26% of the workforce (National Science Foundation, Division of Science Resources Studies [NSF/SRS], 2001).

Research conducted by Campbell and Clewell (1999) states that there has been success in getting girls to take more STEM courses in high school. However, at the same time, fewer girls are interested in choosing STEM as their life's work, or even as a college major. Is this a direct result of telling students that they don't have to like STEM courses; they just have to take enough courses to get into a good college? That is what increasing numbers of students do: They take the courses and do okay, or even well, in STEM, but they aren't engaged and they don't—especially if they are girls—go on to STEM careers (Campbell & Clewell, 1999).

This lack of engagement in STEM may affect girls disproportionately because they are less likely than boys to get involved in STEM activities outside of school, from using meters and playing with electromagnets, to fixing gadgets and reading about technology. Words like *passion* and *excitement* and *joy* rarely come up in discussions of gender in STEM or of how to get more girls involved. Yet without such emotions, why would girls go into these fields? (Campbell & Clewell, 1999).

Nurturing girls' passion for science and mathematics is not easy in our current society. Even when students are asked to draw a scientist, the vast majority of their drawings are of white men. Lurking behind these drawings is the disturbing myth of the math "gene." This is the erroneous, but strongly held, perception that there is a genetic or biological basis for gender differences in STEM. Girls who believe that "real girls don't do math," as Elizabeth Fennema's study found years ago, are less apt to continue in STEM or to do well (Campbell & Clewell, 1999).

The reasons that so few women are in science careers are complex and it is difficult to pinpoint or isolate all of the contributing factors. However, it is known that, historically, men have actively kept women out of STEM fields, as women were not allowed into college until the late 1800s. While most official barriers are gone now, there are many informal and structural barriers which keep women from going into STEM careers and which keep the attrition rate higher for women than men (Grant, 1995).

Research indicates that attitudinal factors contribute to the lower level of interest in STEM for women. For women, perceptions of competition and difficulty with majoring in STEM fields are paired with low self-ratings of ability in analytical fields that have traditionally been male-dominated. Cases of math anxiety and instructors' lowered expectations have also been shown to hinder women from participating (Seymour & Hewitt, 1997).

In addition to the challenges of recruiting students as STEM majors, there are also retention issues. STEM fields report the lowest retention rates among all academic disciplines at the undergraduate level. Approximately 50% of students entering college with an intention to major in STEM change majors within the first 2 years (Center for Institutional Data Exchange and Analysis, 2000).

One reason for this loss of students is that many incoming freshmen lack basic science and mathematics literacy needed for persistence. A study conducted found that 31% of students fail to complete STEM courses, while another 19% complete courses but with a grade of D or F (Feuers, 1990). Not only is the course completion rate particularly low in STEM fields, but the percentage of students requiring remedial work is also increasing. Approximately one third of students at 2-year colleges enroll in remedial mathematic courses (NSB, 2002). These courses are essential for responding to students' lack of readiness for college level STEM coursework.

While deficiencies in students' academic preparation lead to attrition, research suggests that students' negative perceptions of STEM subject material and career options also play an important role. In a survey of undergraduate students who left STEM, the most frequently cited factors contributing to decisions to change majors included the following: the belief that non-STEM majors offer greater intrinsic interest, a loss of interest in STEM, and a rejection of the STEM career-associated lifestyle (Seymour, 1992).

Farrell (2002) explains that STEM fields have failed to highlight the social value and relevance of the subject matter. In particular, the disconnection between subject material and life applicability has been shown to affect the retention of women in engineering. For many female students, the technical nature of engineering does not suggest life skills of creative thinking and communication. Seymour (1992) explains that the image of scientific careers also does not appeal to female students' orientation toward helping others and having a family.

Cultural stereotypes provide one prominent explanation for the gender gap in science and mathematics. Claude Steele, a psychologist at Stanford University, has done some of the most convincing research on the effect of negative cultural stereotypes (Steele, 1994). Steel and his colleagues recruited male and female college students with talent in mathematics, who saw themselves as strong math students. He gave them a difficult mathematics test taken from the Graduate Record Examinations (GRE). In one condition, the students were told this test showed no gender differences.

The male and female college students who took the difficult math test were either told that the test generally showed gender differences—implying the stereotype of women's math inferiority was relevant to interpreting their own frustration—or that it showed no gender differences—implying that the gender stereotype was not relevant to their performance on this particular test. In dramatic support of Steele's effect of negative cultural stereotypes reasoning, women performed worse than men when they were told that the test produced gender differences—replicating women's underperformance in earlier experiments—but they performed equal to men when the test was represented as insensitive to gender differences, even though, of course, the same difficult test was used in both conditions. However, the women in this study never achieved math scores as high as men reached even when the threat of cultural stereotypes was removed (Kleinfeld, 1998b).

Factors That Promote or Encourage Women's Success in STEM

When young women graduate from high school, they have basic science, technology, engineering, and mathematics skills and knowledge in numbers and percentages comparable to young men, although some gaps exist at the most advanced levels. However, young women are much less apt than young men to continue on in STEM fields (Campbell & Hoey, 1999). This situation is one of several factors that prompted National Science Foundation (NSF) leadership in improving preK–12, undergraduate, graduate, professional development, and public science literacy projects as well as advocating for and funding projects that promote gender equity in the STEM disciplines. In partnership with the research and education community, state and local education agencies, civic groups, business and industry, and parents, NSF fosters the invigoration of research-informed standards-based STEM education at all levels.

The National Science Foundation has been in the forefront of gender equity advocacy and education reform in the sciences, having partnered with public and private organizations to research the issues, disseminate research findings, and establish and advance an equity agenda in education and professional practice. As a result, privately and publicly funded STEM programs targeting girls and young women tend to have as goals:

- To increase girls' participation in STEM course taking
- To improve girls' self-confidence and attitudes towards women in STEM
- To increase interest and participation in STEM careers

(Campbell & Hoey, 1999; Clewell et al., 2000)

Research studies and program evaluations provide some information about strategies that have been employed to meet these goals and the impact of those strategies in encouraging girls in STEM. For example, programs for pre-college girls that combine hands-on activities, including student designed projects, and the provision of role models through mentoring, internships and career-oriented field trips have been found to lead to:

- Interest in STEM
- Increased self confidence
- Fewer or decreases in sexist attitudes about girls and women in STEM
- Skill and concept development (within the areas covered by the hands-on activities)

(Campbell & Steinbrueck, 1996; Clewell et al., 2000; Expanding Your Horizons, 1999)

Research studies and practical intervention programs concerning the entrance, retention, and achievement of girls in mathematics indicated probable areas for fruitful programs in science. To reverse these perceptions and increase female participation, educators point to the need to strengthen the educational pipeline, especially at the pre-college and community college level where interest in STEM develops. Intervention workshops and studies in science were initiated in the early 1980s and were often funded by the Women's Educational Equity Act (U.S. Department of Education) or by the Education and Human Resource Directorate of the National Science Foundation, which found that most gender intervention programs that focused on schools and had the objectives of (a) eliminating male gender bias and demystifying science, usually by exposing girls to career information and female role models; (b) improving girls' self-confidence and self-perceptions of their ability to do science; (c) implementing teaching strategies that actively involved girls in science lessons; and (d) developing girls' practical skills in understanding and applications of science.

Kahle (1985, 1997) identified factors that increased the interest levels as well as the retention rates of girls in science courses. This study focused on determining which, if any, teaching strategies and teacher behaviors were successful in encouraging girls to remain in science. The study involved eight sites across the United States and approximately 400 high school biology students. The researchers found that teachers who had a high proportion of girls continuing to enroll in high school chemistry and physics used specific teaching practices. For example, compared with a national sample (Weiss, 1978), they emphasized laboratory work and discussion groups, they quizzed their students weekly, they stressed creativity and basic skills, and they used numerous printed resources rather than relying solely on one textbook. The teachers, mostly females, also provided their students with career information and informal academic counseling. They all had attractive classrooms decorated with posters and projects, and kept live plants and animals in their laboratories. The researchers hypothesized that the identified teaching strategies contributed to more girls continuing to take elective science courses (Kahle, 1985).

The next section reviews research that features girls' own perceptions of their science capabilities in the context of programs, instructional strategies, and approaches that have emerged to make it possible for increasing numbers of girls to participate in the sciences.

Section II

Girls' Perceptions of Their Status Within the STEM Field; An Exploration of the Direct and Logical Connections and Strategies That May Help Girls to Overcome Negative Perceptions

Alternative or magnet schools are defined as public schools that offer specialized programs which allow students to attend their school of choice and whose focus best matches their interest (Cookson, 1994). As a result, numerous alternative schools were designed with a focus in science, math, and technology. Whether the schools were co-ed or single-sex, The New England Consortium for Undergraduate Science Education (1996) implied, based on sociological, psychological, and educational research, that to teach for equality we must first recognize that teaching habits differentially affect various populations in our classrooms.

It has been argued by many educators that by using teaching techniques that recognize a variety of learning styles in our classrooms, we would not serve only women but would attract more students, including men, who are not learning under the standard lecture-style, large-class, science education system. Some faculty who have considered the challenge of teaching for a more diverse "audience" have claimed that more inclusive teaching is simply good teaching. While this belief appears to be widespread, there are two caveats. First, some educators suggest that creating a welcoming climate has more to do with good classroom teaching than using out-of-classroom strategies. Second, by concentrating on what we know to be good teaching practices alone, it is often possible to ignore gender-related difference.

Studies have shown that there are gender differences in communication styles (Hall, 1982). In general, men tend to respond to questions more confidently, aggressively, and quickly, regardless of the quality of their responses; they tend to speak more freely and spontaneously in class, formulating their answers as they speak. Women, on the other hand, tend to wait longer to respond to a question in class, choosing their words carefully, reflecting on the question and constructing an answer before they speak. These studies have also shown that women tend to be interrupted more frequently than men; when this happens, they get the message that their contributions are not as valuable, and they may hesitate to join discussions in the future.

It is a common belief among students that college-level introductory science classes are intended to "weed out" or eliminate those students who are not deemed "fit" to be in the sciences. The perception of a "weeding out" process discourages many interested students from pursuing science in college. Some teachers believe that "a lack of certain ability and/or character attributes distinguishes those students who leave STEM majors from students who remain in them. Widespread acceptance of this theory allows STEM schools to regard their leaving as a kind of 'natural selection' process" (Seymour, 1992). In fact, studies (Astin, Green & Korn, 1987; Astin, Green, Korn, Schaliti, & Berz, 1988; Green, 1989; Seymour, 1992) have repeatedly shown that many students who leave the sciences are intelligent and strongly motivated, but are discouraged by the competitive atmosphere and the belief that the school is trying to judge their abilities at an early stage. Although many classes are designed to set students in competition, students often respond more positively to an atmosphere of cooperative learning. In her research, Elaine Seymour found that over a third of the students switching out of a STEM field indicated that one of their primary reasons for leaving was that their "morale was undermined by competitive culture" (Seymour, 1993).

Cooperative learning is an approach to learning which uses small groups of students working together to solve problems, complete a task, or accomplish a common goal. "Small groups provide a forum in which students ask questions, discuss ideas, make mistakes, learn to listen to others' ideas, offer constructive criticism, and summarize their discoveries in writing" (National Council of Teachers of Mathematics [NCTM], 1989).

Pedagogical Strategies Currently Used in Practice by Alternative School as a Means to Retain Girls Within Science and Overcome Girls' Negative Perceptions of Their "Place" Within Science

Launched by the National Council of Teachers of Mathematics' standards in 1989 and followed by the National Research Council's science standards in 1995, reform efforts advocate instructional strategies such as hands-on science activities and small-group learning that are widely believed to help foster girls' learning. One recent study of performance-based science classrooms in grades 5–8 found that although boys and girls earned similar grades, girls' perceptions of their science abilities actually decreased over the year, in contrast to those of their male classmates. A second study found that even in the early years, boys were more apt to solve problems by developing their own rules, and girls were more apt to follow the rules of others.

The National Science Foundation's (2003) federally funded project, *Get Set, Go!* worked with teachers, parents, and community science museums and centers. The program encouraged middle school girls' active participation in science. Four lessons learned from the project are as follows: The first lesson is *Provide time for teachers to research resources.* Teachers need experience with, information about and materials for hands-on activities and typically have little time to search for them. It is important to designate time during an institute for teachers to research curricula and hands-on activities for their classroom. It is worthwhile having project staff do the legwork of finding resources that teachers at the institute can review and order.

The second lesson is *Explicitly communicate underlying principles and strategies, as those participating may not easily make connections.* It is important in a hands-on session to make one or two key scientific concepts or processes explicit enough for deep understanding and not just do activities for activities' sake. Whether practicing strategies to accommodate diverse learning styles, modeling a parent night program, or conducting a hands-on activity, three steps will make principles more accessible to teachers: (1) Do the activity, (2) Tell teachers what you did (this step is often skipped), and (3) Have them reflect on how they can apply that in their own classes or schools. Similarly, on parent nights, (1) Do the activity, (2) Explain to parents what concept or skill is being developed, and (3) Explain why that is important for the education of their children.

The third lesson is *Coach role models*. Scientists unaccustomed to speaking to middle school students must be told in advance that the science content is less important than how a scientist's experiences prepared her for her career in science. In connection with guest lectures, explicitly discuss gender equity issues, what courses students should take (starting in middle school), how girls can pursue viable careers in science, and how math and science are important to informed citizens.

The fourth lesson is *Improve science displays*. Classroom science displays seldom represent people, much less a diversity of people, and schools rarely have science displays in the hallways.

Another NSF funded project, *The Girl Power* program (NSF, 2003), stressed four general ways to encourage girls' interest in math, science, and technology classes:

1. *Model equity in the academic environment*—This can be done by hanging posters that feature as many girls as boys (and as many women as men), by treating girls equally, by featuring information on careers and colleges, and by making evident math and science's real-life applications. In an equitable environment, teachers use more hands-on lessons, more cooperative groups, and more relevant examples. Teachers and counselors may need extra training.

2. *Use appropriate teaching strategies*—The most important strategy for encouraging girls is to include hands-on activities in which boys and girls can participate equally. Girls should get equal hands-on time, for example, rather than simply record information while the boys do all the manipulation. Teachers should call

on students randomly, to be sure girls and boys are called on equally and get equally complex questions.

3. *Infuse gender equity into the curriculum*—In providing examples, tell how specific women have contributed to science, at the point in the curriculum that is relevant to their accomplishment.

4. *Make assessment equitable*—Girls should see models of what is expected and should be allowed some options for how to demonstrate their competence.

Section III

A Review of Critical Studies That Address the Success or Failure of These Pedagogical Approaches That Are Centered in Retaining Girls in Science Programs

For about 20 years teachers and researchers have been concerned about differences in the enrollments and achievements of girls and boys in science. Early work focused on differences in interest, attitudes, and motivation—it was thought that if girls liked science, they would do well in it. Early intervention projects helped teachers teach science in a "girl friendly" way and focused on the science that girls indicated they preferred (biology). Assessments of those projects indicated that neither the attitudes nor achievements of girls systematically improved. Recently, researchers have proposed a model that explains the complex sociocultural, personal, and educational interactions that must be addressed to increase both the numbers and the achievements of girls in school science (Kahle, Parker, Rennie & Riley, 1993).

Today, research tells us that the issues affecting girls in science must be addressed at an early age and may differ across groups.

Research at the University of Minnesota (Kahle & Meece, 1994) suggests that boys and girls learn socially appropriate behavior by 24 to 26 months of age. At that time, male and female stereotypes are set, and boys, more than girls, define what they will and will not do. Similar sex-stereotypic behaviors are revealed in very young science students. In one study, for example, kindergarten children were interviewed 3 weeks after they entered school. At that age, neither boys nor girls were able to define science, but—even without that knowledge—more boys than girls replied that they wanted to be scientists, that they were good in science, and that they had done science. The importance of their attitudes is reflected in the hypothesis that sex differences in course taking patterns are established as early as kindergarten.

Another study revealed that fourth grade girls showed a preference for biological science, while boys, many of whom had out-of-school experience with mechanical and electrical activities, chose topics in the physical science. Furthermore, in this same study, girls based their selections on what they should know, while boys selected science topics on the basis of what they wanted to know (Kahle & Damnjanovic, 1994).

By the time adolescence is researched, children have a well-defined identity. Some studies show that girls' regard for science begins to decline in junior high school. For example, equal percentages of third-grade girls (67%) and boys (66%) responded that what they learned in science classes is useful in everyday life. In seventh grade, both boys' and girls' responses continued to be fairly high (54% and 57%, respectively). However, boys retained that attitude through high school, while girls' perceptions of the utility of science decreased 11%. The same is found to be true of interest in science related careers. Boys and girls responded the same in the 7th grade, but many girls lose interest by the 11th grade (Jones, Mullis, Raizen, Weiss, & Weston, 1992).

The deterioration of girls' views of science is reflected in their enrollment in elective science courses in high school. Although the last few years have seen a substantial increase in the number of young women enrolling in high school chemistry, they continue to be underrepresented in physics. There is also some indication that girls' increased chemistry enrollment may be due to increased science requirements for high school graduation, and that much of the increase is in nonacademic chemistry courses (National Science Foundation, 1996).

The American Association of University Women (AAUW) has for years been on the leading edge of research in the field of educational equity. Their landmark 1992 study, "*How Schools Shortchange Girls,*" showed that girls in the early school years are no less innately interested or competent in math and science than boys. In fact, they consistently match or surpass boys in these subjects as measured by scholastic aptitude test. Yet at around age 13, girls' interest in higher education—particularly in the STEM (science, technology, engineering, and mathematics) subjects and in nontraditional careers begins a steady decline.

Canadian writer Myrna Kostash (1993), in her book *No Kidding: Inside the World of Teenage Girls,* notes some of the causes of what many educators refer to as The Great Divide:

- math and science-oriented toys and games tend to be designed with boys in mind;
- boys don't like girls who beat them at "their" subjects, therefore girls who show great interest and/or competence in these subjects risk social isolation;
- girls have fewer role models in the STEM sector;
- STEM subjects are often mistakenly seen (and presented) as "cold" and "theoretical", whereas girls tend to prefer people-oriented subjects;
- girls aren't often shown the value and applications that STEM subjects have for them in their lives and career options;
- fear of public failure in tackling the unfamiliar.

Attitudes and practices in both the home and the classroom begin to shape the way girls view themselves and their capabilities. Both educators and parents convey messages about what's "gender appropriate." Educators must reflect on and get rid of any biases that they might possess in order to create an equitable science classroom. However, they cannot alleviate the problem alone; parents must also foster a gender equitable environment. It is important for parents to expose their daughters to science and problem-solving-based activities and to convey the message that science is fun for all (Jovanovic & Dreves, 1995).

Boys are called on more frequently in class, challenged with more difficult questions and tasks, and play a far more active role in hands-on-projects and demonstrations. Teachers may devote more time to boys in math and science classes.

Girls are frequently tracked into low-ability math and science classes—even with scores matching those of boys who are tracked into advanced courses. At critical decision-making stages, girls are not given information about, and, in fact, are sometimes steered away from advanced courses.

Parents shape and direct their sons' and daughters' interests almost daily in everything from dinner table discussions to toy choices. Girls also have to contend with two powerful stereotypes: the first, that females are concerned primarily with feelings and relationships; the second, that work in the STEM sector revolves exclusively around the collection of "impersonal" data; therefore, girls don't "belong."

It can be a complex mix of factors that push girls out of STEM studies. What is clear, however, is that the girls who drop these subjects like in junior high are slamming the door on a myriad of career possibilities. If girls are to be active participants in STEM careers, parents, teachers, schools, businesses, and the larger community must implement targeted interventionist strategies early, consistently, and collaboratively.

There are several ways parents and educators can encourage girls to keep their options open and to pursue all subjects in which they have a talent and interest. First and foremost, parents must remain involved throughout the middle years while their daughters are making these important decisions. If math and science have been a strength in elementary school (and even if that's not the case), encourage girls to enroll in classes that will make them stretch intellectually. In high school, encourage girls to take Advanced Placement and pre-AP courses in these subjects. In addition, parents and educators can help girls become involved in enrichment programs that encourage girls to pursue STEM careers.

For educators, research implies that an inquiry approach to instruction enhances girls' interest in science more than boys (Morran, Demoss, & Barnett, 2001). Inquiry-based science emphasizes collaborative group work, hands-on experiments, and the sharing of data, all of which girls tend to enjoy more than boys. What is inquiry-based science education? It is an approach to science education through which children learn to ask questions, experiment, develop theories, and communicate ideas (Maher, 1998). It consists of five elements: (1) a research-based, inquiry-centered curriculum; (2) professional development; (3) materials support; (4) assessment strategies; and (5) community and administrative support.

Released in October 1995, *Growing Smart: What's Working for Girls in School* (AAUW, 1995) gave educators, policymakers, parents, and students' insights into strategies those foster girls' achievement and healthy development. A national review of more than 500 reports and studies on girls in grades K–12, *Growing Smart* offered compelling evidence that innovative approaches such as team learning, all-girls classes, and greater hands-on access to computers and tools benefit girls' ability to succeed in school. The publication included a detailed summary of the researchers' data; action strategies for schools, families, and community leaders; and a resource list of programs nationwide with photos and firsthand accounts from program participants.

Women in Science: A Report from the Field (Kahle, 1985) speaks to researchers that conducted nationwide surveys to identify teachers who have motivated high school girls to continue in science. In addition to assessing instructional techniques, classroom climate, and teacher-student interactions, a selected sample of students (former and current) responded to questionnaires which assessed attitudes, intellectual, and sociocultural variables. Two types of research, observational and survey, were used to gather data for the research. The case studies, which were the observational part of the project, provided information about the student-teacher and student-student interactions. Case studies were limited in the extent to which they may produce generalizations applicable to other situations. Therefore, they were supplemented with survey data, describing the abilities, activities, and aspirations of the involved students and teachers. These research efforts led to the following conclusions.

Danzl-Tauer (1990) and Kahle, Anderson, and Damnjanovic (1991) found that teachers who successfully *encourage* girls in science:

- Maintain well-equipped, organized, and perceptually stimulating classrooms.
- Are supported in their teaching activities by the parents of their students and are respected by current and former students.
- Use non-sexist language and examples and include information on women scientists.
- Use laboratories, discussions, and weekly quizzes as their primary modes of instruction and supplement those activities with field trips and guest speakers.
- Stress creativity and basic skills and provide career information.

Factors which *discourage* girls in science:

- High school counselors who do not encourage further courses in science and mathematics.
- Lack of information about science-related career opportunities and their prerequisites.
- Sex-stereotyped views of science and scientists which are projected by texts, media, and many adults.
- Lack of development of spatial ability skills (which could be fostered in shop and mechanical drawing classes).
- Fewer experiences with science activities and equipment which are stereotyped as masculine (mechanics, electricity, astronomy).

The teachers, both male and female, who were successful in motivating girls to continue to study science, practiced "directed intervention." That is, girls were asked to assist with demonstrations; were required to perform, not merely record, in the laboratories; and were encouraged to participate in science-related field trips. In addition, teachers stressed the utility of math and science for future careers.

Both male and female students in the schools identified as "positive toward girls in science" were questioned about their attitudes toward science and science careers. When compared with a national sample, the students in these schools had a much more positive outlook. This difference was especially pronounced among girls. When asked how frequently they like to attend science class, 67% of the girls responded "often," compared with 32% of the girls in the national sample. And when asked if they would like to pursue a science-related job, 65% of the girls said "yes," compared with 32% of the girls in the national sample.

This research suggested that teaching styles and other school-related factors are important in encouraging girls to continue in science courses and careers. The path to a scientific career begins in high school and requires skilled and sensitive teachers. The research identified the following "Do's" and "Don'ts" for teachers who want to foster equity in science classrooms.

DO

- use laboratory and discussion activities
- provide career information
- directly involve girls in science activities
- provide informal academic counseling
- demonstrate unisex treatment in science classrooms

DON'T

- use sexist humor
- use sex-stereotyped examples
- distribute sexist classroom materials
- allow boys to dominate discussions or activities
- allow girls to passively resist

Another study assessed the effects of specific types of curriculum to improve retention rates and achievement levels of girls in school science. The study involved 10 rural, male biology teachers, who were introduced to quantitative laboratory activities that included spatial-visual exercises as well as the use of cooperative group learning (Danzl-Tauer, 1990). After the intervention program, most of the teachers increased the amount of time spent in individual and small-group activities as well as with hands-on, manipulative materials designed to develop students' spatial and quantitative skills. Interviews with teachers suggested that the change was due to the availability of quantitative and skill activities that were approaching for alternative classroom interaction modes. By regressing classroom strategies against student variables, Danzl-Tauer found that the use of more interactive activities in an individual format was related positively to girls' enjoyment of science and gains in science achievement. However, Danzl-Tauer found a negative relationship between times spent in small groups and girls' attitudes concerning self-confidence in science ability and usefulness of science.

Finally, Danzl-Tauer reported that the time in whole-class activities seemed unrelated to any of the student variables in the study. She cautioned that the negative relationship between use of small-group activities and attitude might have occurred because the small groups were not cooperative groups. She did not find a relationship between future enrollment in science and math and any teacher variable (interaction mode or number of activities used). Although she concluded that gender differences in enrollment patterns were a function of the schools attended rather than of the science classes and teachers, she did identify a factor (use of manipulative and quantitative materials) related to improved achievement of girls in science.

Intervention programs have been fairly successful in identifying specific factors that influence girls' self-confidence and retention in science courses (Matyas & Malcom, 1991). However, they have been less successful in identifying specific factors that contribute to the continued and growing achievement gap between girls and boys in science. Recent work (Danzl-Tauer, 1990; Kahle et al., 1991; Klanin & Fensham, 1987; Rennie & Parker, 1987) indicates that emphasis on the skills of science may further enhance girls' retention and, with wide-implementation, result in improved achievement levels.

The WTN Foundation, Inc., funded by the Women's Television Network (2003), provided the following list of tips for teachers:

- Observe classroom dynamics and monitor your behavior and interactions with girls and with boys.
- Avoid perpetuating gender bias in your discussions of academic subjects, skills, careers, daily tasks, etc., and in software, textbooks and other teaching materials you may use.
- Don't "talk down" to girls. Use questions and comments to encourage their thinking and problem-solving skills.
- Call on boys and girls equally.
- While the jury is out on "learning styles," girls do seem to prefer collaboration to competition. Set up classrooms to promote co-operative work.
- Present computers as a tool for creating and communicating, not as a machine to be programmed.
- Display a positive attitude and enthusiasm when it comes to acquiring new skills, encourage students to overcome their reluctance.
- Be attentive to girls' requests for extra help. Create tutoring and enrichment opportunities as well as all-girl clubs and classes.
- Design activities that are fun, relaxed and collaborative, and include hands-on work and problem solving. Ensure that girls are front-line participants.
- Encourage girls to pursue high-level math and science classes, particularly at the critical decision-making stages grades 6, 7, and 8.
- Dispel narrow stereotypes of STEM fields and the people in them by putting girls in touch with female professionals.
- Consciously foster a confident, "can-do" attitude in girls in all that they undertake. Self-confidence is the memory of success.
- Involve parents as allies and partners. They have a powerful influence o the choices their daughters make. Encourage them to talk to their daughters

> about the many options open to them and about the importance of pursuing STEM studies to keep their options open. (WTN, 2003)

Conclusion

In conclusion, highly recommended approaches to keep girls actively engaged in learning about and valuing science include strategies that (a) employ inquiry based, hands-on science experiences and structured activities (Ebenezer & Connor, 1998); (b) involve practical applications—girls will learn more if they are given the chance to do science instead of just hear lectures about it (Jovanovic & Dreves, 1995); (c) use themes that are appealing to girls and use any techniques that girls are comfortable with and feel successful in (Ebenezer & Connor, 1998); and (d) present stories and literature about women scientists by exposing girls to women in science, as such stories help to break down the stereotypes associated with competence in science (North Central Regional Education Laboratory, 1996).

In *New Formulas for America's Workforce: Girls in Science and Engineering*, the National Science Foundation (2003) states:

> The world needs a citizenry that understands the discoveries and inventions that are changing our lives. Science and math courses need to entice, excite, and appeal, as well as inform our students. They cannot be boring and outdated and unnecessarily hard—aimed at "weeding" most students out of advanced studies. We need to engage and include more students, and a greater diversity of students, so that they persist further than before in learning the basics of science, math, and technology.

The literature on girls in science, technology, engineering, and mathematics research and practice was helpful in identifying factors that have been found to (a) enhance, and (b) impede or hinder girls participation in science and related courses and careers. The body of literature is growing. Research findings have resulted in a range of lessons learned and useful strategies for fostering greater participation and professional involvement of girls in STEM disciplines. There is some evidence that these lessons are gradually being disseminated and understood by people in the scientific, higher education and K–12 communities. This is necessary before widespread adoption and the needed change can take place. Yet, while it is easy to infer from the literature the external barriers to gender sensitive instruction, support, and career development, few studies have explored and made explicit girls' own perceptions of the factors that enhance and/or hinder their participation in STEM. This study contributes information and insights about girls' perceptions about their successes and failures in STEM to the growing body of knowledge.

CHAPTER III

METHODOLOGY

The purpose of this study was to determine the factors that girls identify as contributing to their success in a program specifically designed to maximize their achievement in science, specifically, what factors they identify that facilitate or hinder their success. Qualitative methodology was used to investigate perceptions and analyze the data obtained from the interviews.

Qualitative Methodology: An Overview

The research methodology is inspired by the criteria established in Strauss' "Grounded Theory" design (Strauss, 1987). According to this methodology, a "sensitizing concept" is formulated from the beginning of the data collection, that is, from the first review of literature as well as from the interview drafting (Dausien, 1994), "and is continuously probed, discussed and reformulated during the ongoing research, with a feedback path which leads to revision of the starting data on the basis of the temporary results obtained" (Bergamini, 1995, p. 353).

The purpose of "qualitative" or "naturalistic" research varies according to the research paradigm, methods, and assumptions. Generally speaking, qualitative researchers attempt to describe and interpret some human phenomena, often in the words of selected individuals (the informants). A qualitative approach is a way of using a systematic logic of inference to understand the experiences of respondents and to draw conclusions from data that are not quantitative and that are intended to describe, either explicitly or implicitly, nonquantifiable aspects of the respondents' experiences (beliefs, feelings, views, attitudes); the ways that respondents order their experience—as opposed to the way a researcher would frame the experience; the role of the researcher(s), the stages of research, and the method of data analysis. Qualitative research is based on the information gained through watching, listening, touching, feeling, smelling, tasting, and interacting. "The sources of knowledge are at least as diverse as the range of information provided by the senses. Each of the senses provides a unique content that is not replicable by other sense modalities" (Eisner, 1979, p. 14).

Grounded theory is a qualitative research approach that was originally developed by Glaser and Strauss in the 1960s. The self-defined purpose of grounded theory is to develop theory about phenomena of interest. Grounded theory is most accurately described as a qualitative research method in which the theory is developed from the data, rather than the other way around. That makes this an inductive approach, meaning that it moves from the specific to the more general. The method of study is essentially based on three elements: concepts, categories, and propositions, or what was originally called "hypotheses." However, concepts are the key elements of analysis since the theory is developed from the conceptualization of data, rather than the actual data.

Grounded theory is an emergent research process with some similarities to action research. It sets out to find what theory accounts for the research situation as it is. In this respect it is like action research: the aim is to understand the research situation. Strauss and Corbin (1998), authors of *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory,* are among the model's greatest advocates. According to Strauss and Corbin, "The grounded theory approach is a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon" (p. 27).

The primary objective of grounded theory, then, is to expand upon an explanation of a phenomenon by identifying the key elements of that phenomenon. The aim of this approach is to discover underlying social forces that shape human behavior, by means of interviews with open-ended questions and through skilled observations.

By utilizing the grounded theory approach, qualitative research data were obtained through informal conversation, interviews, and observations to determine factors identified as contributing to their (students') success or failure in programs specifically designed to maximize their achievement in science. Students volunteered to participate in the interviewing process.

The Research Sample

The school in this study is a girls' school of choice which includes middle and high school, 7th through 12th grade levels. Student enrollment draws from 30 surrounding communities and is racially and economically diverse with 64% of the students who quality for free and reduced meals. The school emphasizes a hands-on, experiential approach to science. This instructional approach helps students gain an understanding of concepts and processes such as chemical interactions, biological effects of chemicals, qualitative and quantitative analysis, and the difference between science and public policy. The school's science curriculum covers aspects of biology, chemistry, and physics. There are three science teachers on staff who are trained in one or more science disciplines.

The participants in this study included girls who had attended the school for at least 3 years, representing ninth and twelfth graders, respectively, during the 2003–2004 academic school year. Having attended the school at least 3 years allowed the girls to have a clear perception of science classes at different grade levels. From the student enrollment list for the 2002–2003 school year, 90 students met the set criteria. The sample for this study was selected from a pool of 35 eighth graders and 55 eleventh graders. The science teachers assisted in the selection process by identifying those girls who were more likely to provide candid responses regarding their thoughts and opinions. As a result of staff input, 20 girls, representing both ninth and twelfth graders, were asked to participate and they all agreed. Concluding the selection and interview process, it was learned that there was an equal distribution of participants who were passing and failing their current science classes. In the final analysis, the sample represented 10 ninth graders (5 passing and 5 failing) and 10 twelfth graders

(5 passing and 5 failing). In the findings, pseudonyms were given to the participants in order to protect their identity.

The Research Design

Easterby-Smith, Thorpe, and Lowe (1990) define research design as the overall configuration of a piece of research: what kind of evidence is gathered from where and how such evidence is interpreted in order to provide good answers to the basic research questions. As such, classroom observations, informal conversation, and interviews were used in this study to assist in determining the factors girls identified as contributing to their success or failure in a program specifically designed to maximize their achievement in science.

Instrumentation

Lincoln and Guba (1985) state that the instrument of choice in naturalistic inquiry is the human because he or she has the ability to interact with the situation, be responsive to environmental clues, provide immediate feedback, and request verification of data (p. 236). The human instrument can collect information at multiple levels simultaneously, explore a typical or unexpected response, and process data as soon as they become available (Hoepfl, 1997).

A structured protocol was used for the interview process. Utilizing closed-ended questions, the interviews were audiotaped and transcribed. The transcribed texts of all the interviews were then subjected to content analysis to identify the central concepts and themes that were present. The instrument was designed to elicit responses from participating girls that would reveal to the researcher some indication of their perceptions and general views with regards to education and careers in science. The interview questions were developed on the basis of the literature review. The questions covered their feelings; views—likes and dislikes, impressions, and thoughts concerning the school; their future career choices; the teachers; the classroom; the science curriculum; teaching techniques; and learning styles. All of the aforementioned areas were covered in order to assist the respondents in determining factors contributing to their success or failure.

Interview questions 1 through 15 were used as ice breaker questions in order to relax the girls and allow them time to become acquainted with the researcher and the interview process. Those questions were personal questions that they could easily respond to. Once that rapport was established, the respondents moved quickly through the interviewing process. The respondents held eye contact and spoke freely. They were attentive to the questions asked and requested that the question be repeated if they did not understand or weren't sure what the researcher was asking. The majority of the girls did not know the researcher by name but knew the researcher as being associated with "some kind of project" at the school of choice. This association was good for the interviewing process and the researcher because the girls were very open and amazingly consistent with their responses, even across grade levels and level of success. The remaining interview questions (questions 16 through 62) were science- and program-related and assigned by the researcher. The researcher assigned the code words, the parent code words, and the key terms accordingly. Based on the frequency of responses and the context in which the girls responded, key themes emerged.

Approaches for Data Collection

Interviews

The interview is a most commonly used approach for data collection in qualitative research. A qualitative interview is an interaction between the researcher and the interviewees through conversation, which is a basic mode of human interaction. When people talk to each other, they interact, get to know each other, and understand each other's experiences, feelings, expectations, and the world they live in (Kvale, 1996). Through interviews, the researcher can enter into other people's perspectives and understand how people make sense of their world and experiences (Restine, 1999). Interviewing is a metaphor of hearing data and sharing experiences. Through it, the researcher can extend his or her intellectual and emotional reach across time, class, race, gender, and geographical divisions (Rubin & Rubin, 1995). The words of the interviewees can give a picture of life changing experiences similar to real world events and demonstrate how the interviewees make sense of their perceptions and views of their success or failure in science.

Interviews constituted the major part of data collection in this research. The interviews conducted in this study were designed as structured interviews. In the structured interview, the interviewer asks predefined questions but also tries to leave more freedom for the interviewees to talk about matters that are important to them, from their own perspectives, concerning STEM (science, technology, engineering, and mathematics) and related issues. The lived experience and insights of the interviewees are released through the interview, and the interviewer tries to gain access to the world of the subject and his or her perspective (Kvale, 1996; Rubin & Rubin, 1995). In this case, the participants had varied experiences and views toward science, and the researcher wanted these detailed depictions of their experiences. A structured interview, rather than a semistructured interview, was considered more appropriate for this research.

Participant Observation

Reinard (1998) points out that in the research settings, qualitative researchers often become "active participants" (p. 192). Researchers immerse themselves in the research setting and gain membership and a close relationship with their participants and obtain insight from within the participant groups (Gay & Airasian, 1996; Wax, 1986). Participant observation constituted a part of this research. The researcher observed that the girls proceeded through the questionnaire rather quickly and easily answered questions. Based on the girls' kinesics (posture, gestures, and facial expressions that mirror feeling, beliefs, and attitudes), respondents appeared at ease with the researcher, with the study, and with their participation in the study.

Data Collection Procedures

Sixty-two closed-ended questions with 20 student participants were asked (see Appendix B). Students were allowed to respond at length and in their own way to the questions, to ask for clarification of any question they did not understand, and to question the researcher to determine whether the responses given were on target. Likewise, the researcher used probing questions to encourage students to give more complete responses to the closed-ended questions. The interviews lasted approximately 40 to 65 minutes and the interview process was completed in 4 days. If in the process of answering one question, the respondent answered another question on the list, the researcher did not ask that question again. The one-on-one interview was scheduled at the participants' convenience and was held at the school in an available room. Notes were taken during the course of each interview and responses were clarified or expanded upon when it was considered useful to the study. The purpose of the interview was initially explained and permission to tape the interview was requested. An informed consent form was provided for those participating in the study. Students were granted the right to withdraw from the study at any time.

Data Analysis

Data analysis is central to grounded theory building research. For the study as a whole, data collection, data ordering, and data analysis were interrelated as depicted in Figure 2 (the attached numbers indicate the activity's analytic sequence).

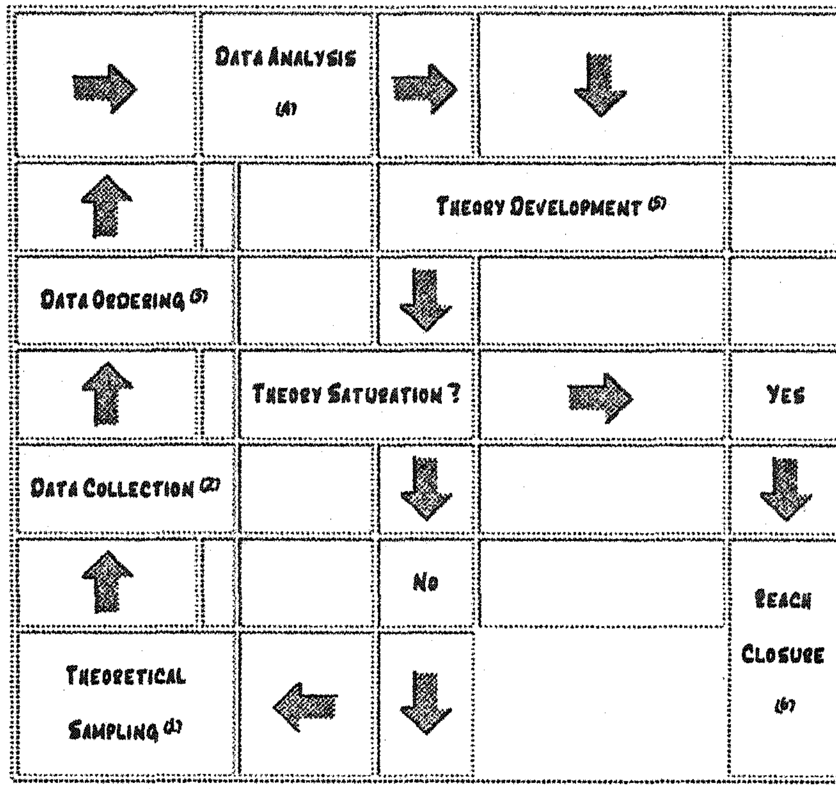

Figure 2. The Interrelated Processes of Data Collection, Data Ordering, and Data Analysis to Build Grounded Theory.

Within the general framework that is illustrated in Figure 2, data analysis for each interview involved generating concepts through the process of coding recurring themes, which represents the operations by which data are broken down, conceptualized, and put back together in new ways. It is the central process by which theories are built from data (Strauss & Corbin, 1990) and a central process for allowing significant findings to be extracted from data.

Rubin and Rubin (1995) and Stake (1995) say that the analysis of qualitative data begins during data collection and involves studying notes and transcripts, organizing or coding interview or observation excerpts into interpretive categories, searching for patterns and connections among the excerpts, and reorganizing excerpts into new and different categories. The excerpts may contradict or connect to passages from other participants or to literature on the subject. This technique of analysis permits freedom to continue to focus the study while gathering new and different data which provide a greater depth to understanding the problem (Miles & Huberman, 1994).

Data analysis for this research began while the interviews and/or observations were underway, and continued after each interview and/or observation and during the review of additional sources, as well. This allowed the researcher to pull out themes and concepts that described the participants' perceptions. This also allowed the facilitation of decisions on which areas to examine in more detail. The ongoing analysis provided direction and the opportunity to clarify information and refine interview questions.

Qualitative inductive analysis was used in this study to discover critical themes emerging from the data (Patton, 1990). At the heart of qualitative data analysis is the task of discovering themes and is one of the most fundamental tasks in qualitative research. Themes are constructs which are identified before, during, and after data collection. Themes may be derived from (a) reviewing the literature; (b) the characteristics of the phenomena being studied; (c) already-agreed-upon professional definitions; (d) local common-sense constructs; and (e) researchers' values, theoretical orientation, and personal experience with the subject matter (Blumer, 1979; Maxwell, 1996). Themes are mostly induced from texts. Grounded theorists call this induction *open coding*, and classic content analyses call it *qualitative analysis* or *latent coding* (Shapiro & Markoff, 1997). There are several techniques used to discover themes in texts. These techniques are based on: (a) an analysis of words (word repetitions, key-indigenous terms, and key-words-in contexts); (b) a careful reading of larger blocks of texts (compare and contrast, social science queries, and searching for missing information); (c) an intentional analysis of linguistic features (metaphors, transitions, connectors); and (d) the physical manipulation of texts (unmarked texts, pawing, and cut and sort procedures). The researcher used the word-based technique by generating a list of the words used in the text and counting the number of times each occurred.

Data were coded into logical, descriptive, and meaningful categories to provide a framework for analysis (Hoepfl, 1997). An appropriate method of analysis for this study has been described by Bogdan and Biklen (1982) as "working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others" (p. 145).

The data analysis software package, Ethnograph v. 5.08, a versatile computer program designed to make the analysis of data collected during qualitative research easier, more efficient, and more effective, was used to manage transcripts, allowing for storing, browsing, indexing, and coding of all text. Ethnograph allowed exploration of the documents and the search for patterns and themes that emerged from the text. As the data were explored, text annotations were coded and an index system was established. Search tools within the software were used to link, explore, and ask questions in order to determine relationships and establish hierarchies within the data.

Transcriptions of the interviews from all participating students provided the text for the initial coding and indexing of data. The Ethnograph editor's reformat function was used to convert data files into the 40-character, hanging-indent format required by the software for analysis. Additional preparation of the data was made by editing the text to include identifiers which were followed by a colon (:) and contextual comments which followed the plus (+) sign. Text from a student interview is presented the example in Figure 3. The student's name, as well as the key terms from the interview questions, are contextual comments following the plus (+) sign. "CP1:" refers to the researcher asking the first question and the "Q1:" refers to the student's answer. "CP1a:" refers to a follow-up question to clarify the student response.

The researcher began the coding process by marking recurring words and ideas emerging from the text by hand. In order to establish a code word index, each text file was then analyzed using the Ethnograph software file coding function. The coding process continued with the numbering of each line of each text file. Each interview was coded individually to discover patterns and determine a word index referred to as the codebook. The researcher repeated the process at several stages in the research, noting patterns as they emerged in order to establish primary categories. These primary categories provided the first level within the coding hierarchy. A family

+Student 1 - Interview

+Subject Matter - 1
CP1: What kinds of things do you like to do **in your science classes?**
Q1: I like having group discussions. cause reading, you know, when you read the information, it doesn't mean you always understand it. I like when we have group discussions and the whole class discusses it cause I want to get people's point of view on what we read.
CP1a: Do you like working on your own or in groups?
Q1a: I like both. Like, by myself, I can count on myself. If I want the information, I got it. But sometimes there's too much to do, I need other people to help. You know, if you need help, you don't have to be scared to ask.

Figure 3. Example of Interview Text From Ethnograph.

tree structure was established with parent code words at the top of the hierarchy. Related code words, referred to as "family code words," were placed into a hierarchical index under the parent code words. The parent code words that emerged through interview data examination were determined to include five level-one categories: (1) learning styles, (2) long-term goals, (3) subject matter, (4) classroom climate/environment, and (5) evaluation.

Determination of the coding hierarchy remained flexible throughout the study. The level-one parent code words were based on the following themes constructed and defined by the researcher on the basis of interpretation of the data:

1. Learning styles—student's personal approach and attitude toward the particular instructional strategy (approach).

2. Long-term goals—student's personal approach and attitude toward her future.

3. Subject matter—student's personal approach and attitude toward science and the science curriculum.

4. Classroom climate/environment—student's personal approach and attitude toward her surroundings.

5. Evaluation—student's personal approach and attitude toward assessment of subject matter and teachers.

In addition, the closed-ended interview questions were analyzed and key terms were assigned from the questions. The relationship of the key terms to the parent code words generated after the completion of student interviews is presented in Table 1.

The primary coding system that developed is illustrated in Table 2.

Student attitudes were explored by coding responses from the interviews. Table 3 demonstrates an example of the fourth- and fifth-level code words used to describe student attitudes.

Table 1

Key Terms From Interview Questions in Relationship to Original Parent Code Words

Learning Styles	Long-Term Goals	Subject Matter	Classroom Climate/ Environment	Evaluation
#6 Group	#15 Job	#1 Enjoyable	#23 Discipline	#8 Interested
#7 Individual	#16 College	#2 Methods	#24 Bullies	#9 Boring
#12 Resources	#17 Encourage	#3 Clear	#25 Competitive	#10 Change
#14 Computers	#18 Work	#4 Understandable	#26 Safe	#11 Compare
	#19 Education	#5 Difficult		#21 Fair
	#20 Grow up	#13 Likes/Dislikes		#22 Helpful

Code counts were generated for each code word used in the research. The code count indicated the total number of times the word was used by the respondents within the interview text data. Search combinations using multiple codes were conducted as well, which allowed for the grouping of related code words. An example of the code count of words that respondents used in answering the questions is presented in Table 4.

After reviewing the five themes that emerged from the initial review of the data, the researcher reexamined the data based on overlap and repetition between the themes, as well as re-examined the theoretical framework of the constructs according to the literature review and the characteristics of the phenomena being studied. The five themes were further refined and reduced in number by grouping them together. It was then possible to select specific themes or categories for further investigation. The

Table 2

Primary Coding System

Learning Styles	Long-Term Goals	Subject Matter	Classroom Climate/ Environment	Evaluation
Approach	Future	Content	Atmosphere	Assessment
• Labs • Experiments • Hands-on • Problem-solving	Career Choices	Attitude • Emotions • Positive • Negative	• Cooperative • Friendly • Hostile	Personal • Self-assure • Self-reflect
Methods • Discuss • Read • Write	Support	Proficiency • Performance • Know • Understand	Class Management	Standards
Resources	Influence	Competence		Feelings
Theory	Advice	Skills		Beliefs
Teaching	Fulfill	Literacy		Personal Views
Group		Problems		Opinions
Individual		Curriculum		
		Views		

Table 3

Words Used in the Coding of Student Attitudes

Positive	Negative	Emotions
Accomplish	Difficult	Comfortable
Confident	Dislike	Excited
Easy	Frustrated	Enjoyable
Good Job	Lack of Background	Fun
Helpful	Not Comfortable	Happy
Like	Problems	Pleased
Motivated		Proud
Success		

Table 4

Code Counts for References to Girls' Perceptions and Views
Frequency Count

Code Word	Count	Code Word	Count	Code Word	Count	Code Word	Count
Bullies	5	Understandable	8	Clear	14	Discipline	20
Competencies	5	Enjoyable	10	College	15	Experiments	20
Problem-solving	5	Dislikes	10	Education	16	Group	20
Read	5	Likes	10	Encourage	17	Hands-on	20
Write	5	Boring	12	Influences	17	Helpful	20
Individual	6	Difficult	12	Computers	18	Labs	20
Interested	8	Resources	12	Fair	18	Safe	20

final stage of the data analysis resulted in the following three key findings: (1) cooperative learning, (2) a custom-tailored curriculum, and (3) positive influences of mentors.

After reviewing the literature, the researcher found it necessary to employ further deductive analysis in order to more effectively align the respondent's comments to reflect the factors that they identified as contributing to their success. Overlapping themes were combined to clarify the five preliminary themes to the final three key constructs. The findings that emerged from the final stage of data analysis were based on the literature review and defined by the researcher on the basis of interpretation of the data:

1. Cooperative learning—student's personal views and interpretations toward the instructional strategy. The teaching style took on a multidimensional learning approach.

2. A custom-tailored curriculum—student's personal views and interpretation toward the content of the subject matter taught in a manner that best matched her learning style.

3. Positive influences of mentors—student's personal views and interpretation toward individuals that impart lasting impressions and/or encourage her sense of belonging.

Trustworthiness of the Study

Two important questions that researchers face when using qualitative research are: "Can the results of this research be trusted?" and "How can I convince the reader that what I wrote was an accurate portrayal of the experience?" In order to answer these questions there are strategies that the researcher can use. One such strategy is structural corroboration. Eisner (1991) describes structural corroboration as "a confluence of evidence that breeds credibility, that allows us to feel confident about our observations, interpretations, and conclusions" (p. 110). This is partially accomplished through careful reviews and thoughtful analyses of the data and of the approaches recommended in the literature for collecting and handling the data. In this study, evidence of structural corroboration occurred in the recurring themes that were derived from a combination of the researcher's observations, the interviews, the coding of responses and informal conversations with school teachers and doctoral committee members—all of which were informed by Eisner's guidance regarding structural corroboration.

Summary

The method used in this study, grounded theory, is a qualitative approach which allowed for the investigation of girls' perceptions and views in relation to their success and failure in science. Qualitative data were obtained through interviews and qualitative methodology utilized the Ethnograph v. 5.08 to analyze the data obtained from the interviews. Thus, the researcher used the Ethnograph to assist in the mechanics of "working with the data." However, it was the researcher who engaged in the inductive process of organizing the data into manageable units, synthesizing them, searching for patterns, discovering what was important and what was to be learned, and deciding what would be presented to others.

CHAPTER IV

RESULTS

This research investigated perceptions on factors related to failures and successes in a science program designed specifically for girls attending a school of choice. The techniques used in this study included interviews, observations, and informal conversations. The following research question guided the research and maintained the direction of the study: What are the factors that girls identify as contributing to their success in a program specifically designed to maximize their achievement in science? As the research progressed, five preliminary themes emerged from the data. They were: (1) learning styles, (2) long-term goals, (3) subject matter, (4) classroom climate/environment, and (5) evaluation. A more thorough examination of the data analysis identified three contributing factors: (1) cooperative learning, (2) a custom-tailored curriculum, and (3) positive influences of mentors. These key findings are attributed to the girls' success in a science program specifically designed to maximize their academic achievement.

Closed-ended interview questions were assigned key terms which related to the five themes that were woven through this study. The intent of each interview question was to gain the student's perspective on factors contributing to girls' success in a science program designed to maximize their achievement. Key words and phrases concerning student attitudes toward the study provided insight into students' perceptions.

The parent code words that emerged in the interview analysis included the five themes. Table 1 in Chapter III demonstrated the relationship between the key terms from the interview questions and the parent code words in the analysis. Table 5 demonstrates the relationship between the five themes, the interview questions, the key terms for interview questions, and the parent code words established.

The preliminary results were presented within the context of the five themes. Discussion of those five themes will follow with quotes that best represent the girls' overall position.

Theme I: Learning Styles

Learning styles are internally based characteristics of individuals for the intake or understanding of new information (Reid, 1995). All learners have individual attributes relating to their learning processes. Some people may rely heavily on visual presentation; others may prefer spoken language; still others may respond better to hands-on activities. It is evident that people learn differently and at different paces because of their biological and psychological differences (Reiff, 1992).

A learning style is multidimensional (Kinsella, 1996). Its elements can be classified into five stimulus categories: environmental elements (sound, light, temperatures, design); emotional elements (motivation, persistence, responsibility); physical elements (perception, intake, time, mobility); sociological elements (self,

Table 5

Relationship Between Themes, Interview Questions, Interview Key Terms, and Parent Code Words

Themes	Interview Questions	Key Terms		Parent Code Words
Learning Styles	Questions 27, 37–40	# 6 # 7 #12 #14	Group Individual Resources Computers	Approach (Group, Individual, Labs, Experiments, Hands-on, Problem-solving)
Long-term Goals	Questions 51–55	#15 #16 #17 #18 #19 #20	Job College Encourage Work Education Grow up	Future (Career Choices)
Subject Matter	Questions 16–26, 32–36, 41, 45–47	# 1 # 2 # 3 # 4 # 5 #13	Enjoyable Methods Clear Understandable Difficult Likes/Dislikes	Content (Curriculum)
Classroom Climate/ Environment	Questions 48–50, 60–61	#23 #24 #25 #26	Discipline Bullies Competition Safe	Atmosphere (Cooperative, Friendly, Hostile)
Evaluation	Questions 28–31, 43–44, 56–59, 62	# 8 # 9 #10 #11 #21 #22	Interested Boring Change Compare Fair Helpful	Assessment (Opinion, Views, Feelings, Beliefs, Self-assure, Self-reflect)

partner, team, mentor, varied); and psychological elements (global/analytical, impulsive/reflective) (Reiff, 1992). Clearly, learning styles include not only a cognitive domain, but also the affective and physiological domains (Oxford, Hollaway, & Horton-Murillo, 1992).

Research on learning styles is based on the premise that learners receive information in different ways through all of their senses and may favor or prefer some senses to others in specific situations (Kroonenberg & Reid, 1995; O'Brien, 1989; Oxford & Ehrman, 1993). Usually, students learn more effectively when they learn through their own initiatives. When their learning styles are matched with appropriate approaches in teaching, their motivation, performances, and achievements will increase and be enhanced (Brown, 1994). Thus, researchers and educators try to establish optimal environmental and psychological climates that foster learning by allowing students to learn in accordance with their own preferred learning styles.

When asked the research question "Do you like working on your own or in groups?" Respondents offered "Working in groups" with the most consistency. The following excerpts are taken from selected responses.

I like working in groups because . . .

Brook: It allows you to work with other people because you are not going to work by yourself all the time. This allows you to get to know them and how they work and how they cooperate.

Cathy: If I don't know the answer I don't have to be scared to ask because I can get help from the group.

Mary: Sometimes I don't understand what the teacher is saying, but someone working with me can explain it to me better where I can understand it.

Shannon: You can get help; if you don't know what to do, then there's always like, your helper.

The girls' perceptions were consistent with current research. Studies (Brandt, 1996; Johnson, Johnson, & Stane, 2002; Mueller & Fleming, 2001) show that girls learn better when they work cooperatively on assignments or projects. So what is cooperative learning? "Cooperative learning is structured instructional strategy which emphasizes active learning through interpersonal interaction, where students act as partners with the teacher and each other. In cooperative learning participants are both the teacher and students" (Joubert, n.d.). Joubert suggests that cooperative learning is advantageous for (a) academic content-related achievement (cognitive), (b) developing higher order thinking skills (cognitive and meta-cognitive), and (c) social interpersonal skills (affective). The role of the teacher in cooperative learning becomes predominantly that of planner and facilitator of active learning, as opposed to that of instructor. Students become more active role players in learning—they become peer experts and act as peer instructors, responsible for each other and the group. Group roles may be assigned, rotated, or shared (Joubert, n.d.).

Along with the girls' favorable responses of working together in groups, they also noted working on computers as a positive factor to their success. In computer-assisted cooperative learning, the "computer" also takes on an active role in the girls' learning process, in the sense that the instructional design of the program used impacts both interaction and learning. Related interview questions were "Do you work on the computer in science classes?" and "What do you do on the computer in science classes?"

Positive responses were received from the girls because computer activities have been tailored to the girls' interest of working collaboratively in groups to do their research, and they perceived working on computers as fun and entertaining. As noted below, the girls' responses emphasized interaction and cooperation.

> Cassandra: When we get to work on the computer, it's fun. We get to look up information for our research project and look up different things.
>
> Heather: We get to use the computer to do PowerPoint presentations for our projects. I think it's a lot of fun because in our technology class, we get to work on designing a web page.
>
> Melissa: Usually when I'm on the computer, I'm doing my class assignments. I'm always learning something new and working together we find things quicker than working alone.

The comments revealed that using the computers for educational purposes is a positive perception of their success in relationship to science because they enjoy working on computers and tend to view it as an effective medium for expression.

Theme II: Long-term Goals

A long-term goal is accomplished over a longer period of time. Some long-term goals, like graduating from high school or learning to fly an airplane, may be reached sooner. All long-term goals are made up of some short-term goals.

A long-term goal gives one a clearer idea of the things to accomplish over time, as they are usually big and central to one's life. The steps taken to reach long-term goals are short-term goals. Short-term goals are achievable within a relatively short period of time (6 months to a year). Short-term goals may also be accomplished daily or attained within a month.

The girls exhibited confidence, empowerment, and high levels of self-esteem in selecting science-related careers. From the responses to the interview questions, these career aspirations can be attributed to their attendance at a school of choice.

When the girls were asked, "When (or why) did you come to the school?" or "Why do you think your parents/guardians sent you to this school?" the girls were quick to respond that their parents or some other family member steered them to the school. Based on their responses, the girls clearly attributed career aspirations to the philosophies of the school and the positive influences that their parents appeared to believe that the school would have on their development. Therefore, parental influence was an influential factor in the choice of school.

Therefore, when the girls were asked, "What kind of work would you like to do when you grow up?," "Do you plan to go to college?," or "Do you think that your science teachers encouraged you to go to college?," they responded as demonstrated in the following excerpts:

Denise: I plan to go to college.
I want to be a nurse or X-ray people.
I know it's a lot of math and science involved.
Yeah, my science teacher encourages me to go to college.

Carol: I'm trying to be a veterinarian 'cause I like animals and I like helping people or living things.
I know I need science, that I know. I know I need math because if the animal needs a certain amount of medicine; I need to know milliliters, milligrams, whatever I need. So I know I need that too.
And of course I need to know how to read.
Yes, I plan to go to college.

Yes, my science teacher encourages us all the time. They tell us, 'cause sometimes when we do labs, well, they ask us, "Will you need this information when we get older?" and we say "yes." Then they will tell us "you will apply this in everyday life so when you go to college you will already know this, if you go to college."

Barbara: I want to be a computer programmer and I plan to get into college on a basketball scholarship.
I know I'll need some science.
I get encouragement all the time from my science teacher.

Shannon: I want to be a Medical Assistant or a Pharmacist Tech.
I'm doing well in science and I know I'll need it.
Yes, she encourages me to attend college.

Megan: I want to be an Engineer and be in a 3+2 program, like going to Spelman and Georgia Tech.
She is very encouraging.

In this study, the majority of the girls expressed aspirations to have science-related careers and felt encouraged by their teachers to go to college. This finding reflects an attitude that is somewhat different from the prevailing attitude that is widely reported in research studies which suggests that engineering, mathematics, and science are inappropriate fields for women—an attitude that is still culturally pervasive. Studies show that girls, as young as age 2 or 3, are aware of occupational segregation by gender, and the appropriateness of this segregation is then reinforced in many ways throughout their lives (American Association of University Women, 1989). In addition to perceiving careers as gender specific, misperceptions about the careers themselves can prevent girls from pursuing certain fields. For example, the traditionally feminine values of listening, feeling, and maintaining strong interpersonal relationships may seem incongruent with scientific careers perceived as impersonal. But what the girls have in their favor by attending this school of choice is that the school capitalizes on the power of the relationship between the school's mission and the girls.

Theme III: Subject Matter

For many, the term *science* refers to the organized body of knowledge concerning the physical world, both animate and inanimate, but a proper definition also would have to include the attitudes and methods through which this body of knowledge is formed; thus, science is both a particular kind of activity and also the results of that activity.

Science may be roughly divided into the physical sciences, the earth sciences, and the life sciences. Mathematics, while not a science, is closely aligned to the sciences because of the extensive use of mathematics in the science fields. Indeed, mathematics is frequently referred to as the language of science, the most important and objective means for communicating the results of science. The physical sciences include physics, chemistry, and astronomy; the earth sciences (sometimes considered a part of the physical sciences) include geology, paleontology, oceanography, and meteorology; and the life sciences include all the branches of biology such as botany, zoology, genetics, and medicine (*The Columbia Encyclopedia,* 2003).

Science is recognized as underlying the technological societies of the late 20th century, but there are conflicting views of the nature of science and scientists. Many students and some teachers view science as a body of factual truths that are derived by direct observations and tested by rational and objective experiments (McComas, 1996). This view of science disregards the impact of social, historical, emotional, and economic factors. An alternate view of the nature of science is a multimethod, human endeavourer to study our environment, a study subject to cultural influences but also constrained by a real, physical world.

So what does that mean to girls? In the report *Shortchanging Girls, Shortchanging America,* the American Association of University Women (AAUW, 1991) identified the relationship between confidence and educational opportunities as critical to girls' success, particularly in science and math:

> Unintentionally, schools collude in the process by systematically cheating girls of classroom attention, by stressing competitive—rather than cooperative—learning, by presenting texts and lessons devoid of women as role models, and by reinforcing negative stereotypes about girls' abilities. Unconsciously, teachers and school counselors also dampen girls' aspirations, particularly in math and science. The survey finds a strong relationship between perceived math and science skills and adolescent self-esteem. Of all the study's indicators, girls' perceptions of their ability in math and science had the strongest relationship to their self-esteem; as girls "learn" that they are not good at these subjects, their sense of self-worth and aspirations for themselves deteriorate.

When asked to define *science,* many of the girls could not define *science.*

> Amy: I think, I think, oh, I don't know. That's a hard question.
>
> Chelsea: Umm, umm, I'm not sure. Is it a way of defining nature or technology?
>
> Margareta: What do you mean? Define it how? You just want me to talk about it?
>
> Rosa: I'm not quite sure. But maybe how you look at the world.
>
> Shanea: Uh, uh, the plants, earth, and water? Is that right?

Although the girls are receiving positive reinforcement from the school to seek STEM careers, it is clear from the girls' overall responses that they did not recognize the relationship between science and their future career aspirations. They know they need math and science classes and know they need it to do well, but they still carry negative attitudes about STEM fields in general. On several occasions when the girls were asked the subjects they liked the least and the subjects they liked the most, sometimes they would mention liking math but not liking science. Even when wanting to make a career in a science-related field, math and science would be their least favorite subjects. So does that mean even though they do not like those fields, they're willing to do what they have to do in order to accomplish their long-term goals?

During one interview, Shanika said that during her first 3 years at the school she progressively received failing marks. In her junior year, the school counselor notified her that she probably was not going to graduate. At that point, she decided in order to graduate she had to do better. During the interview, she said she was scheduled to graduate on time. She had made a complete turnaround. She also said she was a first-generation high school graduate. When asked what kind of work she wanted to do when she grew up, her response was to be a midwife. When asked what subjects did she like the least and what subjects did she like the most, she said humanities and technology were her favorite and math and science were her least favorite. Despite the importance of math and science in relation to her career choice, she talked more about wanting to go into midwifery because she wanted to stay with the patients from the beginning of pregnancy until delivery. "Have you thought about being a doctor or a physician's assistant?" She said, "No," because the doctors couldn't stay with the patients until delivery and she had no knowledge about what a physician's assistant did.

While the responses to the interview questions were not exactly the same in every instance, they were very similar in context. There were no discernable differences in the quality or depth of responses between the 9th and 12th grade respondents. The girls did not display a balanced association between educational requirements and career choices. They were quick to express verbal support for STEM careers while at the same time, exhibiting low levels of support and attraction to math and science. This phenomenon led the researcher to conclude that the girls in this sample were not yet making a complete cognitive connection between the disciplines of science, options for further study, and options for careers.

The following story also captures the essence of the aforementioned findings. Judith Kleinfeld (1998a), a professor of psychology at the University of Alaska, Fairbanks, offers the story in the spirit of a case study, her experience with her own daughter, Rachel. The title of her story, "What My Daughter Rachel and (Many) Women Want," reveals that Rachel, like so many other young women, insisted that she was "not interested" in science but wanted "to work with people." Why?

> I first realized Rachel was gifted in mathematics when she entered junior high school. She had scored high on a mathematics test that her school gave to select students for "MathCounts," a national mathematics competition. MathCounts winners are overwhelmingly male. Rachel was hardly a victim of cultural stereotypes about women. She was the only one of our three children (the other two are boys) who learned to use tools. For her birthday, she asked for building sets. On her sixth birthday, I found her packing up the new Barbie

> doll her grandmother had sent her. "If grandma likes dolls so much," she said with disgust, "she can have all of mine."
>
> The more I thought about Rachel's interests and skills, the more it all fell into place. I had a mathematically and technically inclined daughter whose talents I should develop. Rachel was already getting tutored in advanced mathematics twice a week to prepare her for the statewide MathCounts meet. Her school had arranged private tutoring for her and another high-scoring student, a boy. But there was more I could do! I got her to enroll in a science course sponsored by the Center for Talented Youth. She had qualified for both the writing and science courses but had always chosen the writing courses.
>
> To give her practical experience in a scientific career and let her meet female role models, I arranged for her to work after school with a doctoral student (female, of course) at the University of Alaska's Institute for Arctic Biology. Rachel got to look at samples of Bering Sea water using an electron microscope. I was thrilled. Rachel was not. She told me to lay off. "I am not part of your agenda for the advancement of women in science," she informed me in a tone that left no room for further discussion. "I want to work with people. I want to help people."

These are the standard reasons given when women explain why they are not interested in scientific careers. As I thought more about Rachel's experience, I realized that there was more to her decision than her preference for working with people. Her response masked other reasons, good reasons, for not choosing science as a career.

Mary Pipher (1995), author of the best selling book, *Reviving Ophelia*, explains that girls' self-esteem is dependent on other people's approval of them. And because of this, girls are always trying to please others. By the time they enter adolescence, they quickly discover that playing into society's expectations of what is to be feminine is the way to get that stamp of approval. But society's notion of femininity is more in line with a helpless, slightly feather-brained, looks-conscious female rather than being recognized as assertive and competent (Te Kete Ipurangi [TKI], 2001, p.11).

Theme IV: Observation in Classroom Climate/Environment

Warm, well-run classrooms begin with the room's physical layout—the arrangement of desks and working space, the attractiveness and appeal of bulletin boards, the storage of materials and supplies. The environment must ensure that students influence the nature of the activities they undertake, engage seriously in their study, regulate their behavior, and know of the explicit criteria and high expectations of what they are to achieve. Throughout each day many interactions occur among students and with the teacher. The atmosphere of a classroom must be comfortable and respectful, a classroom community. This type of environment nurtures students to be part of a community of learners and to explode and challenge their thinking, as well as others, in a safe setting. Classroom procedures and routines are established from the first day, along with behaviors conducive to learning and positive social interactions. The physical environment is organized as well to support the learning environment.

Classroom environment consists of five components: creating an environment of respect and rapport, establishing a culture for learning, managing classroom procedures, managing student behavior, and organizing physical space.

Observation of Creating an Environment of Respect and Rapport

The teacher within a classroom is the primary example of how to be a positive member of the classroom community. The ways in which they interact with students, parent, faculty, and community members set the tone for what is expected of students in regards to student interactions. Conflict, put-downs, and negative actions are not tolerated. All students are members of a safe and supportive environment. Students are not only physically safe, but also intellectually safe. Students are not afraid to take risks in their thinking and are encouraged to do so in the open environment.

Respect is a part of the school of choice's philosophy. While the teachers demonstrated general warmth, caring, and respect for students, some of the students exhibited a lack of respect for the teacher, as well as for other students. Disruptive classroom behavior showed a lack of respect for themselves, the teacher, and other students. This is an area were improvement is needed.

Observation of Establishing a Culture for Learning

In a classroom that supports and nurtures learning, both the teacher and student are engaged in valuable quests for knowledge. Both groups are actively involved in the classroom and exude pride in their work. High expectations and a safe environment support a culture for learning. Students are aware that they must respect others and their thoughts when they are proposing ideas and thoughts. Teachers respond to students in an attentive manner within this type of classroom. Students are recognized for their contributions, which can be seen in displayed work within the room and school. Through the viewing of such work, an expectation of high standards is evident.

The school of choice exhibited a culture for learning. Through group projects, classroom activities, and homework, students appeared motivated by their desire to do well and they took pride in their work. Group projects were displayed in the hallways and classrooms. The teachers encouraged students to do well and acknowledged the efforts before the entire class.

Observation of Managing Classroom Procedures

Teaching requires good management before good instruction is possible. "The best instructional techniques are worthless in an environment of chaos," as stated by Danielson (1996). This is the basis of managing classroom procedures. Without the development of procedures within the classroom, instruction is not effective.

During a classroom observation, 10 to 15 minutes of class time was devoted to getting the class under control. There were loud outbursts in class, talking at their seats during class instruction and/or talking about nonclassroom-related situations when they should have been paying attention to the day's lesson. This is an area that the teachers felt they lacked administrative support. There was no formal discipline policy enforced.

Observation of Managing Student Behavior

If the learning environment is out of control, true learning cannot take place and students will not be able to engage themselves with the content. Usually misbehaviors are a result of other issues—being unprepared, lack of interest in content/activities, and poor social skills or low self-esteem. A knowledgeable teacher can spot these signs and act as such. A key component of managing student behavior lies in set standards of conduct that students create at the beginning of the school year, and clear consequences because of these actions. Expectations of students must be made clear and should be appropriate to the developmental level of the students. An effective way for teachers to encourage students to exhibit good behaviors is to suggest that students monitor their own behavior. In addition, students should be encouraged to monitor their classmates, reminding them the proper way in which to act.

The girls acknowledged classroom discipline as a major concern. Listed below are several responses to questions which were associated with managing student behavior.

+Student 5 – Interview (Cassandra)

+Classroom Climate/Environment
CP1: Are there things you would change in your science classroom?
Q1: Not what the teacher's doing but what the students are doing. Being disrespectful to the teacher. I think that's ignorant. 'Cause what's the point of her coming here and you disrespect her?
CP1a: Tell me what you mean by disrespectful.
Q1a: They talk when she does and I think that's really mean.

+Student 17 - Interview (Megan)

+Classroom Climate/Environment
CP1: Are there things you would change in your science classroom?
Q1: Not much, I guess, no.
CP2: What if you were the science teacher?
Q2: I might, I would try and reinforce the rules more. She's a little too loose I guess.
CP2a: When you say "she's too loose," too loose in terms of what?
Q2a: Punishment. She just lets people get away with things. She usually gives them lots of warnings but then doesn't do much after that. So she lets them run over her a little, I guess.

The students treated male staff differently from female staff and they knew what they could get away with. With the female staff, the students often took it to the limit. On several occasions, they reduced a female teacher to tears.

Observation of Organizing Physical Space

The organization of physical space is an integral part of the classroom environment. Areas must be organized in terms of their function—noisy areas versus quiet ones, individual work areas versus group work areas. Effective educators try to create an environment that encourages students to work with each other and explore ideas and concepts. To create a room that supports this, students must be able to access the board, the teacher, and learning resources. All classrooms must support a working traffic flow.

It may not be conducive to have students sitting in uniform rows of desks. In order to induce an environment of true learning, students must be able to consult with each other. This is not to say that all learning results from collaboration, but that students feel freer to communicate with their classmates and share ideas. By grouping students, teachers help to provide them with the best of both worlds—they can work individually and as a group, when warranted.

The school of choice has adopted the cooperative learning approach in the science classrooms. The girls sit at tables (4 tables, 5–6 girls at a table) instead of individual desks (see seating arrangements in Figure 4 below). This arrangement allowed the girls to become actively involved in their own learning; it increased group communication skills, provided social interaction, and enhanced higher order thinking. Seating arrangements were changed twice a trimester so all girls learned to work cooperatively with their classmates.

Front of Classroom

Teacher taught from the front of the room

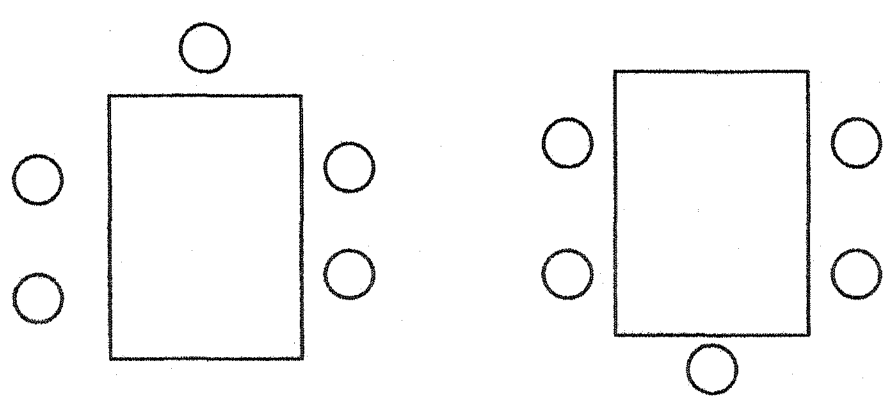

Figure 4. Seating Arrangements in Science Classrooms.

Theme V: Evaluation

The term *evaluation* was used in the context of getting opinions from the girls relating to science, teachers, and teaching styles and what was interesting, boring, fair, and/or helpful. In this context, their answers to the interview questions are perceived as their views, feelings, and beliefs.

Mixed responses were received concerning whether the girls felt that science was interesting or boring. One response expressed their overall opinions very well— "Science has its moments; it's interesting when it's related to everyday things, but boring when I don't get the connections." In an informal conversation with a student during their study of water quality (What is the water quality like in your river?), students took a field trip to the local water plant and performed water quality testing in class. The student thought this was interesting because she could apply the classroom application to how it related to the real world and to her everyday life. She found it interesting and helpful. A few students expressed their difficulty with assignments/projects in relation to a teacher's teaching style, and often perceived their science teacher as ineffective for the simple reason the teacher had not helped them to understand and apply science.

Probing questions were asked as an extension of answers received from the primary interview questions. The girls were verbally asked to fill in the blanks to the following questions: *When I need help with science, I usually ask* ________________; *Girls who enjoy science are* ________________; *Boys who enjoy science are*

__________________; and, *In science classes, teachers expect the girls to*

_____________________.

When asked, *When I need help with science, I usually ask* _____________, their first response was "my science teacher," second was "my friend," and third was "a family member," because the family member worked in a STEM field. When asked, *Girls who enjoy science are*_____________, first responses were "Uh"—they really had to think about it, but when they finally responded they usually filled in the blank with a student's name. When asked *Boys who enjoy science are*_____________, they used words like "smart" and "intelligent." Their response to the question, *In science classes, teachers expect girls to*_____________, "do their best work" was the answer most frequently given.

The girls' responses are consistent with research. Kahle (1984) reported that data from the National Assessment of Educational Performance (NAEP) had indicated that 13- and 17-year-old girls had strong negative attitudes toward science and had little belief that the discipline could be useful to them.

Summary

In summary, Table 6 provides an outline of the findings, which summarize the factors that facilitate or hinder success.

Embedded in Table 6 are the key findings that contributed to girls' success in a program specifically designed to maximize their achievement in science: (a) cooperative learning, (b) a custom-tailored curriculum, and (c) positive influences.

Table 6

Outline of the Findings

Factors That Facilitate Success	Factors That Hinder Success
Group work	Individual work
Hands-on activities	Lectures
Science labs	Independent reading
Positive influences of mentors	Lack of classroom discipline
Cooperative learning	Teachers who did not have a good grasp on the subject matter
Table(s) of 5–6 students	Individual desks
Classroom safety	Problem solving
Role models	
Experiments	

Cooperative Learning

Cooperative learning is a classroom technique that has been found to be very advantageous for girls. Cooperative learning promotes small group learning in which students' maximize their own and each other's learning.

Respondents in this study preferred working in groups rather than working individually. They stated when they didn't understand the work, another student in the group could explain it to them and they understood it better from the student rather than the teacher, which was another point raised by them in favor of cooperative learning. Also, the group interaction among the students allowed them to be supportive and helpful to one another. In keeping with the school of choice's mission and vision, they promote cooperative learning in the classroom. Learning activities were performed that were best handled through group work, they worked together in small groups containing two to five members, they used cooperative, pro-social behavior to accomplish their learning activity, activities were structured so that students needed each other to accomplish their common tasks, and students were individually accountable or responsible for their work and learning. In one group project, a student served as the recorder (the person taking the notes), two students served as statisticians (the persons responsible for providing the statistics on the project), and two students served as the researchers (the persons responsible for providing the background information—past and present).

A Custom-Tailored Curriculum

The school of choice addressed social science evidence which has shown that there are many complex phenomena contributing to girls' disengagement from science and in adolescence, including:

- peer interactions in coed learning environments
- teaching approaches
- a shortage of role models
- a set of deeply rooted social dynamics and expectations.

As a result, the school of choice used a hands-on, experiential approach to science which helped students gain an understanding of concepts and processes such as chemical interactions, biological effects of chemicals, qualitative and quantitative analysis, and to explore the difference between science and public policy.

The school supported a science curriculum which was issue-oriented and hands-on. Students completed a series of activities—such as experiments, debates, readings, and projects—that taught important scientific ideas related to the issue at hand. For the past 3 years the focus of the science curriculum has changed but the school has attempted to maintain the hands-on cooperative learning approach.

Positive Influences of Mentors

The subjects of this study identified the following factors having positive influences on their success and failure in the study of science: parents, teachers, and role models. This supports the findings from other researchers who had similar findings. Researchers seem to agree that the presence of positive female role models in the sciences as being the single most important factor in sustaining girls' interests in the sciences. In fact, most professional women scientists can point to a single individual whose support enabled them to pursue their careers (Advocates for Women in Science, Engineering, & Mathematics [AWSEM], n.d.).

Mentors can help young women envision themselves as scientists by providing them with an image of a "scientist" that differs from the stereotype of the man in the lab coat, as well as with a model of how to balance career with family, friendships, activities, and hobbies beyond work. In addition, mentors can help girls with scientific and mathematical concepts, open their eyes to an array of scientific fields, give them a realistic sense of the challenges and rewards of science careers, and help them to understand the educational paths necessary for scientific career options.

Role models can take other forms than formal mentorships while still having a significant impact on girls' perceptions of the sciences. In one study, women scientists were brought into middle schools as part of the students' science instruction. Within just a 2-month time period, students developed a more positive attitude toward scientists and specifically women scientists (Smith & Erb, 1986).

Women scientists speaking before student groups, at career fairs and other events, can respond to questions and encourage girls interested in careers in science. Even one-day programs like "Take Your Daughter to Work Day" offer girls the chance to see firsthand what it would be like to hold a job in a scientific field. Thus mentoring—whether formal or informal, on-going or short-term—is one of the most successful tools for reversing the underrepresentation of women in the sciences (AWSEM, n.d.).

CHAPTER V

CONCLUSIONS, DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

This study examined the factors that girls perceived as contributing to or hindering their success in a program specifically designed to maximize their achievement in science. These factors were primarily explored through interviews with 20 students in the 9th and 12th grades attending a school of choice. The study was guided by the research question: What are the factors that girls identify as contributing to their success in a program specifically designed to maximize their achievement in science? The need to examine girls' own perceptions of the factors that enhance and/or hinder their participation in STEM provided motivation for this study.

Chapter I introduced the background, need, purpose, and significance of the study. A review of the literature supporting the study was presented in Chapter II. The procedures and processes used to examine ideas and patterns as they emerged throughout the study were described in Chapter III. A qualitative software package, *Ethnograph*, offered features that allowed for advanced search, analysis, and coding of data imported from text transcriptions. The results of the study were discussed in Chapter IV. In the final chapter, the conclusions, implications of the study, suggestions for further research, and recommendations have been discussed from the point of view of the researcher.

The Research Opportunity

The researcher's interest in the topic of this study developed as a result of an opportunity to work as a doctoral research associate responsible for collecting data for an evaluation project at a school of choice located in the United States (a school of choice is a pseudonym used throughout this dissertation). In order to make this opportunity a win-win situation for the project principle investigator, the Office of the Vice President for Research/Graduate College and the researcher, the collaborative hands-on research experience was the perfect opportunity to develop a dissertation project by making use of the data being collected for an existing project. In this instance, it was the grant which engendered the research that led to the dissertation, thereby providing a paradigmatic synergy that aligned a funding opportunity with a dissertation research project.

Discussion

By referring to the original research question, a framework was provided for the conclusions and discussion. It was found in this study that the factors cited by the girls that contributed to their success in a program specifically designed to maximize their achievement in science were (a) cooperative learning, (b) a custom-tailored curriculum, and (c) positive influences.

Cooperative Learning

Since the respondents perceived cooperative learning techniques as a contributing factor of success, the responses from the girls led the researcher to view cooperative learning, group learning, and hands-on activities interchangeably. In other words, the researcher defined cooperative learning as any activity that the girls worked together on or in groups, and any activities that allowed the girls to work together using applied "hands-on" learning. Hands-on learning involved learning by doing—helping the girls acquire knowledge and skills outside of books and lectures. Along with working in groups and working with computers, the respondents favored lab activities. They profoundly emphasized a preference for lab work. Even when the girls talked about lab activities, their answers were more energetic as opposed to individual group work. When the respondents had reading assignments or individual class presentations, they did not appear to be that excited about those learning strategies. The respondents answered with statements such as the following remarks which were extracted from the interviews.

> Amy: I like working on lab activities better than reading or working on individual projects.
>
> Heather: I learn better when I'm actually doing something like working on a lab activity.
>
> Barbara : I enjoy experimenting; it keeps my mind from wandering because I have to be busy working on something to say focused.

The girls exhibited strong feelings concerning cooperative hands-on learning. The researcher also concluded that the girls felt more comfortable doing lab work as opposed to class lectures or individual reading assignments.

A Custom-Tailored Curriculum

Since the girls displayed an obvious preference for hands-on cooperative learning activities in which they performed better, it could be concluded that curricula designed with their preferred learning styles and teaching techniques would have better outcomes for girls participating in science. Such science curricula require the studied and focused implementation of "experiments, debates, readings and projects" that are centered in scientific knowledge and method. With this as a given, the custom-tailored curriculum requires rigorous preparation and training of teachers in order to be successful. The 12th grade girls were aware of this inadequacy. They were able to analyze and comment on the quality of the teaching and instruction. As a result, most of the time they had to depend upon classmates to assist them in class because the teachers were unable to assist them. They were working without textbooks, but they received photocopies of chapters from a textbook to work from as needed for class assignments and class discussions. The 12th graders observed that although the school's mission purportedly is to prepare girls for the 21st century, the science teachers appeared to lack science knowledge, professional preparation, depth of knowledge, and skills to effectively teach the science subjects, as in the instance of the trained engineer who taught a physics class.

STEM fields, although related to each other, are not interchangeable. Without appropriate pedagogical procedures and practices at hand, the success of such an endeavor is debatable. It is unfair to the educator, and certainly unfair to students whose education may be compromised. In addition, lack of training is only compounded when there is a dearth of teaching materials—textbooks, videos, and other discipline-specific tools or "instruments" that serve the teacher in enhancing the education of the students. These were unfortunately missing at the school. The mission of such "schools of choice" then is seriously handicapped by both of these factors. The preparation of young girls to meet the academic, scientific, and technological demands of the 21st century will only remain jeopardized in the light of this inadequacy. This lack of adequate teacher preparation for science instruction is as much of an issue in the science education of girls as it is in the general population. The lack of adequate science instruction of teachers assigned to teach science in the school of choice is contrary to the school's mission. While the mission is a good one, the school has a long way to go to make the mission a reality—at least from the 12th grade girls' perspectives.

Positive Influences of Mentors

This school of choice has an intern program where the girls can spend as many as three afternoons each month at sites such as technology companies, law firms, arts and community organizations, and hospitals, providing community service. They develop and submit resumes and actually participate in the interviewing process for the internship program. The respondents' career choices and future goals were directly related to the mentoring and internship program. They responded favorable to the support and being a part of the program. The positive influences were not restricted to the mentoring and internship program but extended to family and friends as well. They talked about the "time" given and the "activities" scheduled with the mentors that really brought enthusiasm to their voices when they answered the researchers questions.

Following up with a probing question after one of the responses, the researcher asked, "Where do you see yourself 10 years from now?" This question yielded several interesting responses. Cynthia, who played on the girl's basketball team, commented:

> Ten years from now I see myself as part of the Women's National Basketball Association (WNBA).
>
> But of course around here, right now this is high school and I don't see any great influences around here to help.
>
> Although I plan to go to college, hopefully on a basketball scholarship, but if I don't get a scholarship, I still plan to go to college because I want to be an engineer.
>
> Maybe while I'm in college, I'll find somebody that would have my back.

Barbara, on the other hand, is the oldest sibling in her family and really had no career plans or goals before coming to the school of choice. Barbara, also a senior, responded as follows:

> I've been participating in the mentoring and internship program, and my mentor has been a great influence on me because she takes me to lunch, she invites me on outings some weekends, and talks to me about all kinds of possibilities of what I could do when I graduate.

I really appreciate how she looks out for me.

These two responses are examples of how the tone for their beliefs regarding how positive influences/role models can make a difference.

Implications of the Study

The implications of this study suggest that cooperative learning, custom-tailored curriculums, and positive influences of mentors are highly effective approaches to supporting girls participation, achievement, and retention in the sciences. Advocacy by parents and schools for these findings can successfully assist in bridging the gender gap. The information gained in this study would indicate that teachers should re-evaluate their choice of classroom activities and teaching styles; administrators should empower teachers to be forces for change addressing gender equity needs in the school curriculums; and parents and others can serve as role models, as well as encourage their daughters/students to explore nontraditional career opportunities. Teachers should pay special attention to providing background information and instruction about the breadth and scope of science or STEM disciplines so that girls understand the range of available options and can use that information to make informed decision about courses to study and careers.

Recommendations for Future Studies

Further research of the students who participated in this study is recommended after they graduate from high school and enter college. It would be beneficial to follow the students after 2 years of college against their initial science-related career choices as noted during their interviews. Furthermore, it would be useful to examine their attitudes toward science upon graduation from a school of choice and their perceptions of pursuing a nontraditional career. The researcher would be interested in determining in what ways attending a school of choice might have influenced their career paths.

Other suggested studies might include further research on interventions such as cooperative learning and custom-tailored curricula. As well, additional studies regarding enhancing girls' attitudes about their competency to be successful in STEM field professions would help to reverse the trend that has resulted in a general absence of girls and women in STEM careers. The translation of these findings into indicators that are useful and accessible to public and private funders, teachers, educators, and science professionals will serve to advocate for and support strategies and programs which facilitate preparation of girls in middle and high schools for eventual careers in STEM fields.

Conclusion

The purpose of this study was to determine the factors that girls identified as contributing to or hindering their success in a program specifically designed to maximize their achievement in science, specifically, what factors they identified that facilitated or hindered their success. Public and private funders, teachers, educators, and science professionals can use these findings to advocate for and support girls' success rates in STEM fields. Above all, teachers must adopt more cooperative learning styles and techniques in the classroom, and school administrators must empower their faculty to be forces of change in addressing girls' successes in science programs specifically designed to maximize their achievement.

Throughout the study, there were no discernable differences in the quality or depth of responses between the 9th and 12th grade respondents. They were clear regarding their preferred instructional style, such as cooperative learning, group learning, computer-assisted cooperative learning, science labs, and hands-on activities in the science classroom. Whereas the girls were precise about their preferred instructional style, they were less precise with their perceptions of a successful STEM career regarding educational requirements and career choices. They did not display a cognitive connection between the disciplines of science, options for further study, and career options.

Classroom teachers, family members, and friends, as well as mentors through the school's mentoring program, served to influence, encourage, and support the girls. The respondents have implied that when they see females in STEM fields, they are much more likely to create goals for themselves within the field because it appears more accessible. Girls need positive role models and constant encouragement.

In a science-focused school for girls, the respondents had difficulty defining science, even though the school, ironically, was structured to focus on science. It was evident that the respondents were not given a description or definition of "what science is." For whatever reason, it apparently was not a focus of discussion or was not of personal interest to the girls. Therefore, before or after students began to take science courses, a definition or description of science must be established. This could very well have a direct impact on their desire and/or interest to study STEM fields.

Appendix A

Human Subjects Institutional Review Board
Letter of Approval

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Centennial
1903-2003 Celebration

Date: October 13, 2003

To: Bill Cobern, Principal Investigator
Gunilla Holm, Co- Principal Investigator
Jane Davidson, Co- Principal Investigator
Paula Roberts, Student Investigator for dissertation

From: Mary Lagerwey, Chair

Re: HSIRB Project Number 03-07-23

This letter will serve as confirmation that your research project entitled "Evaluation of the YWLCS Curriculum" has been **approved** under the **full** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 20, 2004

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B

Interview Protocols for Students

Interview Protocols for Students

1. When did you come to _______________?
2. Where did you go to school before?
3. Did you like your former school? Why? Why not?

4. Did you have to work hard at your former school? Did you have science?

5. Do you live with your family?
6. Who lives at home with you?

7. Is your main language English or something else?
8. In school or in class is it okay to speak in .....(your native language if it is not English)?

9. Why do you think your parents/guardians sent you to this school?

10. Can you describe your neighborhood?
11. How do you get to school (public transportation, walk, car)?

12. Do you like attending this school?
13. Is it different from your previous school?

14. What kinds of things do you do now in your leisure time after school and during weekends?

15. Do your parents or other adults in your life take you to museums or things like that?

16. What is science?

17. Do you like science?
18. Do you enjoy science?

19. What kinds of things do you learn in your science classes?

20. Do you have labs?
21. Are the lab projects clear and understandable?
22. Are they difficult?

23. Do you use textbooks in science classes?
24. Is the reading in science classes difficult?
25. What other materials do you use?

26. Do you like working on your own or in groups?

27. Are your science classes interesting or boring?
28. Are they difficult?
29. Do you feel you understand what is going on in science classes?

30. Are they different this year compared to last year? (Or two years ago? Or at your old school?)

31. What kinds of things do you do in your science classes?

32. Did you do the same kinds of things last year? (Or two years ago?) If not, how and why has this changed?

33. Do you work on solving problems?
34. From where do the problems come?
35. Are the problems interesting to you?

36. Do you watch videos?
37. Do you learn much from them?

38. Do you work on the computer in science classes?
39. What do you do on the computer in science classes?

40. What kinds of things do you like to do in your science classes? (read, discuss, write)
41. What do students talk about during science class?

42. What kinds of things would you like to do in your science classes that you are not doing?

43. Do you like some topics or classes in science better than others?

44. Do you go on field trips?
45. What have you learned from the field trips?

46. Have you participated in any science related Friday workshops or in any other science related after school programs (like camp or special museum programs)?

47. Are science classes orderly or is there a discipline problem?
48. Are there bullies in the school and in science classes?
49. Do the students compete with each other or do you work together more?

50. What kind of work would you like to do when you grow up?

51. What kind of education do you think you need for this kind of job?

52. Do you plan to go to college?

53. Do you think your parents/guardians would like for you to go to college?

54. Do you think that your science teachers encouraged you to go to college?

55. Is your science teacher fair?

56. Does your science teacher help you when you need help?

57. Does your science teacher like teaching at your school?

58. Are there things you would change in your science classroom?

59. Do you feel safe in your science classroom?
60. Has someone ever bothered you?

61. Do you need science in your daily life now or in the future?

62. Do you think it is possible to be a scientist and have a family too at the same time?

BIBLIOGRAPHY

Advocates for Women in Science, Engineering and Mathematics (AWSEM). (n.d.). *In their nature: Compelling reasons to engage girls in science.* Retrieved March 29, 2003, from http://www.saturdayacademy/pdx.edu.awsem/_Articles/AWSEM_ In_Their_ Nature.pdf

America 2000: An education strategy. (1991). Washington, DC: U.S. Department of Education. (ERIC Document Reproduction Service No. ED 332 380)

American Association of University Women (AAUW). (1989). *Equitable treatment of girls and boys in the classroom.* Washington, DC: Author.

American Association of University Women (AAUW). (1991). *Shortchanging girls, shortchanging America.* Wellesley College, MA: Center for Research on Women.

American Association of University Women (AAUW). (1992a). *How schools shortchange girls: A study of major findings on girls and education.* Wellesley College, MA: Center for Research on Women.

American Association of University Women (AAUW). (1992b). *Shortchanging girls, shortchanging America: A call to action. AAUW Initiative for Educational Equity.* Washington, DC: Author.

American Association of University Women (AAUW). (1995). *Growing smart: What's working for girls in school.* Washington, DC: Author.

American Association of University Women (AAUW). (1998). *Gender gap: Where schools fail our children.* Washington, DC: AAUW Educational Foundation and National Education Association.

Astin, A. W., Green, K. C., & Korn, W. S. (1987). *The American freshman: Twenty year trends.* University of California Los Angeles: Higher Education Research Institute.

Astin, A. W., Green, K. C., Korn, W. S., Schaliti, M., & Berz, E. (1988). *The American freshman: National norms.* University of California Los Angeles: Higher Education Research Institute.

Backes, J. S. (1994). Bridging the gender gap: Self-concept in the middle grades. *Schools in the Middle, 3*(2), 19–23.

Bergamini, S. (1995). Becoming European: Ways of integration within biographies of Italian immigration into Germany. In Skevos Papaioannou et Aluminiu (Eds.), *Education, Culture and Modernisation.* Roskilde: Roskilde University Centre.

Blumer, M. (1979). Concepts in the analysis of qualitative data. *Sociological Review, 27*(4), 651–677.

Bogdan, R. C., & Biklen, S. K. (1982). *Qualitative research for education: An introduction to theory and methods.* Boston: Allyn and Bacon.

Brandt, F. (1996). *Effective teaching techniques: Cooperative learning.* Retrieved from http://www.ilt.columbia.edu/k12/bbs-old/bbsl/messages/70.html

Brown, H. (1994). *Principles of language learning and teaching* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall Regents.

Campbell, P. B., & Clewell, B. C. (1999). Science, math, and girls. *Education Week, 19*(2), 50–53.

Campbell, P. B., & Hoey, L. (1999). *Saving babies and the future of SMET in America.* Groton, MA: Campbell-Kibler Associates.

Campbell, P. B., & Steinbrueck, K. (1996). *Striving for gender equity: National programs to increase student engagement with math and science.* Washington, DC: American Association for the Advancement of Science.

Cannon, R. K., & Simpson, R. D. (1985). Relationships among attitude, motivation, and achievement of ability grouped, seventh-grade, life science students. *Science Education, 69,* 121–138.

Center for Institutional Data Exchange and Analysis. (2000). *1999–2000 SMET retention report.* Norman, OK: University of Oklahoma.

Chang, J. C. (2002). *Women and minorities in the science, mathematics and engineering pipeline.* ERIC Clearinghouse for Community Colleges (ERIC Document Reproduction Service No. EDO-JC-02-06). Retrieved August 25, 2003, from http://www.gseis.ucla.edu/ERIC/digests/dig0206.htm

Clewell, B., Darke, K., Tartre, L., Davis-Googe, T., Forcier, L., Manes, S., & Raphael, J. (2000). *Summary report on the impact study the National Science*

Foundation's program for women and girls (NSF Contract No. RED9452967). Arlington, VA: National Science Foundation.

The College Board. (1998). *Advanced Placement Program, National summary report*. New York: Author.

The Columbia Encyclopedia (6th ed.). (2003). New York: Columbia University Press.

Cookson, P. W. (1994). *School choice: The struggle for the soul of American education*. New Haven, CT: Yale University Press.

Danielson, C. (1996). *Enhancing professional practice: A framework for teaching.* Alexandria, VA: Association of Supervision and Curriculum Development.

Danzl-Tauer, L. (1990). *The relationship between intervention, equity, and excellence in rural high school biology classrooms*. Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Dausien, B. (1994). *Biographies: To the biographic construction of social reality in women's life stories.* Bremen: Donat. Zugl.: Univ. Diss.

Easterby-Smith, M., Thorpe, R., & Lowe, A. (1990). *Management research—An introduction*. London: Sage.

Ebenezer, J., & Connor, S. (1998). *Learning to teach science: A model for the 21st century*. New Jersey: Prentice-Hall.

Eisner, E. (1979). *The educational imagination*. New York: Macmillan.

Eisner, E. W. (1991). *The enlightened eye: Qualitative inquiry and the enhancement of educational practice*. New York: Macmillan.

Expanding Your Horizons. (1999). *1998–1999 Expanding your horizons in science and mathematics annual report.* Oakland, CA: Math/Science Network.

Farrell, E. F. (2002). Engineering a warmer welcome for female students. *The Chronicle of Higher Education, 48,* A31.

Fennema, E. (1990). Teachers' beliefs and gender differences in mathematics. In E. Fennema & G. Leder (Eds.), *Mathematics and gender* (pp. 169-187). New York: Teachers College Press.

Feuers, S. (1990). Student participation in mathematics and science programs. In D. P. Gallon (Ed.), *Regaining the edge in urban education: Mathematics and sciences.* Washington, DC: American Association of Community and Junior colleges. (ERIC Document Reproduction No. ED 341 450)

Fleer, M. & Hardy, T. (2001). *Science for children: Developing a personal approach to teaching* (2nd ed.). Sydney: Prentice Hall.

Fleming, T. (2001). Cooperative learning: Listening to how children work at school. *The Journal of Educational Research.*

Gay, L. R., & Airasian, P. (1996). *Educational research: Competencies for analysis and applications.* New Jersey: Merrill Prentice-Hall.

Glatthorn, A. (1994). *Developing a quality curriculum.* , Alexandria, VA: Association for Supervision and Curriculum Development.

Gonzales, C., Calsyn, C., Jocelyn, L., Mak, K., Kastberg, D., Arafeh, S., Williams, T., & Tsen, W. (2000). *Pursuing excellence: Comparisons of international eighth-grade mathematics and science achievement from a U.S. perspective, 1995 and 1999.* National Center for Educational Statistics, U.S. Department of Education.

Grant, A. (1995). *Women in science: An exploration of barriers.* Retrieved August 25, 2003, from http://www.angelfire.com/indie/90sough/paper.html

Green, K. C. (1989, September/October). A profile of undergraduates in the sciences. *The American Scientist*, pp. 475–480.

Hall, J. A. (1987). On explaining gender differences: The case of nonverbal communication. In P. Shaver & C. Hendricks (Eds.), *Sex and gender* (pp. 177–200). Newbury Park, CA: Sage.

Hamilton, R., & Ghatala, E. (1994). *Learning and instruction.* New York: McGraw-Hill.

Hargreaves, A., & Fullan, M. (1998). *What's worth fighting for out there?* Mississauga, ON: Ontario Public School Teacher's Federation.

Heller, R. S., & Martin, C. D. (1992, May). Bringing young minority women to the threshold of science. *The Computing Teacher*, pp. 53–55.

Hoepfl, M., (1997). Choosing qualitative research: A primer for technology education researchers. *Journal of Technology Education, 9*(1).

Holloway, M. (1993). Trends in the sociology of science: A lab of her own. *Scientific American, 269*(5), 94–103.

Hueftle, S. J., Rakow, S. J., & Welch, W. (1983). *Images of science: A summary of results from the 1981–82 National Assessment in Science*. Minneapolis, MN: University of Minnesota, Minnesota Research and Evaluation Center.

Johnson, D., Johnson, R., & Stane, M. (2002). *Cooperative learning methods: A meta-analysis.* Retrieved March 27, 2004, from http://www.clcrc.com/pages/cl-methods.html

Jones, L. R., Mullis, I. V. S., Raizen, S. A., Weiss, I. R., & Weston, E. A. (1992). *The 1990 science report card: NAEP's assessment of fourth, eighth and twelfth graders*. Washington, DC: National Center for Educational Statistics, U.S. Department of Education.

Joubert, T. (n.d.) *Roles and social interaction*. Retrieved from http://hagar.up.ac.za/catts/learner/cooplrn/cl.ntml

Jovanovic, J., & Dreves, C. (1995). *Math, science and, girls: Can we close the gender gap*? National Network for Child Care. Illinois: Illinois Cooperative Extension Service.

Kahle, J. B. (1997). *Encouraging girls in science courses and career*. National Association for Research in Science Teaching, 9703.

Kahle, J. B. (1984). *Girls in school: Women in science: A synopsis*. Paper presented at the eighth annual Women's Studies Conference, Greeley, CO.

Kahle, J. B. (Ed.). (1985). *Women in science: A report from the field.* New York: The Falmer Press.

Kahle, J. B., Anderson, A., & Damnjanovic, A. (1991). A comparison of elementary teacher attitudes and skills in teaching science in Australia and the United States. *Research in Science Education, 21*, 208–216.

Kahle, J. B., & Damnjanovic A. (1994). The effect of inquiry activities on elementary students' enjoyment, ease, and confidence in doing science: An analysis by sex and race. *Journal of Women and Minorities in Science and Engineering, 1*, 17–28.

Kahle, J. B., & Meece, J. (1994). Research on gender issues in the classroom. In D. Gable (Ed.), *Handbook of research on science teaching* (pp. 542–557). New York: Macmillan.

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (1993). Gender differences in science education: Building a model. *Educational Paychologist, 28*(4), 379–404.

Keating, D. P. (1996). The transformation of schooling: Dealing with developmental diversity. In J. Lupart, A. McKeough, & C. Yewchuk (Eds), *Schools in transition: Rethinking regular and special education*. Toronto: Nelson.

King, L., Tayler, C., & Maloney, C. (1991). Small group cooperative learning: Developing a category system. *Issues in Educational Research, 1*(1), 7–22.

Kinsella, K. (1996). Designing group work that supports and enhances diverse classroom work styles. *TESOL Journal*, *6*(1), 24–31.

Klanin, S., & Fensham, P. J. (1987). Activity based learning in chemistry. *International Journal of Science Education, 9*(2), 217–227.

Kleinfeld, J. (1998a). *The Morella bill, my daughter Rachel, and the advancement of women in science*. Washington, DC: Women's Freedom Network. Retrieved from www.judithkleinfeld.com/ar_daughter.html

Kleinfeld, J. (1998b). Q: Do public school shortchange girls on educational opportunities? No: In fact, the public schools are biased against boys, particularly minority males. *Insight on the News, 14*(46), 24.

Kober, N. (n.d.) What special problems do girls face in science? What can schools do? *EdTalk: What we know about science teaching and learning*, 26–28.

Kostash, M. (1993). *No kidding: Inside the world of teenage girls*. Toronto: McClelland and Stewart.

Kroonenberg, N., & Reid, J. (Eds.). (1995). Meeting language learners sensory-learning style preference. In *Learning styles in the ESL/EFL classroom*. Boston: Heinle and Heinle.

Kvale, S. (1996) *InterViews: An introduction to qualitative research interviewing*. London: Sage.

Lee, S. (2001). *Viewpoint: Seven experts on funding strategies to increase science and technology opportunities for girls*. San Francisco, CA: Three Guineas Fund. Retrieved August 19, 2003, from http://www.3gf.org.viewpoint.htlm

Lee, V. E., & Burkam, D. T. (1995, April). *Hands-on science would help eliminate the gender gap in science*. Paper presented at the meeting of the American Educational Research Association.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Maher, L. (1998). Bring thrills and skills to science teaching. *New Jersey Education Association, 72*(1), 28–32.

Matyas, M. L., & Malcom, S. M. (1991). *Investing in human potential: Science and engineering at the crossroads*. Washington, DC: American Association for the Advancement of Science.

Maxwell, J. (1996). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage.

McComas, W. F. (1996). Ten myths of science: Reexamining what we think we know about the nature of science. *School Science and Mathematics, 96*(1), 10–16.

McIntosh, P. (1997). White privilege and male privilege: A personal account of coming to see correspondence through work in women's studies. In R. Delgado & J. Stefancic (Eds.), *Critical white studies: Looking behind the mirror* (pp. 291–299). Philadelphia: Temple University Press.

McNees, P. (2004, January 6). Why Janie can't engineer: Raising girls to succeed. *The Washington Post*, p. C09.

Miles, M. B., & Huberman, M. A. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage.

Moncure, S. S. (1994). Gender sensitive; Awareness makes science teaching equitable. *Update, 13*(30), 3.

Morran, J., DeMoss, S., & Barnett, M. (2001). *2000–01 action research project using science inquiry to teach water quality monitoring, Ellettsville Elementary*. Retrieved March 27, 2004, from Indiana University Instructional Technology website: http://www.inkido.Indiana.edu/mikeb/ActionResearchClass/assignments/sample_action_project.pdf

Mueller, A., & Fleming, T. (2001). Cooperative learning: Listening to how children work at school. *The Journal of Educational Research, 94*(5).

A nation at risk: The imperative for educational reform. (1983). Washington, DC: National Commission on Excellence in Education.

National Assessment of Educational Progress. (1988). *The science report card: Elements of risk and recovery: Trends and Achievement Based on the 1986 National Assessment.* Princeton, NJ: Educational Testing Service.

National Coalition for Women and Girls in Education. (1992). *The task force reports: Teaching strategies for girls in math and science*. Washington, DC: National Coalition for Women and Girls in Education.

National Council of Teachers of Mathematics, Commission on Standards for School Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Research Council. (1996). *National Science Education Standards.* Washington DC: National Academy Press.

National Research Council. (2002). *National Science Education Standards.* Washington DC: National Academy Press.

National Science Board. (2002). *Science and engineering indicators—2002* (Report No. NSB-02-1). Arlington, VA: Author.

National Science Foundation. (1994). *Women, minorities, and persons with disabilities in science and engineering*. Washington, DC: Author.

National Science Foundation. (1996). *REC Indicator Series: The learning curve: What we are discovering about U.S. science and mathematics educations.* Washington, DC: Author.

National Science Foundation. (2003). *New formulas for America's workforce: Girls in science and engineering.* Arlington, VA: Author.

National Science Foundation, Science Resources Studies Division. (2001). *Characteristics of doctoral scientists and engineers in the United States: 1999.* Detailed Statistical Tables. Arlington, VA: Author.

The New England Consortium for Undergraduate Science Education. (1996). *Achieving gender equity in science classrooms*. Providence, RI: Brown University, Office of the Dean.

North Central Regional Education Laboratory. (1996). *Gender inequities.*

Oakes, J. (1999). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education, 16,* 153–222.

O'Brien, L. (1989). Learning styles: Make the student aware. *National Association of Secondary School Principals' Bulletin, 73,* 85–89.

Orenstein, P. (1994). *Schoolgirls: Young women, self-esteem, and the confidence gap*. New York: Doubleday.

Oxford, R., & Ehrman, M. (1993). Second language research on individual differences. *Annual Review of Applied Linguistics, 13,* 188–205.

Oxford, R., Hollaway, M., & Horton-Murrillo, D. (1992). Language learning style and strategies in the multicultural, tertiary L2 classroom. *System, 20*(3), 439–456.

Patton, M. Q. (1980). *Qualitative evaluation methods.* Beverly Hill, CA: Sage.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage.

Piirto, J. (2000). *Why are there so few? (Creative women: Visual artists, mathematicians, scientists, musicians).* Retrieved August 25, 2003, from www.ashland.edu/~jpiirto/why_are_there_so_few.htm

Pipher, M. (1995). *Reviving Ophelia: Saving the selves of adolescent girls.* New York: Ballantine Books.

Rasmussen, C., & Moffitt, M. (1997). *Real-life problem solving. A collaborative approach to interdisciplinary learning*. Washington, DC: American Psychological Association.

Reid, J. (Ed.). (1995). *Learning styles in the ESL/EFL classroom.* Boston: Heinle and Heinle.

Reiff, J. (1992). What research says to the teacher: Learning styles. Washington, DC: National Education Association.

Reinard, J. (1998). *Introduction to communication research* (2nd ed.). Boston: McGraw Hill.

Rennie, L. J., & Parker, L. H. (1987). Detecting and accounting for gender differences in mixed-sex and single-sex groupings in science lessons. *Educational Review, 39,* 65–73.

Restine, K. A. (1999). *How beliefs about teaching and learning influence the technology training experience: An explanatory case study.* Unpublished doctoral dissertation, Oklahoma State University, Stillwater.

Ride, S., & Stysek, D. (2003, October 23). Science is cool for girls, stereotypes must be overcome early when their aptitude equals boys. *Mercury News.*

The Rising Tide: A report on women in science, engineering, and technology. (1994). London: HMSO.

Rubin, H. J., & Rubin, I. S. (1995). *Qualitative interviewing: The art of hearing data.* Newbury Park,CA: Sage.

Sadker, M., & Sadker, D. (1994). *Failing at fairness: How our schools cheat girls.* New York: Macmillan.

Sadker, M., Sadker, D., & Klein, S. (1991). The issue of gender in elementary and secondary education. *Review of Research in Education, 17,* 269–334.

Scantlebury, K. (1994). Emphasizing gender issues in the undergraduate preparation of science teachers: Practicing what we preach. *Journal of Women and Minorities in Science and Engineering, 1,* 153–164.

Schroeder, C. C., & Jackson, G. S. (1987). Creating conditions for student development in campus living environments. *National Association for Student Personnel Administrators Journal, 25*(1), 45–53.

Seymour, E. (1992, February). The problem iceberg in science, mathematics, and engineering education: Student explanations for high attrition rates. *Journal of College Science Teaching*, 230–238.

Seymour, E. (1993, April 10). *Why are the women leaving?* Lecture at the New England Consortium for Undergraduate Science Education (NECUSE) Conference, Brown University, Providence, RI.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave sciences.* Boulder, CO: Westview Press.

Shapiro, G., & Markoff, J. (1997). A matter of definition. In C. W. Roberts (Ed.), *Text analysis for the social sciences: Methods for drawing statistical inferences from texts and transcripts.* Mahwah, NJ: Lawrence Erlbaum.

Sheriff, B., & Svenne, J. P. (1993, Winter). Are women excluded from careers in science? *Women's Education,* 7–10.

Smith, W. S., & Erb, T. O. (1986). Effect of women science career role models on early adolescents' attitudes toward scientists and women in science. *Journal of Research in Science Teaching, 23*(8).

Spertus, E. (1991). *Why are there so few female computer scientists?* Retrieved August 25, 2003, from www.ai.mit.edu/people/ellens/Gender/pap/pap.htlm

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Steele, C. M. (1994). *Under suspicion of inability: Stereotype vulnerability and women's math performance.* Unpublished manuscript. Stanford University.

Strauss, A. (1987). *Qualitative analysis for social scientists.* Cambridge: Cambridge University Press.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: Sage

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Newbury Park, CA: Sage.

Te Kete Ipurangi [TKI]. (2001). *Science in the New Zealand curriculum.* Retrieved March 27, 2004, from http://www.tki.org.nz/r/science/curriculum/p11_e.php

Thom, M. (2001). *Balancing the equation; Where are women and girls in science, engineering, and technology?* National Council for Research on Women.

Turkkan, J., Domske, H., & Josef, C. (2004, March 21). Helping young girls expand their horizons to embrace science. *The Buffalo News,* p. H2.

Third International Mathematics and Science Study (TIMSS). Washington, DC: National Center for Education Statistics.

Third International Mathematics and Science Study-R (TIMSS-R). (1999). Washington, DC: National Center for Education Statistics.

U.S. Department of Education. (1997). Washington, DC: National Center for Educational Statistics, Institute of Education Sciences.

U.S. Department of Education. (2000). Washington, DC: National Center for Educational Statistics, Institute of Education Sciences.

U.S. Senate Hearing. (2002, June 20). *Hearing convened on educational initiatives at NASA to discuss the barriers that discourage girls and women from studying and working in the fields of math, science, and technology*, 107th Cong., 1st Sess. (Testimony of Geraldine L. Richmond).

Wax, R. (1986). *Doing fieldwork: Warnings and advice.* Chicago: University of Chicago Press.

Weiss, I. R. (1987). *Report of the 1985–86 National Survey of Science and Mathematics Education.* Research Triangle Park, NC: Research Triangle Institute.

What happens to women and men with SET degrees? (2003, February). *Labour Market Trends, 104*(2), 63-67.

Why girls turn their backs on a science education: Barriers in the early school years. (1996, March). In *Opportunity 2000: Towards a Balanced Workforce.* The Prudential Corporation.

Women's Television Network (WTN). (2003). *Resources to teaching girls math, science and technology*. Retrieved March 29, 2003, from WTN Foundation website: http://www.wtn.ca/foundation