

Gender Equity in Science Education

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Submitted in Partial Fulfillment of the Requirements for the Degree

Master of Science in Education

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Dominican University of California

San Rafael, CA

June 2011

Acknowledgements

I would like to thank Dr. Madalienne Peters and Dr. Sarah Zykanov for their assistance in this creation of this paper and my family for their unfailing support.

Abstract

The dearth of females in high-level science courses and professions is a well-documented phenomenon in modern society. Inequality in science instruction is a crucial component to the under representation of females in science. This paper provides a review of current literature published concerning gender inequality in K-12 science instruction. The existing literature suggests that the competitive nature of traditional science classrooms and the view of science as a male field of study inhibit female scientific performance.

In an effort to provide educators with guidance in creating a gender equitable science classroom, this paper documents methods, such as creating a collaborative learning environment and increasing inquiry-based opportunities, which effectively counteract the disempowerment of females in science. Identifying aspects that disempower and empower females in K-12 science classrooms should provide a context for creating improvement in the gender equity of science instruction.

Table of Contents

TITLE PAGE	1
ACKNOWLEDGEMENTS	2
CHAPTER 1 INTRODUCTION	5
STATEMENT OF PROBLEM	5
PURPOSE STATEMENT	6
RESEARCH QUESTIONS.....	6
THEORETICAL RATIONALE	6
ASSUMPTIONS	10
BACKGROUND AND NEED	11
CHAPTER 2 REVIEW OF THE LITERATURE	12
INTRODUCTION	12
DISCUSSION	12
<i>Disempowering Aspects of the Conventional Science Classroom</i>	12
<i>Empowering Aspects of the Gender Sensitive Science Classroom</i>	15
GENDER EQUITY INTERVENTIONS	16
SUMMARY OF MAJOR FINDINGS.....	26
LIMITATIONS/GAPS IN THE LITERATURE.....	27
OVERALL SIGNIFICANCE OF THE LITERATURE.....	28
CHAPTER 3 METHOD	31
SAMPLE AND SITE	31
ETHICAL STANDARDS	31
ACCESS AND PERMISSIONS	32
DATA GATHERING STRATEGIES.....	32
DATA ANALYSIS APPROACH.....	33
CHAPTER 4 FINDINGS	34
INTERVIEW WITH DR. JENNINGS	34
INTERVIEW WITH DR. WARREN.....	36
INTERVIEW WITH DR. CHASE	37
MAJOR THEMES	37
CHAPTER 5 DISCUSSION /ANALYSIS	39
SUMMARY OF MAJOR FINDINGS.....	39
COMPARISON OF FINDINGS TO PREVIOUS RESEARCH	39
LIMITATIONS/GAPS IN THE STUDY.....	39
IMPLICATIONS FOR FUTURE RESEARCH.....	40
OVERALL SIGNIFICANCE OF THE STUDY.....	40
REFERENCES	42
APPENDIX	48

Chapter 1 Introduction

Throughout my time in elementary and junior high school, I felt great pride in my scientific accomplishments. I considered my feelings of empowerment in my science education to be universal. It was only during my high school years that I came to understand the existence of a chasm between female students and science education.

While my science classes were filled with equal numbers of male and female students, the enthusiasm for the subject in my fellow females was lacking. Where were all my fellow female students eager to become physicists? In college, my eagerness to embrace science led me to a large lecture hall for Physics 101. In the class, I saw a scattering of female faces among the hoards of males and I was once again confronted with the uniqueness of my desire for a scientific education.

Due to the impersonal and intimidating format of the class, it became the last science class of my academic career. Now, as a teacher and mother of three girls, I am determined to provide my female students the opportunity to experience the joy and wonder of scientific exploration, unadulterated by gender inequality or bias.

Statement of Problem

Females are underrepresented in advanced science classes and careers. The number of female students pursuing advanced college and graduate level science and engineering courses is substantially less than their male counterparts and, while females make up 46% of the work force, only 22% of these females are working in science fields (Davis, 2001).

Purpose Statement

The purpose of my research is to identify traditional teaching strategies being implemented in science classrooms that work to disempower female students. A second purpose is to discover effective techniques that empower girls to study science.

Research Questions

What traditional teaching strategies implemented within the science classroom are disempowering to female students? What strategies empower females?

Theoretical Rationale

The concept fueling my research interest in gender equity in science instruction is twofold. First, there is the women's suffrage movement of the late 1800s, during which women leaders and activists fought to establish equal voting rights for women. "Men, their rights, and nothing more; women, their rights, and nothing less" (Betts, 2007, para. 3). Second, there is the Civil Rights Movement of the mid-1900s during which time leaders and activists fought to establish equal rights for all people. "I say to you today my friends, even though we face the difficulties of today and tomorrow, I still have a dream. It is a dream deeply rooted in the American dream. I have a dream that one day this nation will rise up and live out the true meaning of its creed: - 'We hold these truths to be self-evident, that all men are created equal'" (Ashbrook Center for Public Affairs at Ashland University, 2008, para. 22). As a result of the Women's Rights movement and

the Civil Rights movement, various legal ramifications exist. Amendment XIX to the United States Constitution states “The right of citizens of the United States to vote shall not be denied or abridged by the United States or by any state on account of sex” (U.S. Government, 2010, para. 3). Title IV of the Civil Rights Act of 1964 (U.S. Department of Education, 2010) prohibits discrimination in public schools because of race, color, religion, sex, or national origin . Finally, Title IX of the Education Amendments bans sex discrimination in schools, stating, “ No person in the United States shall, on the basis or sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any educational program or activity receiving federal financial assistance” (U.S. Department of Labor, 2011, para.1).

The belief that all individuals deserve and require equal rights in society is shaping my research purpose. Without equal legal rights, on the federal, state and personal level, women were kept from their basic human rights - health, education and employment opportunity. With the equal protection afforded to women through the tireless efforts of Women’s rights and Civil rights activists, there is now the expectation that women will receive equal treatment in all aspects of their lives. Education is a crucial component in the genuine acquisition of equality. On a basic level, without literacy, a woman is excluded from making informed decisions regarding her health and family. On a more advanced level, women receiving less of an education than their male counterparts in a particular subject matter will be excluded from realizing their full potential in that subject. While full potential is a rather ambiguous concept, this potential could be as

simple as a deep understanding of the subject or as complex as an advanced career based on the subject; both are valid goals deserving protection.

Gender equity in science education ensures that all males and females, regardless of age, culture, and ethnic background or disability, have the support they need to become successful, respected and challenged science students (National Science Teachers Association [NSTA], 2011). When exploring the historical context from which the research of gender inequality in science education stems, it is to the general question of gender in education as a whole, which one is pulled. Looking at the history of females in the educational realm, one finds a rich tradition of inequality, misconception and exclusion. Unscientific theories have been long used to keep females out of the educational system. As Kern (2005) states, in the 1700s, renowned educational theorist "...Rousseau believed that women were not qualified for research in abstract areas such as mathematics and science because their brains were unfit" (Lucidi, 1994, p.10). The use of unscientific explanations for excluding females from education continued for centuries with justifications based upon dangers of diverting blood flow from the reproductive organs to the female brains, the inferior size of the female brain relative to the male brain and the concept of an evolutionarily stunted female brain due to reproduction were all employed to keep women from pursuing a formal education (Lucidi, 1994).

Women continued to be excluded from education until the 1800s when women were allowed access to formal educational institutions with the express understanding that women and men would pursue vastly different educational goals. With the advent of

compulsory education, by the end of the 1800s, females represented a higher percentage of high school students than males (Lucidi, 1994). The women's suffrage movement of the late 1800s, during which female leaders and activists fought to establish equal voting rights for women was a time of great momentum for women's educational rights. Despite these advances, females continued to be commonly viewed as mentally inferior and their educational programs reflected this biased view of their capabilities (Lucidi, 1994).

With America's fear of being outperformed in the fields of math and science exacerbated by the Soviet launch of Sputnik in the 1950s, the National Education Act was passed with hopes of bolstering America's scientific abilities. To this end, the educational curriculum embraced and encouraged overwhelming images of males pursuing advanced scientific careers (Lucidi, 1994). The Feminist Movement of the 1970s brought with it increased attention on women's rights in society; including the passage of Title IX of the Educational Amendment and the Women's Educational Equity Act (WEEA) with the express purpose of protecting women's rights to an equitable education (Lucidi, 1994). The National Organization for Women (NOW) illustrates the impact of such equitable legislature by explaining that in the early 1970's, women earned only 7% of all law degrees and 9% of all medical degrees while following the passage of Title IX and the WEEA, in 2001, women earned 47% of law degrees and 43% of medical degrees (Grunberg, 2007). Such an increase in female participation and success in education, while heartening, does not spell an end to gender bias and inequality in the educational setting as women continue to be underrepresented in science and mathematic

degrees recipients, fields of study which lead to greater earning potential in the workforce (Grunberg, 2007; Freeman, 2004).

The considerable history of gender bias in education creates an institutionalized gender inequality, which, centuries old, has become all but invisible to the general population and educational policy makers. In recent national educational reform programs, little to no attention has been placed on gender equity in education (Lucidi, 1994). In order to correct a problem, it is necessary to first recognize that problem exists. To that end, more attention needs to be placed on the educational inequalities of women in education. Recognizing the historical context from which a modern disparity stems works to help modern researchers and policy makers understand, frame and address the inequality.

Focusing my research on discovering teaching strategies that will work to empower girls in science instruction, I am making the assumption that regardless of the legal and societal tenets to the contrary and tireless efforts of humanitarians; gender equity has not been fully achieved in our society; not in issues of health, law or education. It is my firm desire that in outlining female empowerment strategies in science instruction, we will move closer to gender equity in this one area of education.

Assumptions

It is my assumption that traditional teaching strategies do not empower female students in science instruction It is my belief more female scientists are needed in our society.

Background and Need

The American Association of University Women's [AAUW] (Wellesley College and AAUW, 1992) 1995 report *How Schools Shortchange Girls* presents a significant examination of how females are disadvantaged in America's schools. This important report explains how the current research reveals the traditional classroom dynamics that work to disempower females in science and math classrooms. The AAUW Report (Wellesley College and AAUW, 1992) explains girls do not receive equitable amounts of teacher attention, do not see themselves reflected in the materials of study and are often discouraged from pursuing higher-level math and science classes and careers. The report presents a comprehensive action plan for educators to counteract the inequality of science and mathematic education.

Chapter 2 Review of the Literature

Introduction

Gender equity in science education ensures that all males and females, regardless of age, culture, ethnic background or disability, have the support they need to become successful, respected and challenged science students (NSTA, 2011). Males and females have no difference in their general intelligences based simply upon their gender (Hines, 2007). It is documented that male and female pre-school ages children possess equal scientific thinking skills abilities (Unutkan, 2006). While male and female students begin their academic careers with an equal ability in scientific thinking skills, a precursor to scientific ability, something occurs during the subsequent schooling of males and females that disempowers the female students in science education and careers. Davis and Irwin (2001) illustrates this point by explaining that while females make up 46% of the work force, only 22% of these females are working in science fields.

Discussion

Disempowering Aspects of the Conventional Science Classroom

The inequality of male and female students' achievement and advancement in scientific fields, is closely tied to the science classroom. As Hammrich (1997) and Halpern, Aronson, Reimer, Simpkins, Start & Wentzel (2007) explain, the conventional science-learning environment is competitive and individualistic. This type of learning

environment greatly excludes female participation. In addition to the competitive nature of the traditional science classroom, gender disparity in science classrooms is also attributed to the verbal and no-verbal male dominance allowed throughout science classroom. Guzzetti (1998) and Chatman, Nielsen, Strauss and Tanner (2008) explain how the male students' interruptions, call outs and general loudness within the classroom result in less active verbal and non-verbal participation of females within science classrooms. Cited as an equally important factor in the disempowerment of females in science education, is the perception that science is a male dominated field of study and employment (Hammrich, 1997; Halpern et al., 2007; Hill, Corbett & Rose, 2010 & AAUW, 2010). Reinforcing this stereotype is a science curriculum base of materials, which provide biased language, content, and illustrations of science as primarily a male endeavor (Sanders, 1997; Halpern et al., 2007; AAUW, 2010). While current science textbooks are far less sexist than those of the past 40 years, showing females engaged in the pursuit of science, these often cursory and minimal additions do not adequately address the full history of females in science or work to inspire future female scientists or present the history of only extraordinary women in science creating unattainable expectations (AAUW and American Institute for Research, 1998; Halpern et al., 2007; Chatman et al., 2008).

Spatial visualization ability is considered of great importance in the pursuit of scientific understanding, interest and advancement (Ceci & Williams, 2009; Halpern et al., 2007; Sanchez & Wiley, 2010). Spatial visualization is the ability to mentally

manipulate 2-dimensional and 3-dimensional figures, visualize trajectories and rotate stimuli rapidly and accurately within the mind. These spatial visualization skills are connected to science learning as better-developed spatial visualization abilities correspond with higher science related test scores and science based academic performance (Halpern et al. 2007; Hyde, 2007, Newcombe, 2007). While research shows that female and male students begin school with equivalent spatial visualization abilities, male students quickly begin to out perform female students on spatial visualization tasks (Halpern et al., 2007; Hyde, 2007; Ceci & Williams, 2007; Newcombe, 2007; Lubinski & Benbow, 2007; Hines, 2007, Hill et al., 2010).

Within the research, there is sound support for the concept that one's spatial visualization abilities are not fixed. "Even though sex differences in spatial ability are substantial, mean levels of spatial ability do not seem to be biologically fixed" (Newcombe, 2007, p.74). Through learning opportunities focused on spatial visualization skill acquisition, research has shown that female spatial visualization abilities can improve substantially within a relatively short time period (Halpern et al., 2007; Hyde, 2007; Ceci & Williams, 2007; Newcombe, 2007; Lubinski & Benbow, 2007; Hines, 2007, Hill et al., 2010). There is a marked disparity between female and male spatial visualization skills by the time they enter high school (Ceci & Williams, 2007). Hyde (2007) and Hill et al. (2010) suggest that in order to effectively increase female success within science education, spatial visualization training for females should occur prior to middle school, instituting a spatial curriculum in elementary school.

Empowering Aspects of the Gender Sensitive Science Classroom

In order to create gender equity in science education, researchers have focused on correcting the imbalances of the traditional science classroom. To counteract the inherent competitive learning environment of traditional science classroom, it is recommended that science classrooms be restructured to provide a safe and nurturing collaborative learning environment (Hammrich, 1997; Barton, 1998; Chatman et al., 2008; Halpern et al., 2007). Davis and Irwin (2001), the NSTA (2011) and Hill et al., (2010) reiterate the need for the development of a sense of community, in which all participants are encouraged to substantially participate, within the science classroom. In order for equitable participation to exist in a science classroom, Davis and Irwin (2001), Halpern et al. (2007) and Hill et al. (2010) contend that trust, shared leadership and cooperative learning must be foundational in the creation of the culture of respect in the classroom.

In addition to creating a safe and open learning environment, the research suggests that giving attention to the different learning styles of males and females will provide much opportunity to improving gender equity in the science classroom (NSTA, 2011). Female learning styles are generally more cooperative and interdependent than their male counterpart. In order to better serve this type of female learning, it is recommended that science instructional practices be primarily inquiry-based, including

open-ended discussions and hands-on learning opportunities (Hammrich, 1997; Davis & Irwin, 2001; Hyde, 2007; AAUW, 2004; Halpern et al., 2007; Hyde, 2007).

Research commissioned by the American Association of University Women (1992, and Wellesley College & AAUW, 1992) and Hyde (2007) has also shown that female science participation and advancement can be improved by providing female students opportunities for informal learning, usually out of school opportunities for science experiences, and female scientist mentoring programs, informal and formal connections between students and science professional and teachers. Finally, gender sensitive teacher professional development programs, in which science teachers focus on gender equity awareness, are recognized as important to the success or failure of female science students.

Gender Equity Interventions

While there are many ways in which the educational community has attempted to correct the gender inequality in science education, when reviewing the current literature on gender equity interventions, there are three major types of gender equity interventions regularly implemented in conjunction with science education; enrichment programs, mentoring programs and teacher education programs (AAUW, 2004). These intervention programs can be and have been implemented independent of each other or operated in conjunction with one or all of the various program types. For the purposes of this paper;

however, the three major types of gender equity interventions will be examined as separate and unique entities.

Enrichment programs in the area of gender equity interventions in science are a multifaceted and varied lot. These enrichment programs, generally referred to as Informal Learning, are defined by the National Science Foundation Directorate for Education and Human Resources as

...Projects in which learning is voluntary and self-directed, life-long, and motivated mainly by intrinsic interest, curiosity, exploration, manipulation, fantasy, task competition, and social interaction... It provides an experimental base and motivation for further activity and learning (and) the outcomes of an informal learning experience... include a better understanding of concepts, topics, processes, and thinking in scientific and technical disciplines, as well as increased knowledge about career opportunities in (science) (National Science Foundation, 1999, p. 9).

Examples of Informal Learning range from activities at after- school centers, summer camps, science museums and Girl Scouts programs to lectures and films on science topics. While this list is far from exhaustive, it provides a general understanding of the ways in which Informal Learning can occur. Two such Informal Learning programs, *Get in Gear* and *Sisters in Sport Science*, whose goal it is to promote gender equity in science education, will be further addressed.

The *Get in Gear Girl Scout Workshop* of 1999 was a program in which the Society of Women Engineers of Los Angeles invited over 1000 local Girl Scouts troops to attend a daylong science workshop. The purpose of the workshop, which included an

introductory presentation entitled “Engineer Barbie” followed by seven activities; Mad Scientist Lab, Cyberscouts, The Airport, Water Works, Machine Shop, Robot Zone and Energy Tour, was designed to “expose girls to the field of engineering and encourage them to consider a career in science or engineering” (Society of Women Engineers, 1999). Members of the Society of Women Engineers of Los Angeles served as volunteer activity leaders and Girl Scouts rotated between the seven activities. The event organizers administered a simple pre- and post-test survey to judge the overall effectiveness of the Informal Learning event. The survey showed a marked improvement in the participants’ interest and understanding of science, math and science related careers.

In contrast to the single day *Get in Gear Girl Scout Workshop* of 1999, *Sisters in Sport Science: A Sport-Oriented Science and Mathematics Enrichment Program (SISS)* was designed as a three-year intervention for middle school girls from six inner-city Philadelphia middle schools. The program worked with the existing science and mathematic curriculum of the middle schools and incorporated what was being taught into the many program activities to enhance the concepts being taught during the school year through the innovative vehicle of sports.

The goals of *SISS* are to:

Increase science and mathematics achievement of middle school girls through the vehicle of sports. Increase the number of effective teachers and coaches who use sports as an avenue for teaching, problem solving, and communicating about science and mathematics. Enhance the self-identities of middle school girls who come from disadvantaged environments. Increase middle school girls’ careers awareness of science, mathematics and sport related fields. Increase families’ and

caregivers' knowledge of sports as an effective way to foster science and mathematics achievement (Hammrich, Richardson, Green and Livingston, 2001, p. 6).

To these ends, the *SISS* program incorporated five components: after school programs; Saturday academics; special sport day events; academic and summer internships; and career connections. Each program activity used a specific sport and focused on how scientific and/or mathematic principles were used to perform the sport. In addition to incorporating science and mathematics concepts into the performance of a sport, each activity of the program used an actual athlete from the sport or a scientist to provide a role model for program participants.

While the *SISS* facilitators acknowledge that the results obtained from their three-year program were preliminary, the results did illustrate positive overall program effectiveness. Results were obtained from performance on pre- and post-test that tested the science and mathematics skills and concepts being studied during each activity. The test results showed statistically significant increases in scientific and mathematics knowledge between pre- and post-tests. In addition to these results, the *SISS* program facilitators found the high retention rate of program participants, 67% of sixth grade participants returned as seventh grader and 54% returned as eighth graders, an important indicator of the effectiveness of the *SISS* program. Also seen as positive, was the overall increase in program participants' academic grades and the parents of participants increased recognition of the connection between sports and science and mathematic concepts (Hammrich et al. 2001). Taken together, the overall outcome of the *SISS*

program was positive. While further time will test the long-term effects of this Informal Learning program, the short-term results were encouraging.

Much like enrichment programs, mentoring programs in the area of gender equity interventions in science can vary greatly in their design and scope. Mentorship refers to a developmental relationship between a more experienced mentor and a less experienced partner referred to as a mentee. A person guided and protected by a more prominent person.” The manner in which the mentor develops a relationship with the mentee for the purposes of promoting gender equity in science education can vary greatly between mentoring programs. Mentoring programs can occur in workshops, and in job shadowing formats, there can be meetings during camp or school settings where the participants can meet face to face, over the telephone or the Internet. While many effective mentoring programs facilitate more than one meeting, some can have mentor and mentee meetings occur only once. Any and all of the aforementioned components can be used in combination with any other component. In reality, the possibilities for mentoring program designs are innumerable.

The goal of most science gender equity mentoring programs is to increase academic competence and science career connections for females. To this end, many mentoring programs incorporate connecting successful female scientists with school-aged females into the foundation of the mentoring program. Mentoring programs to promote gender equity in science education are; however, not exclusively for bringing together school aged females and scientists. Peer mentoring of both youth and teachers can be

another useful mentoring program format in the quest for gender equity. One such program is outlined in Sanders and Campbell (2001) *Using Mentors and Interdisciplinary Teams to 'Genderize' Teacher Education*.

Following Sanders' *Teacher Education Equity Project 1993-1996*, Sanders used previously trained teacher educators as mentors for the national project promoting gender equity in mathematics, science and technology, the Teacher Education Mentor Program (TEMP). Of the sixty-one interested graduated of the *Teacher Education Equity Project*, seven mentors were chosen to each work with one of seven universities. Each university created an interdisciplinary team to work with their mentor to increase gender equity institutionally in college of education programs and practices. Each university was given five thousand dollars to fund their mentorship, though only two institutions spent the entire allocation.

While the focus of increasing gender equity in pre-service teachers of mathematics, science and technology was the same for all seven mentorships, all seven created unique mentoring relationships and used their mentoring opportunities differently. Overall the interdisciplinary teams were encouraged to look at their universities gender practices, and carry out a variety of gender equity activities with the help of their mentor. Equity activities ranged from holding a program-wide conference on gender equity for all education students and integrating gender equity into the conceptual framework of the teacher education program, to adding consideration of gender in hiring, promotion and tenure decisions (Sanders & Campbell, 2001).

The results of the Teacher Education Mentor Program were varied, yet, promising. Just as each mentoring relationship was unique to the individuals and institutions, so to were the outcomes. In order to assess the effectiveness of the TEMP, the program facilitators evaluated school of education syllabi from before and after the program, asked for written gender equity sensitivity self-assessments of program participants and institutional policy evaluations pre and post program inception.

In general, the self-assessments of individual change showed a “movement” towards increased gender equity, reporting increased professional activities and promotions within the universities for those participating as team mentees. The assessment of institutional change showed an increase or improvement in education courses in their inclusion of gender equity in the teaching of mathematics, science and technology. It is important to note that while this move towards gender equity awareness and action was promising, the assessment of pre- and post- program syllabi showed less of a dramatic increase in the number of syllabi including gender issues in their course descriptions and readings. In fact, during the project period, the number of syllabi including gender issues in their course descriptions and readings decreased. There was, however, an increase in the percentage of syllabi that included equity in assignments and topics (Sanders & Campbell, 2001).

In the final evaluation of the Teacher Education Mentor Program, there were two important factors considered crucial for the improvement of the program and the effective implementation of any mentoring program. First, the need for the interdisciplinary team

leaders to be schooled in the art of group facilitation surfaced as an important factor in the overall effectiveness of the mentoring relationship. Although the team leaders were chosen internally, this did not guarantee they possessed the requisite skills to effectively lead the group through the various gender equity tasks and activities. For the purposes of this mentoring program, and others similarly created, initial group facilitation workshops should have been mandated for all team leaders. In addition, it became clear that although all of the chosen mentors were well trained in the subject of gender equity in education, they were only given minimal training as to how to mentor. For a mentor to be effective in this mentoring situation or any, it is important that she or he be *both* well versed in the subject or area of mentoring *and* well trained in the skills of effective mentoring (Sanders & Campbell, 2001).

Teacher education programs, specifically in-service professional development opportunities, are also a valuable type of gender equity interventions in science education. The AAUW defines professional development as the opportunity for teachers to talk about subject matter, student thinking and teaching. (AAUW, 2004). The main goals of in-service gender equity teacher education programs are to provide specific tools to increase gender equity in the classroom and increase awareness of gender equity issues in general (Wellesley College and AAUW, 1992). Unfortunately, the concept of professional development has received a bad reputation, due largely to poorly formulated programs. In addition, professional development programs are often difficult to mandate and achieve positive results.

Professional development programs, much as enrichment and mentoring programs, do not conform to a standard formula. Instead, a professional development program can be as specialized as a teacher initiated research project or as general as a district wide book club on gender equity related issues. While it is normal to think of professional development programs as one-time workshops, there are many professional development programs that have multiple components or are ongoing or meet over time. One such example of a professional development program concerned with increasing gender equity in science education is the computer science based Alabama Supercomputing Program to Inspire Computational Research in Education, ASPIRE.

ASPIRE, a one or two week professional development program for junior and high school teachers, was begun in 1994 in Alabama. The program was created to help teachers “instruct students in solving problems using a computational science approach to problem solving...and inspire students to become excited about mathematics, science, and core subjects” (Department of Education, 2001, p. 23) What makes this professional development program unique is its incorporation of teacher education *and* student informal learning. In conjunction with the junior and high school teachers, ASPIRE worked with middle and high school students. Throughout the one or two week program, the students, twenty to each teacher, worked to develop and implement projects for submission to the Alabama state EXPO competition, a specialized computational science fair. The ASPIRE program had an average of two hundred students participating each year with an emphasis on female and minority students. In addition, an overwhelming

77% of the teachers participating in the professional development program were female. The program cost two thousand one hundred dollars per teacher per week with twenty students per teacher included. Materials were provided free through the ASPIRE website.

The teacher participants of the ASPIRE program were instructed on how to teach with an emphasis on techniques which encouraged female empowerment. The teachers were instructed that female students responded positively when technology was integrated into writing and various content areas.

Cooperative learning groups were shown to foster female participation and empowerment and teachers were encouraged to give the choice of working alone, in all female or mixed gender groups for program work. At the end of the one or two week program, the teachers were able to return to their schools with the necessary training to facilitate further equitable instruction with access to free materials, tools and resources available through the official ASPIRE website. During the seven years the ASPIRE program occurred, the ASPIRE website was frequently updated and provided a host of ongoing learning and support for the professional development begun during the weeklong teacher trainings (Department of Education, 2001, p. 23).

When evaluating the effectiveness of the ASPIRE professional development program, it is interesting to note that program fascinator gave considerable attention to the student participants and their performance. "Success was measured in terms of female enrollment, attitude, project performance, and gains on content tests." Evaluating the multiple ASPIRE program sites in Alabama in conjunction with the EXPO science fair

project results gave the general impression that “the gender equity results were positive.” (Department of Education, 2001, p. 24). The success of student participants, particularly female, translated to an understood success of the teacher training on gender equitable instruction methods. While the evaluation of the professional development program resting in the student outcomes was somewhat convoluted, the initial teaching instruction and continued support online was solid. As a professional development exercise, the ASPIRE program worked to make an impact in teaching and learning incorporating gender equitable teaching strategies into a meaningful context.

Summary of Major Findings

The literature regarding gender equity in science education provides focused attention on how traditional science classrooms work to disempower female. Through the competitive nature of the traditional science classroom, the cooperative, hands-on and interdependent learning style of female students is stifled (Hammrich, 1997; Davis & Irwin, 2001; Hyde, 2007). Having minimal female representation in science curriculum and materials, female and male students come to the conclusion that science is a male subject of study and career path appropriate only to males (Sanders, 1997; Hammrich, 1997; AAUW, 1998; Halpern et al., 2007; Hill et al., 2010). In addition to these factors, the literature also underscores the importance of providing science enrichment programs for female students (Hammrich et al. 2001; SWE, 1999; AAUW, 2004; Sanders & Campbell, 2001). Equally important, the current research supports that visualization skills, while commonly

found to be less developed in females than their male counterparts, are fully capable of being enhanced through uncomplicated and brief training (Halpern et al., 2007; Hyde, 2007; Ceci & Williams, 2007; Newcombe, 2007; Lubinski & Benbow, 2007; Hines, 2007, Hill et al., 2010).

Limitations/Gaps in the Literature

While there is a good amount of literature concerning the reasons females are under represented in science careers, there is a need for more research and plans of action for solving the problem. As the classroom climate (range of competitiveness allowed, the amount of gender inclusive material available, opportunities for spatial visualization training) appears to be tantamount to the success or failure of female scientific empowerment, it seems only logical that the first step in correcting these missteps is to adjust the classroom environment.

Teachers and administrators are primarily responsible for creating gender equitable classrooms, so it is with these educators that the power of change must stem. Sanders (1997) explains that while gender equity has received considerable attention in the last three decades, gender equity in pre-service teacher education has not been similarly considered. While a national survey of teacher educators demonstrated that 72% of professors reported doing some gender equity instruction in their teacher training, it was shown that the longest period of instruction on gender equity was an average of 2

hours (AAUW, 1998). It is clear that their needs to be further research into the most effective pre-service teacher training for gender equity and science education.

Implications for Future Research

From the review of literature of this paper, there can be taken an understanding of how traditional teaching strategies and classroom environments are working to disempower females in science classrooms and how gender equity intervention programs can work to offset the inequality. In addition, understanding the teaching methods needed to empower females in science should present a foundation for future research focused on creating a gender equitable science classroom.

Educational research can be generated to better illustrate the importance of equalizing strategies such as hands-on activities, or collaborative learning, in an effort to educate more in the characteristics of a gender equitable science classroom. Further research can also be focused on methods of developing spatial visualization training into the general education of all students.

Overall Significance of the Literature

Educational equity is a right and a requirement in our society. Although the expectation is that schools provide instruction fairly to all students, the reality is far from fair. Without equity, society is deprived of its full potential. The ultimate hope of gender equitable minded teachers and parents in science education is to promote in all females what the American Association of University Women calls academics, affect and awareness in the

science field. Academics includes work to increase the skills and achievements of females in science. Affect includes work to increase interest and engagement in science, and Awareness includes work to increase knowledge of science career opportunities and gender equity issues in general (AAUW, 2004).

As seen through the gender equity intervention programs presented, informal learning, mentoring and professional development programs all work to increase the academics, affect and awareness of females in science education. For this reason, these equity interventions are crucial components in the movement towards a gender equitable science education.

In order for gender equity intervention programs to continue to do the important work of creating an equitable science education and workforce, increased awareness of the need for such gender equity intervention programs is necessary. With increased awareness will come an increase in impetus which will facilitate a much needed increase in funding which will provide for the various types of informal learning, mentoring and professional development programs crucial to creating gender equitable science education and career opportunities.

The literature reviewed in this paper presents one aspect of educational equity; scientific gender equity. By addressing the need for gender equity in science instruction, the literature calls into question the assumption of an ethical and equitable educational system. Focusing attention of the ways in which traditional teaching and learning hinders

female scientific learning, educators are able to appreciate the need for addressing the gaps in gender equity in science instruction, and beyond.

Chapter 3 Method

The methodology used for this paper is a combination of qualitative interviews and an extended literature review. Interviewing experts in the field of science and education, themes and recurrent answers will be examined in the light of the current research.

Sample and Site

The interviewees are science educators, and researchers in the field of education and science and a female scientist and medical doctor. Dr. Lily Jennings (pseudonym) is an Associate Professor in the Department of Biology at a public university in California. Dr. Jennings is also the director of a science education partnership program in her metropolitan area. Dr. Molly Warren (pseudonym) is a Trustee Professor of Psychology & Roberts Fellow at a private university in California and past-president of the American Psychological Association. Dr. Rose Chase (pseudonym) is MPhil in neuroscience and a practicing medical physician in California specializing in internal medicine.

Ethical Standards

An IRB form was completed and approved by my academic advisor and consequently approved by the Institutional Review Board for the Protection of Human Subjects at Dominican University of California, approval number 8277 . The participants were offered complete confidentiality in the reporting of their interviews.

Access and Permissions

The interview participants in this report were found by a variety of methods. During the research of current literature on the topic, I kept record of researchers and institutions, which seemed at the forefront of gender equity and science education. I sent emails to a large number of researchers and experts in the field, introducing myself and the purpose of my research and requesting that they participate in a research interview. From the individuals who responded to my initial request, I followed up and clarified that they would be willing to participate, scheduled interview times and locations when feasible and Internet communications when location made face-to-face interviews impossible. I also spoke with current female scientists within my community and requested interviews from them verbally. Prior to actual interview, I provided each participant with Consent to Interview form, which they were to complete.

Data Gathering Strategies

In preparation for the interview sessions, I formulated a number of interview questions relevant to my research topic. These questions were verbally asked of those participants who participated in face-to-face interviews and electronically asked of those participating via Internet connections. The answers to the questions were recorded by a digital voice recorder and downloading onto a computer. Extensive notes were taken in written form from the responses of each participant.

Data Analysis Approach

In order to create an appropriate analysis of the interview responses I obtained, I explained the interview responses individually and as a whole. Organizing the responses by commonalities, I was able to identify recurrent themes and points of divergence.

Chapter 4 Findings

Dr. Lily Jennings is an Associate Professor and Director at a University of California. Dr. Jennings research group through her university is interested in how people learn science and how teachers and scientists can collaborate to make science teaching and learning in classrooms work best.

Dr. Molly Warren is a Trustee Professor of Psychology & Roberts Fellow at a private university in California and extensive researcher in the field of gender equity and science education.

Dr. Rose Chase is a Board Certified medical doctor specializing in Internal Medicine in California, whom, prior to becoming a medical doctor earned her MPhil in neuroscience. Dr. Chase works to prepare future physicians while running her medical practice.

Interview with Dr. Jennings

When interviewing Dr. Jennings, I was immediately struck with the unique position in which she was set. Having been initially put off by the white male culture of the science community, Dr. Jennings found a passion, science education, and was able to advance herself within the scientific community using, what she called, her social capital of possessing a PhD in neurobiology, to further the research in science education, particularly connecting science education to traditionally unrepresented groups, women and minorities (personal communication, April 2011).

Dr. Jennings focused attention on many of the themes, which I had come in contact with during my research process. The competitive nature of the traditional science classroom, the male dominated science culture and the lack of female role models all connected to the themes found in my research.

The need for science teachers to build a classroom culture to encompass a community of collaborative learners, in which peoples' voices were validated and heard echoed the research on how to create an empowering science classroom for females. As did the need for science teachers to be explicit about the bias that has and still exists in science by providing examples of women in by historical and modern scientific endeavors.

One idea that emerged in the interview with Dr. Jennings provided an exciting opportunity for further research and discussion: Stereotype Threat. Dr. Jennings explained and discussed stereotype threat as it relates to science education and learning. Stereotype threat is the experience of anxiety in a situation where a person has the potential to confirm a negative stereotype about their social group. First discovered by social psychologist Claude Steele and his colleagues, stereotype threat has been shown to reduce the performance of individuals who belong to negatively stereotyped groups. As related to females and science education, stereotype threat provides an important tool for understanding lower female performance in science education and, ultimately, lower engagement and participation in science careers.

When asked, “Do you think gender equity in science education can be attained?” Dr. Jennings responded, “Yes, but the culture of science has to change first. There has to be less of a set of assumptions of what it means to be a “good scientist.” The people doing the science – affects the kind of knowledge that is getting produced – so there needs to be diversity in those asking the science questions to obtain a breadth of perspectives.”

Interview with Dr. Warren

Dr. Molly Warren, Trustee Professor of Psychology & Roberts Fellow at a private university in California and extensive researcher in the field of gender equity and science education provided a heartening perspective on female representation and science fields (personal communication, April 2011). From Dr. Warren’s research, she asserts “the percentage of women in all areas of science is increasing, although the increase is slow in some areas.”

As an important factor in the debate on gender equity and science education and career advancement, Dr. Warren points to women having the primary responsibility for childcare and elder care as an important aspect adversely affecting the ability of many females to pursue and advance within the science community.

Interview with Dr. Chase

Dr. Rose Chase provided both a neuroscientist and medical practitioners view of gender equity and science education. Dr. Chase pointed to the overall lack of encouragement for females to be interested in science at an early age as a major hindrance to females in science. (personal communication, June 2011). Dr. Chase explained that traditional early science education does not provide females with engaging hands-on activities, and that this lack of excitement and attachment for females leaves them vulnerable to the general societal stereotype that science is not for them.

When asked how she believes gender equity in science education will be achieved, Dr. Chase stated that females need to become interested in science at an early age by making science fun and exciting and that science education needs to present and highlight science careers which are fun. Females, Dr. Chase asserts, need to get engaged in science at a young age, before they are taught by society that science is not for them. For, if females are interested and engaged early, the societal messages that science is boring and not for females, will not hold as much weight.

Major Themes

The major themes that arose during the interview process can be separated into the disempowering aspects of the traditional science classroom and those aspects, which work to empower females in traditionally underrepresented science fields. The interviews pointed to similar reasons for the underrepresentation of women in science.

Disempowering females in science education was the stereotype, both implicit and explicit, that science is an endeavor best suited to males. Similarly, the competitive and male dominated traditional science classroom worked to disempower females in their attempts to become science literate. Finally, working against bringing female science success was the lack of science teacher training specifically to the purpose of providing science education accessibly and effectively to all.

Themes among the interviews also revolved around those aspects working to empower females in science education. Mentoring, providing real world examples of female scientists and creating connections between young females and female scientists was shown to be important for female science success and at counteracting the inherent bias in the male dominant science culture. Creating engaging early science opportunities in which females were able to do more hands on science work was also a notable sentiment throughout the interviews. A theme which was also repeatedly sighted as a part of the reason for females' underrepresentation in science fields within the interview process was the notion that as long as females have the primary responsibility for child care, those areas of science that are time intensive to the exclusion of family and outside experiences, will have less ability to attract females.

Chapter 5 Discussion /Analysis

Summary of Major Findings

The interview process provided need for science teachers to build a classroom culture to encompass a community of collaborative learners, in which peoples' voices were validated and heard echoed the research on how to create an empowering science classroom for females. Lack of female scientist role models and mentors also worked to hinder female participation and success within science education.

Comparison of Findings to Previous Research

The review of literature and the interview responses concur that the male dominated, competitive nature of the traditional science classroom works to disempower female students. There is also agreement that stereotypes of males as the only appropriate gender to pursue scientific education and careers, coupled with the lack of female scientist role models, mentors and textbook examples, fosters an implicit and explicit biased against women in the sciences.

Limitations/Gaps in the Study

While the information obtained through the interview process was elucidating, it must be acknowledged that this is a small interview based qualitative study. Using researchers and experts rather than classroom teachers has also limited the practical examples and findings, taking them largely from the research base of knowledge and personal experiences as female scientists.

Implications for Future Research

The interview process and review of literature have both provided valuable insights into the world of science education and the impediments and assistances towards gender equity. Further research naturally flows from the major themes presented in this work.

The existing research suggests that developing a spatial visualization curriculum to be implemented beginning in elementary school, closely recording the results of participants spatial visualization abilities during the implementation and demonstrating the effects of spatial visualization training on females spatial visualization task assessments would be valuable. Research attention would also be beneficial directed towards pre-service and in-service teacher education and gender equity. In addition, research could be directed at the impact of childcare and homecare on the ability of female scientists to pursue advanced science education and careers.

Overall Significance of the Study

“Equal access to science is not only a social and ethical requirement for human development, but also essential for realizing the full potential of scientific communities world-wide and for orienting scientific progress towards meeting the needs of humankind. The difficulties encountered by women, constituting over half of the world’s population, in entering, pursuing and advancing in a career in the sciences and in participating in decision-making in science and technology, should be addressed urgently” (UNESCO, 1999, para. 42).

Despite advances in female representation in a number of areas of the sciences, females continue to be substantially underrepresented in the STEM related science fields of physics, engineering, computer sciences and chemistry. In order to allow for females to fully access and advance in these fields, it is necessary that the scientific community and, society as a whole, understand how science education is failing females and how, through recognizing, researching and ultimately remediating these shortcomings, female scientists and, society as a whole, will be ameliorated.

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Appendix

A Conceptual Model for Building Spatial Visualization In Girls

Preschool:

- Puzzles
- Art
- Building with Blocks

K-5th

Elementary School:

- Building with Blocks
- Lego's
- Paper Airplane Construction
- Lincoln Logs
- Woodworking
- Simple Origami

6th-8th

Middle School:

- Mechanical Drawing
- Drafting
- Lego's
- Woodworking intermediate
- Origami

9th-12th

High School:

- Mechanical Drawings
- Drafting
- Woodworking advanced
- Advanced Origami

All grades:

- Work with hands
- Take apart and put back together
- Work with maps
- Play Chess
- Explain that these skills are improvable with practice

(Hill, 2010)