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Effective Practices in Science Instruction in an All Girls School

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Abstract

Girls can be successful in science education depending on their learning environment. This paper studies factors such as curriculum and instructional strategies that facilitate student success in learning science.

The problem is that as girls get older, they shy away from science instruction. They allow boys to monopolize the science activities, and they appear to lose interest in science. Their grades slip, and they tend not to pursue science in higher education or in their career. The purpose of this research is to explore factors that can lead to girls' success in learning science.

Teachers were interviewed at a school site and asked questions about their strategies in teaching science and their perceptions of girls in science at this school.

Chapter 1 Introduction

When I began my undergraduate studies, the university I attended had only seven graduating classes of women ahead of me. It had been an all-male institution for 161 years prior, and it was slow to incorporate the needs and rights of women. Unpredictably, I fell in love with science after a required science class my freshman year, and I decided to double major in the subject. Fast forward to the present, and passionate as I am about science, I was pleasantly surprised to discover that at the all girls' school where I teach, the girls love science. These students are excited about their science classes, and from what the teachers say, it sounds to me as if they are doing well academically. The girls who go on to our high school prove to be better prepared than students who come from other elementary and middle schools. I have overheard countless exclamations of things like, "I loved our science class today!" and "Science is really fun in X grade!" and, "Science is my favorite subject!" Letters written to an incoming class by the outgoing class often contain something like, "You will love science!" Girls want to do investigations and research in science on their own time just because they are interested.

Statement of the Problem

News reports and education articles indicate that girls and boys perform about the same in science until age nine. After that, girls' interest, achievement and enrollment in science courses decline relative to boys. Girls tend to drop out of science earlier than boys and fewer girls study science in college or enter science fields as a career. The stereotypical attitude that girls do not like science and therefore are not good at it is still pervasive.

Science, technology, engineering, and mathematics (STEM) are widely regarded as critical to the national economy. There is considerable concern about America's ability to be

competitive in the global economy. Expanding and developing the STEM workforce is a crucial issue for government, industry leaders, and educators. Although girls and women have made significant gains in education and the workforce during the past 50 years, progress has been inconsistent and certain scientific and engineering disciplines remain primarily male. Some of the largest employment increases will be in engineering and in computer-related fields, where women hold relatively few positions. By attracting and retaining more women in STEM fields, innovation, creativity and competitiveness can be maximized (American Association of University Women (AAUW), 2010).

Another important consideration is pay equity. Women still earn less than men in the overall workforce, as well as in science and engineering fields. However, women in STEM fields tend to earn more than women earn in other sectors of the workforce (AAUW, 2010).

Purpose

The purpose of this paper is to identify what makes science instruction successful for girls and how their interest can be sustained. What are the effective practices and teaching strategies that allow girls to enjoy science and feel successful?

Theoretical Rationale

Title IX of the Education Amendments was passed in 1972, and required that boys and girls have equal opportunities in all aspects of education at all schools receiving federal funds. The law states, "No person in the United States shall, on the basis of 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" (20 U.S. Code 1681). This law was intended to help women achieve equal access to all aspects of education at all levels. Forty years later, we have seen much improvement in its application to sports, but little has been done to ensure that

schools comply with Title IX and improve the climate for and representation of women in STEM fields. Critics argue that women do not face discrimination in STEM fields but rather that women are less interested than men in certain STEM fields. Title IX cannot address gender gaps in participation due to personal interest. However, it could help create a climate where men and women of similar talent who want to be scientists or engineers have equal opportunity to do so (AAUW, 2010, p.13).

Assumptions

Science in STEM includes physical, biological and agricultural science. Technology in STEM includes computer and information technology. The term *successful* is used in this paper to mean the gaining of something desired, planned or attempted. Hands-on inquiry-based learning in science makes it easy for girls to be engaged, to have fun and to experience what they are being taught.

When given the opportunity to experience and use what they have been taught, girls are able to make connections and the learning sticks. Science instruction in other settings where students simply watch videos, read, or listen to teacher lectures may be interesting, but it is not engaging.

Background and Need

American Association of University Women reviewed the research to examine how girls are performing in school since the enactment of Title IX. Girls are now performing as well as, and in some cases even better than boys on test scores in science. However, fewer girls are actually enrolling in elective science courses in high school and college and far fewer women are employed in STEM careers compared to men.

Historically, boys have outperformed girls in math and science in testing, in their grades and in the number of science courses in which they enroll. However, in the past few decades, the gap has narrowed and girls are now demonstrating comparable performance when compared to boys. Girls are earning high school credits at the same rate as boys and earning slightly higher grades. Boys continue to outscore girls on high stakes tests, but by a much smaller margin. Fewer girls take AP exams in STEM subjects, such as calculus, physics, computer science, and chemistry, and earn lower scores. (AAUW, 2010, p.4) The stereotype threat may explain why girls perform better in the classroom and weaker on high stakes tests.

Both boys and girls from historically disadvantaged groups such as African Americans and Hispanics, are less likely to have access to advanced classes in science and math in high school, which then affects their ability to select and complete STEM majors in college. Even among under-represented racial and ethnic groups, an increasing number of girls are graduating from high school well prepared in math and science and capable of pursuing STEM majors in college.

Although women are now the majority of college students, they are less likely to major in a STEM field than their male classmates. In 2006, women earned the majority of bachelor's degrees in biology (60%), 52% in chemistry, and 45% in math. A much smaller proportion of women earned degrees in physics (20%), engineering (19%) and computer science (20%) (AAUW, 2010, p.9). Many girls and women report that they are not interested in science and engineering. From early adolescence, girls express less interest in math or science careers than boys do (AAUW, 2010, p.21).

Chapter 2 Review of the Literature

Introduction

This section addresses some of the previously published material relevant to girls' success in science. Some of the key points addressed here are self confidence, parental influence, stereotype bias, interest in the subject, and strategies to promote girls' interest and success.

In the review there was limited data that considered gender, race and ethnicity simultaneously. Most of the literature discussed girls in science and described girls alone or girls in comparison to boys. Since race and ethnicity were rarely mentioned, it is assumed that the researchers were referring to Caucasian boys and girls. This is a limitation in the research omitting how girls of different races and ethnicities perform in co-ed or all-girls settings in the area of science.

Historical Context

Twenty years after Title IX was passed, differences were still seen between girls and boys. Girls did not receive equitable amounts of teacher attention, they did not see themselves represented in study materials, and they were not expected to pursue careers in math or science. Gender bias was obvious. Teaching methods that fostered competition were standard, despite research that demonstrated that girls and many boys actually learn better when they are engaged in projects and cooperative group activities. Boys came to class with more out-of-school experience in science than girls did and teachers allowed boys to perform scientific demonstrations more often than girls. Girls viewed math and science as something that boys do, and by middle school, many girls had experienced a drop in their self-confidence followed by a drop in their achievement. The gender gap in science appeared to be increasing. Even girls who were highly

competent in science were much less likely to pursue science or technological careers than their male peers.

Review of the Previous Research

Self Confidence

Girls and boys begin first grade with comparable skills and ambitions. By the time they finish high school, most girls have a disproportionate loss of confidence in their academic abilities. Concerned about the deflation of girls' self-esteem, the American Association of University Women (AAUW) commissioned an extensive national study in 1990. The researchers examined comparative self-esteem levels, career aspirations, educational experiences, and math/science interests of American girls and boys of ages 9-15.

AAUW's 1991 report, *Shortchanging Girls, Shortchanging America*, determined that girls aged eight and nine are confident and assertive. Sixty percent of these girls said they are "happy the way I am." Of the boys surveyed, 67% felt the same. Over the next eight years, 46% of boys retained their high self-esteem. Girls showed a dramatically greater loss and their self-esteem fell to only 29% feeling "happy the way I am." The gap between boys and girls had widened from 7% to 17% after adolescence. According to this report, the percent of girls who like science in elementary school was 75% and dropped to 63% in high school. The percent of boys who like science in elementary school was 82% and dropped to 75% in high school. Enjoyment of science may be related to career choice. By high school, 52% of boys think they would enjoy a career in science, but only 29% of girls feel similarly. The AAUW concluded that students who like science have more self-esteem, feel better about schoolwork and grades and feel better about family relationships. This is important for girls as this greater sense of self-

confidence allows them to feel better about their appearance and worry less about others liking them.

Bhanot and Jovanovic (2009) reported that recent national assessments show that girls no longer lag behind boys in science and are in fact, close to equal in their performance. Despite these huge gains, girls continue to report less self-confidence than boys in their math and science performance and less enjoyment of the subject. Previous research has shown that parent evaluations of their children's abilities strongly influence their child's beliefs in their achievement. Bhanot and Jovanovic (2009) learned that parents of boys spend more time on science-related activities outside of school than did girls' parents. Their research found that parents of boys believed their boy liked science more than did parents of girls. However, girls valued science more than their parents thought. It was also revealed that mothers of boys provided more encouragement if her son was a low achiever than if he was a high achiever. In contrast, mothers of girls provided less encouragement if their daughter was a low achiever and more if she was a high achiever. Mothers tended to get involved only if their daughter was doing well. This study suggested that children's attitudes about science are related to the interactions they have with their parents, particularly the mothers.

Goetz (2007) provides an overview on how girls develop differently from boys and how their learning styles are different.

> A great deal of research indicates that not all girls achieve at the same level as boys in science and that they do not continue in these content areas into high school, or beyond in college and careers. Several studies confirm that as girls move through the educational system, their achievement and enrollment in science courses declines relative to those of boys. At age nine, girls and boys

> perform about the same on science assessments, except in the physical sciences. By around the age of thirteen, an achievement gap appears in most science content areas, and by age seventeen, girl achieve at a notably lower level than boys, particularly in physics. It is important to note that by age eleven, boys show a more positive view of science on interest surveys than girls do. (p.1)

Goetz (2007) also discovered that "Girls tend to drop out of the science 'pipeline' sooner than boys. At the secondary level, girls select biology, but fewer girls, even high-achieving ones, opt for chemistry or physics compared to boys" (p.1). Of the students who take chemistry, 34% are girls and 66% are boys; for physics it is 22% girls and 78% boys (Goetz, 2007). The author believes this is due to both social pressures and science skills. Brain research indicates that girls are more successful in the verbal and communication area than boys.

At the high school level, many girls begin to spiral downward in science enrollment, achievement, and interest in physical sciences when science courses become optional. "In a typical U.S. high school, boys outnumber girls by more than two to one in most physical science courses, and by three to one in physics" (Goetz, 2007, p.5). Girls' early science avoidance has resulted in lower salaries for women and demand for women in higher-paying, science-related fields. Educational psychologists believe there are fundamental differences between the factors motivating girls and those motivating boys. Researchers have found that girls want to please adults and boys tend to be more motivated by material that interests them (Goetz, 2007). Educators must encourage girls' growth of self-confidence and the development of their problem-solving skills in order to help girls succeed more in science. Some strategies that can build girls' confidence and problem-solving skills needed in the study of science are to include

science activities that are hands-on, involve group work, are relevant, and include female role models in science (Goetz, 2007).

Vanmali and Abell (2009) reviewed research conducted in 2000, that claimed that boys and girls are both positive about science, but girls prefer life science and social science to physical science. Girls view their science abilities differently from boys. Girls perceive themselves as less competent in science. Jones, Howe & Rua conducted a study (as cited in Vanmali and Abell, 2009) which showed that boys in grades 4-6 perceived themselves as more competent than girls even though claims by both boys and girls were that they liked science.

Parents' perceptions were surprising. Parents felt that science was more important for boys, held higher expectations for boys, and felt that careers in science were male-dominated. Jovanovic and Steinbach King's study (as cited in Vanmali and Abell, 2009) which examined students in grades 5-8, concluded that only girls showed a decrease in science ability perceptions over the school year. The researchers hypothesized that girls and boys might have different experiences in the classroom and that the girls' views of themselves might be influenced by parental attitudes. Others have found that boys and girls participate equally in hands-on activities, but boys tend to manipulate the equipment more. Girls tended to do exactly as the teacher instructed and boys tended to participate in more exploration.

Stereotype Bias

The AAUW 2010 report *Why So Few?* highlights the effects of societal beliefs as well as the learning environment on girls' achievements and interest in science and math. One finding shows that when teachers and parents tell girls that their intelligence can expand with experience and learning, girls do better on math tests and are more likely to say they want to continue to study math in the future. This shows that teachers' and parents' confidence in girls' potential for

intellectual growth in science actually improves outcomes. This is true for all students, but it is particularly helpful for girls in math and science since negative stereotypes continue to persist about girls' abilities (AAUW, 2010, p. xiv).

The stereotype that boys do better than girls in science still appears to affect girls today. Research shows that negative stereotypes about girls' abilities in science do lower girls' test performance. It also shows that stereotypes can lower girls' aspirations for science and engineering careers over time. Teachers and parents can encourage girls' achievement in science by creating a growth mindset environment. When test administrators tell students that boys and girls are equally capable, the difference in test performance essentially disappears (AAUW, 2010, p. xv).

Girls tend to hold themselves to a high standard and believe that they have to be exceptional in order to succeed in what they consider "male" fields. They assess themselves as low in ability, even if they have the same grades and scores as boys. Few girls aspire to STEM careers. Parents and teachers can encourage girls to assess their skills more accurately and can emphasize that girls and boys achieve equally well.

Beginning in middle school and increasing in high school and college, girls report less self-confidence than boys in their math and science ability. Carol Dweck (as cited in AAUW, 2010) has extensively researched the effects of presenting a growth mind set to students versus a fixed mindset. Her theory is that with a growth mindset, students understand that often important discoveries come with a struggle and great effort. It is important that students understand they can enjoy this effort. Dweck's research showed that girls who were in classrooms that communicated a fixed mindset and negative stereotypes felt that they just had to get through the semester and had no desire to continue. These girls believed that they could not

do well and lost interest. She noticed that with a growth mindset students could maintain a spark of interest.

> When girls and women believe they have a fixed amount of intelligence, they are more likely to believe the stereotype, lose confidence, and disengage from STEM as a potential career when they encounter difficulties in course work. The messages we send girls about the nature of intelligence matter. Eradicating stereotypes is a worthwhile but long-term goal. In the meantime, communicating a growth mindset is a step educators, parents, and anyone else who has contact with girls can take to reduce the effect of stereotypes and increase girls' and women's representation in STEM areas. (AAUW, 2010, p. 35)

Cherney and Campbell (2011) reported that previous studies have shown that girls in single-sex schools have higher levels of self-esteem than girls in co-ed schools. It was hypothesized that if students were confident in the subject matter, then they would be more likely to enroll in optional math and science courses. Therefore, they predicted that girls at single-sex schools would be more likely to pursue STEM careers. This study has many limitations, particularly with the homogenous and white sample group. Women remain a minority in STEM fields, although many women do go into the health and life sciences where people are a key focus. Boys and men, as a group, tend to prefer to work with things, and higher numbers of men work in STEM fields. The authors suggest that in addition to providing opportunities for girls and young women to succeed in math and science, it is important to demonstrate to girls that STEM fields involve communal goals of helping other people (Cherney and Campbell, 2011).

AAUW (2010) reports that even girls and women who excel in math do not pursue STEM fields. Instead, these women are more likely to major in the humanities, life sciences and

social sciences. There is documented evidence showing that women place more value in doing work that contributes to society than men do. Because most people do not view STEM occupations as directly benefiting society, these careers often do not appeal to women who value making a social contribution. There are ways to increase girls' interest in STEM areas and ways to emphasize the people-oriented and socially beneficial aspects. AAUW also believes it is important for educators to make students aware of how scientists and engineers contribute to society.

Negative stereotypes about girls' and women's abilities in math and science persist despite their considerable gains in these areas during the last few decades. Two stereotypes are prevalent: 1) girls are not as good as boys in math, and 2) scientific work is better suited to boys and men. Research has shown that as early as elementary school, children are aware of these stereotypes and can express stereotypical beliefs about which science courses are more suitable for boys than girls (AAUW, 2010, p.38).

There is much experimental research that has found that negative stereotypes affect women's and girls' performance and aspirations in math and science through a phenomenon called "stereotype threat." Even female students who think that they are good at math and being good in math is important to them—are susceptible to these effects (AAUW, 2010). This stereotype threat may help explain the discrepancy between female students' higher grades in math and science and their lower performance on high-stakes tests in these subjects, such as the SAT-math and AP calculus exam. Additionally, stereotype threat may also help explain why fewer girls than boys express interest in careers in STEM fields. Girls may attempt to reduce the likelihood that they will be judged through the lens of negative stereotypes by saying they are not interested and by avoiding these fields.

The AAUW reports that over 300 studies have been published to support these stereotype threat findings. This threat is present in many testing environments. It can easily be induced simply by asking students to indicate their gender before beginning a test or even by having a larger number of males in the testing room. Repeated or long-term threat can undermine a student's aspirations. The student then "disidentifies" in order to avoid the risk of being judged by the stereotype. Some students may even decide to avoid math and science altogether. Researchers have shown that this stereotype threat can be alleviated by teaching students about it and reassuring them that tests are fair and exposing them to female role models in math and science. Carol Dweck recommends the approach of encouraging students to think of their abilities as expandable and that struggles are a normal part of the learning process, not a sign of low ability. These approaches can help raise test scores of minority students and girls (AAUW, 2010, p. 41).

The purpose of the Weisgram and Bigler (2007) study was to learn what role "knowledge of discrimination" plays in shaping female's occupational judgments and aspirations. The researchers used an experimental design in which adolescent girls attending a program aimed at increasing females' interest in science were randomly assigned to one of two conditions: 1) a standard intervention, consisting of four sessions led by female scientists, or 2) a modified intervention, consisting of three sessions led by female scientists and one session that provided information about gender discrimination in scientific fields. They examined the effect of learning about gender discrimination on girls' task-specific attitudes toward science (e.g., self-efficacy, utility value, egalitarianism) and interest in pursuing careers in science in a pre–post design.

Participants were 158 middle-school-aged girls (79 European American, 38 Hispanic, 10 African American, 6 Asian American, 6 other ethnic origin, and 19 unreported) who elected to

attend an intervention program aimed at increasing girls' interest in science. Girls ranged in age from 11 to 14 years. Participants attended a one-day conference aimed at increasing girls' interest in science. As part of the conference programming, all girls attended four sessions led by female scientists in which they heard presentations about the presenters' careers and participated in hands-on activities. Presenters included 24 female scientists recruited from local businesses, colleges, and universities. The majority of these presenters made multiple presentations. Girls were randomly assigned to treatment conditions and intervention sessions. Girls in the two conditions were exposed to approximately the same pool of presenters with the exception of the session on discrimination. Prior to and after the sessions, participants completed measures assessing perceptions of gender discrimination, task-specific attitudes toward science, and interest in science.

Sixty-two girls in the discrimination condition attended three one-hour sessions led by female scientists in which they heard presentations about the presenters' careers and participated in hands-on science activities. They also answered a short survey about their reactions to information about gender discrimination. In addition, participants attended a one-hour session about common types of gender discrimination in scientific fields led by psychology graduate students who were trained in the manipulation and memorized a scripted lesson. Specifically, the presentation contained a definition of gender discrimination, examples of the ways in which gender discrimination affects female scientists today, and biographies of four notable female scientists who faced gender discrimination during their careers.

Ninety-six participants made up the standard condition and attended four one-hour sessions led by female scientists in which they heard presentations about the presenters' careers

and participated in hands-on science activities. They did not participate in a session on gender discrimination.

All participants were asked to complete a measure of their interest in science by indicating their interest in 25 scientific tasks. Research results indicated that girls in the discrimination (but not standard) condition showed increases in self-efficacy within science. The second outcome was utility value. Results indicated that girls in the discrimination (but not standard) condition showed increases in their belief that science is a worthwhile subject of study. Highlighting the accomplishments of famous and important women in science may have emphasized the important and worthwhile discoveries of scientists in the field. However, exposure to information about women who have struggled to become scientists and contributed to the field despite being the victims of gender discrimination could have served to increase girls' own belief that science is an important and worthwhile area of study (Weisgram and Bigler, 2007).

The researchers predicted that learning about discrimination would increase girls' interest in science, partly by encouraging them to enter the field to fight discrimination. The data indicated that there was no effect of condition on girls' interest in science, nor was there a main effect of time, indicating that girls' interest in science was not affected by participation in the EYH program. "Unfortunately, this finding is consistent with those of other interventions studies and together, these results suggest that adolescent girls' interest in science is difficult to modify with short-term programs such as the one used here" (Mason and Kahle as cited in Weisgram and Bigler, 2007, p. 267).

There were several limitations in this study: 1) It took place within a program designed to increase girls' interest in science. The girls in this study elected to participate in an intervention

program aimed at increasing girls' interest in science, so one can speculate they probably showed higher levels of interest than other girls. 2) Girls in the discrimination condition learned about discrimination and were simultaneously exposed to models of female scientists which surely produced a different outcome than if they were not. 3) There was an absence of boys. 4) Only the immediate consequences of the standard and discrimination lessons on girls' attitudes and interests were assessed. It is possible that the positive effects of learning about gender discrimination on girls' self-efficacy and the valuing of science diminish—or strengthen—over time. Future research should examine the long-term effects of lessons concerning gender discrimination on girls' and boys' task-specific attitudes toward science, interest in science, enrollment in science courses, and employment in science fields. 5) Only four presenters were able to be trained to lead the discrimination sessions, so the standard condition and discrimination condition groups were imbalanced.

This research influences my study because it brings to light the idea that if discrimination in relation to females in the field of science is discussed and explained to young girls, it may influence their interest in and attitudes toward science. These may or may not be different than they would have been if discrimination had not been highlighted.

West-Olatunji, Pringle, Adams, Baratelli, Goodman, and Maxis (2008) explored the intersectionality of African American academic achievement, female students in math and science education, and schools with high poverty levels, through the framework of positionality. The researchers believed that the African American girls' constructed cultural, gender, and class identities dictated their positionalities in relation to math and science, and were affected by the perceptions, expectations, and support behaviors of parents, teachers and counselors. The purpose of the research was to investigate African American girls' positionalities in relation to

their math and science interest and achievement within a high poverty school.

The researchers used qualitative research in the form of a focus group with students and one-on-one interviews with adults. Participants were recruited from a local elementary school where the researchers had a relationship. This school has two programs: a magnet (advanced) program and a non-magnet program. Five African American girls in the first semester of 6th grade were recruited from the non-magnet program, plus one mother of a participant, an African American female principal, an African American female math and science teacher, a white female school counselor and a white female science teacher.

Researchers administered informed consent forms to the parents of the participating girls. They were then scheduled for a 90-minute focus group held at school. Each of the adult participants was interviewed separately in a semi-structured 50-minute interview held at school. A white female doctoral student in counselor education conducted the focus group and interviews.

The researchers reviewed literature on African American girls and math and science learning. They found similarities between the literature and their own findings. The researchers asked the question, "How do African American middle school girls position themselves as math and science learners in relation to their cultural, gendered, and class identities?" (West-Olatunji et al., 2008, p. 221). The results suggest that the participants see themselves positioned outside the math and science excellence in the way that resources are allocated to low-income and culturally diverse students at their school. Researchers also asked this same question to the teachers, parents and administrators. In this study, the parents and administrators seemed unaware of the ways they could provide opportunities for the participants to advance their math and science competence (West-Olatunji et al., 2008).

The researchers identified four themes: inspired knowledge, positioning, pedagogy, and encouragement. The first theme of inspired knowledge summarized the girls' ability to articulate their positive attitudes about math and science up through fifth grade, but they were not able to sustain their interest level.

The theme of positioning was used to describe how the girls spoke to compare the difference between the magnet and non-magnet programs. They felt unsupported in their math and science education compared to their perception of the magnet program. They also believed that their home environment and school environment were both very different from those in the magnet program.

The theme of pedagogy contained what the school counselor said about how if the subjects were fun and not too much work then students enjoyed them. The teaching methods need to be creative and engaging. The parent in the group believed that the students needed support and encouragement from the teachers.

The students in the focus group did not state that adult support or encouragement were important, but when comparing themselves to students in the magnet group, they did express that those students' parents and teachers were very involved and encouraging. The principal interviewed believed that she tried to be motivating to the students. The teachers thought that they were motivating but also that parents played a more important role in motivating and encouraging their children (West-Olatunji et al., 2008).

Afterwards, the researchers were interested in how other middle school African American girls might perceive the results from the girls who were interviewed. They also wanted to know how these other girls might position themselves in relation to the research participants. They put together four groups each of four eighth grade girls who were similar to the research participants.

Each group was from a different school. Overall they shared similar experiences and the common feedback was the lack of identification with math and science.

The researchers concluded that some students do not feel that their math and science teachers incorporate their experiences into the lessons and were therefore boring. Teachers who did use cultural artifacts and student experiences to make connections in the classroom had more engagement from the students. They also concluded that students had an awareness of how more support and privileges were provided to students in the magnet program. The researchers felt it was important for educators to facilitate students' ability to recognize their own positionality, understand this dynamic, and be able to challenge it. The conclusions seem to relate to the original research question but perhaps do not fully answer the question and more research is needed (West-Olatunji et al., 2008).

One of the strengths of this research is that they had located a school which contained both a magnet and non-magnet program to compare. I see several limitations. A very small sample size of students and adults was used with just one short session with each. We do not know what part of the country this school is in or how well either the magnet or non-magnet program performs.

This article was helpful in informing my study because I can now consider how the culture of African American girls may affect their learning. Educators need to ensure that they are being culturally responsive to the specific needs of the students in their classroom in order to gain girls' engagement in math and science classes.

Successful Strategies for Girls

AAUW (1992) documents that in order for America to have a first class workforce and rank higher in the world in math and science, a first-class education must be provided to girls.

Schools continue to exhibit gender bias. There is concern about teaching methods and how they meet the individual learning styles of girls and boys. Competitive learning is still favored in many classrooms and is a style that often puts girls at a disadvantage. Many children and most girls learn better in cooperative settings. The AAUW is committed to working with educators, parents and activists to make changes in the classroom, to improve teaching strategies and to include more hands-on science, and to enhance girls' self-esteem.

Heilbronner (2009) reported that in 2004, women earned 58% of all bachelor's degrees and 59% of all master's degrees in the U.S. In some STEM fields women are highly represented, such as biology 62% and psychology 78%. However, in other fields such as physics, computer technology, engineering and math, women are underrepresented. In order to promote and encourage talented girls in science, educators must use new strategies to motivate girls in science. Some effective strategies for teachers suggested in the report are:

* read biographies about scientists, particularly women, who have continued to develop their abilities
* provide prescriptive, informational feedback
* expose girls to female role models who have succeeded in the field of science
* create a classroom environment that sparks initial curiosity and fosters long-term interest
* get to know your female students and their interests
* encourage risk-taking by providing some ungraded assignments
* teach appropriate goal-setting
* identify students' strengths, interests and learning styles
* broaden instructional strategies to include a range of non-threatening response modes
* assign cooperative group roles

* use think-pair-share activities

* encourage participation in classroom activities

* start a girls' science group before/after school

* provide equal access to technology

* provide spatial skills training (Heilbronner, 2009)

The AAUW Educational Foundation has documented some innovative teaching techniques and strategies to raise girls' interest in science. The report recommends that schools:

* reinforce girls' individuality in single-sex classes for science and boost lagging self perceptions

* encourage girls' involvement through cooperative learning groups

* eliminate competitive classroom practices

* provide girls with mentors and role models

* provide hands-on experiences

* empower girls to achieve goals by working with community groups and businesses

(Brown University Child & Adolescent Behavior Letter, 1995. p.1).

Vanmali and Abell (2009) suggest that teachers need to do more to promote gender equity in the classroom. Teachers could consider these strategies:

* celebrate successes of boys and girls by displaying learning products

* help girls relate to all sciences by linking their experiences and ideas with scientific ideas

* show current examples of science in the news

* encourage girls to become competent with the equipment by making same sex groups and rotating tasks

* provide opportunities for collaboration on projects

* promote science-related careers

Interview with an Expert

I interviewed Vania Coelho, Ph.D. Associate Professor, Department of Natural Sciences and Mathematics at Dominican University of California (personal communication, December 18, 2012) to understand her perspective on where girls stand in science in general and what she sees in particular at the college level. Dr. Coelho has only ever taught in co-ed environments and does not see much difference in teaching to boys versus girls. What she does see in her non-science major science students is a difference in the commitment to learning. This varies equally, not by gender. For many of these students it depends on what kind of science background they've had previously. If they had a weak background or teachers, they may think they're "bad at science" and it becomes a block for them. They believe they cannot learn. Dr. Coelho also has discovered that at the college level, many students lack basic study skills and do not know how to study for science. This can be a steep learning curve and can be very discouraging. She has found that she actually needs to teach study skills to her struggling students.

Dr. Coelho believes that people go into a field if they think they are good at it. Some give up because they are not good. Some give up because they do not have inspiring role models or teachers who are interested. She believes children should always be encouraged and their investigative spirit should be nurtured. Dr. Coelho also believes that the method used to teach something can influence students' feelings on the subject. She has worked with an art teacher before to incorporate science into art in order to get kids interested. She also emphasizes the importance of integrating science into other subjects – a layered learning approach. She has used a school organic garden as a tool for learning math, art and history in addition to science.

Dr. Coelho has experienced discomfort being the only female scientist at conferences. Men have been so surprised to see one woman present and have treated her like a curiosity. She thinks the theory of women wanting to care for and be with people so therefore science is too isolated (with the exception of biology) is not really valid. She thinks it really comes down to more of a personality issue, not a gender issue. If one is going into science as a profession, one needs to go where the job is and be committed. Many times women give up their profession in order to have a family and they allow the man to be the provider.

In order to promote girls' interest and achievement in science, Dr. Coelho believes there need to be good science teachers who also teach good study techniques. Good teachers need to love what they are teaching, be enthusiastic, and must not spread stereotypes. It is important to empower girls to know they have a choice in life and should not give up on their dreams. Girls can achieve anything they want. She finds it amazing that so many parents never say anything about this to their daughters, so teachers must say it and be encouraging. It is important to let girls know that they can do what they want. Give them pep talks about tests and help them deal with stress, planning and study skills. Students should be empowered on every level. Many of her college students go on to medical school. She thinks the reality of something like medical school must be presented and put into perspective. She recommends that students shadow a medical graduate student to uncover what it is really like and to understand the competition. Dr. Coelho also believes that teachers should be rewarded for providing more creative learning opportunities. Teachers need an incentive to take the extra steps or she believes most will not.

Summary

Girls are capable of doing as well or better than boys do in science, but they need encouragement to pursue science. The setting should be neutral so boys and girls are supported and girls do not

feel at a disadvantage. Effective study techniques need to be taught for success. Opportunities for hands-on experiences should be provided so that students can make learning connections.

Role models of women in science are particularly important and beneficial to girls.

Chapter 3 Method

Research Method

This is a non-experimental design study using interviews to gather qualitative information from professionals in education.

Sample and Site

I conducted one-on-one interviews with teachers in grades 2-4 who teach science and with science teachers in grades 5-12 at the school where I am employed. I also attended a STEM summit on March 20, 2013, hosted by the school for girls in grades 7-12. Eight women in STEM fields were participants.

Teachers were selected to participate in an individual interview to discuss their views of teaching strategies and practices that are effective in engaging girls in science. All teachers interviewed are women, with the exception of one male high school science teacher. Interviews included three second grade teachers (confidential, personal communication, February 12th, 13th and 26th, 2013) who have worked at the school for five to eight years. Two are young and have not taught at other schools. One third grade teacher (confidential, personal communication, February 27, 2013) was interviewed who has worked at the school for four years. Two fourth grade teachers (confidential, personal communication, February 8th and 23rd, 2013) who have worked at the school for three and six years were interviewed. The one fifth grade science teacher (confidential, personal communication, February 5, 2013) who is quite experienced and has been at the school for 22 years was interviewed. The one 7th/8th grade science teacher (confidential, personal communication, February 12, 2013) who has been at the school for seven years and teaches 7th Grade Biology and 8th Grade Chemistry and Physics was interviewed. She is young and has not worked at any other schools.

At the high school, interviews included the male teacher (confidential, personal communication, February 15, 2013) who has been there for 23 years and teaches 9th Grade Honors Biology, AP Biology, Physiology, and Conservation Biology of the Redwoods. He is now getting his master's in digital technology. He believes he would be doing a disservice to his students if he were to continue to teach the same way he always has. Things have changed dramatically with technology and he feels it is critical for him to be current in order to provide the best for his students. Another high school teacher (confidential, personal communication, February 4, 2013) who has been there for eleven years and teaches 10th Grade Chemistry and Honors Chemistry was interviewed. The teacher (confidential, personal communication, February 26, 2013) who teaches 9th Grade Biology, Marine Biology, and AP Environmental Science who has taught there for 13 years was also interviewed.

Most of the teachers have participated in science specific professional development. Several of them have been participants in the two-year Teacher Institute on Science and Sustainability at the California Academy of Sciences. The high school teachers all majored in science and their single subject credential in science. Only two teachers do not have a master's degree. One high school teacher, a male who teaches AP Chemistry and Physics, was unable to be interviewed. At the elementary school, the 6th grade science teacher was unable to be interviewed.

Access and Permissions

I work with these teachers at an all-girls independent Kindergarten-8th grade school and its sister high school on the same campus. Each teacher read and signed the *Dominican Consent to be a Research Subject* form.

Ethical Standards

This paper adheres to the ethical standards for the treatment of human subjects in research as proposed by the American Psychological Association (2010). Additionally, this proposal was reviewed by the Dominican University of California Institutional Review Board for the Protection of Human Subjects, approved, and assigned Number 10065.

Data Gathering Strategies

Data was gathered by personal interviews. Questions posed to teachers were:

1. Please describe your education, training and background in the area of teaching science.
2. Prior to teaching all girls, have you taught science in a coed environment?
3. If so, what are some differences you have noticed in girls' interest and achievement?
4. How would you describe your teaching method as it pertains to science?
5. What practices have you implemented specifically to engage girls in your science classes?
    a. Are these practices different from those you may use in other subjects?
    b. Do you feel they are effective and what evidence do you have?
6. What do you see as the necessary next steps in the area of promoting girls' interest in science?

Data Analysis Approach

Responses were reviewed to detect similarities in teaching strategies among teachers and similarities in ideas on how to promote girls' interest in science. Common themes were

compared to those presented by participants in the STEM Summit and in the review of the literature.

Chapter 4 Findings

Description of Site, Individuals, Data

I conducted one-on-one interviews with teachers at the school site. The school is an independent all-girls Kindergarten-8th grade school and sister high school next door, located in northern California. Funding comes from tuition, fundraising within the parent community, and generous alumni support. The school serves families in multiple counties. Approximately 20% of students receive financial assistance. The high school offers a rigorous college preparatory curriculum, and 100% of graduates attend college. Teachers receive competitive compensation and exceptional professional development opportunities.

Overall Findings, Themes

Overall, it seems that all teachers interviewed would agree that the majority of their students like learning about science. At the high school, the students who are in the advanced placement (AP) and honors classes are more serious about science than those girls in the general classes. Those that do well in math have an easier time.

Teachers at all levels reflected that the girls feel comfortable in the classroom working cooperatively in small groups and asking questions. All teachers talked about the importance of keeping the classroom environment comfortable so that everyone can relax, feel confident and be comfortable participating.

In the absence of boys, the girls are comfortable and confident. Teachers compared this environment to their experiences in coed classrooms where the boys dominated in terms of the amount of attention needed either for behavior management, instruction or desire to share. Boys tended to rush into things and take over, compared to the girls who were more patient and

wanted to plan things out. One high school teacher, who teaches at a local college as well, pointed out that the boys are more technical and like the detail. Girls tend to like the big picture and want to know how what they are studying fits in and how it connects to their lives. Girls learn a lot by talking through things with their peers.

Girls in the high school come from 19 different schools, but the ones who are from the sister all-girls school are most comfortable asking questions. The high school chemistry teacher loves that chemistry is a challenge for students. She has high and low achievers, but with just 8-15 girls in a class, she can focus on all of them and all are engaged.

A common theme with all teachers interviewed was with non-fiction text. This is always more difficult, and as the girls get older, it can pose more of a challenge. The second and third grade teachers usually begin each science lesson with a read aloud. Sometimes they may explicitly discuss how to read this type of non-fiction text. At the higher grades, students are expected to be able to read the science literature on their own. For many girls who are not strong readers, this task is too hard for them in 7th and 8th grade. The 7th and 8th grade teacher uses some textbooks, but also includes parallel literature. She wants them to take their strength of reading into science and believes all teachers need to be explicit with word study to contribute to the girls' success.

In the second and third grades, teachers feel the goal of science is to build interest and enthusiasm for science and to leave the grade loving science. The girls do seem to enjoy science and can talk about what they've learned, but teachers do not hear them talking about any interest in pursuing science yet. Every teacher reported that the girls in their classrooms like science. Beginning in seventh grade, some girls appear to enjoy science more than others. These girls may not necessarily be good at science, but they try harder. This is similar to what Dr. Coelho

said she has noticed at the college level. From an early age girls are introduced to the scientific process. They begin to keep a simple science journal in second grade and learn to set up an experiment, learn what are true facts, make predictions, list materials, make and write observations and compare outcomes to predictions. This science journal is a great way for teachers and parents to see how much the students understand. The girls can be proud of their work over time. In fourth grade they have a "gallery tour" at the end of a unit where the girls pick a lesson they are proud to show others in their science journal. In seventh and eighth grade they are taught how to write a lab report with a proper hypotheses, observation and conclusion. They are given lots of modeling and in-class writing practice. The teacher stresses the importance of providing background knowledge before conducting any experiment. Otherwise, she feels there is no value in the experiment other than entertainment.

Many teachers interviewed commented on the importance of teachers who teach science having a strong science background, showing interest and enthusiasm for the subject, and visibly exploring and engaging in science. Teachers who lack interest and confidence in their science ability are transparent to students. This can have a long-term and lasting effect on students' interest and success in science. All experienced teachers interviewed, including Dr. Coelho, have seen this occur. A few also pointed out that the student support system and tutors often do not have the content background to assist with science. One teacher suggested that the school should offer more professional development in specific science areas and teaching strategies for science. One high school teacher believes that sixth grade is the critical turning point for girls in science and when they must have an excellent teacher. This is also when math begins to play a more important role in science. Girls need to be motivated in math – it is a huge factor in future science success.

Probably the most notable point repeated from every teacher interviewed is the importance of providing hands-on activities, observations, exploration and project-based learning. This was consistent in every grade and in every class. This commitment combined with teachers' firm belief that content must be applicable and relevant to students is crucial to their success. First of all it makes science fun. Girls love the hands-on aspect of science. They learn to make observations, ask questions, and draw conclusions. In fifth grade they begin to experiment with variables. The fifth grade classroom also has animals for the girls to care for and feed. They enjoy caring for them and no one is "grossed out" by the creatures as the teacher has seen girls behave in her co-ed classrooms.

In high school the lab portion of science class is the most important piece. The students look at the lab results and their methodology. One teacher even breaks longer labs into two or three mini labs in order to have more hands-on sessions. She knows that after a 90-minute block, her students are still bright and peppy when they leave if they have a short lecture, a lab period and are able to keep moving in the classroom. She has also noticed that the quality of her students' notes and the quality of her students' tests are better since she has implemented this. Another teacher provides most of his lectures on YouTube and this is viewed at home. When the girls come to class they ask questions, he proposes challenges and they spend most of the period working in the lab. His students love this format. He also engages and motivates his students by having girls produce one to two-minute instructional videos using Educreation on the iPad to demonstrate specific instructions. This teacher also knows that there are multiple ways to creatively share one's understanding. He tries to find ways to relate science to art. His Redwoods class is producing an iBook. The chemistry teacher's strategy is to allow no longer than 20 minutes for her lectures to match the 20-minute maximum attention span of her students.

After the lecture they have practice time which involves lots of math and figuring out the calculations. After this practice, they move on to the lab. She is able to set up a lab for most every class. Later in the year, she presents a CSI unit involving mild teenage interest topics to keep them engaged and to relate chemistry to their lives. She also modifies the organic unit to incorporate nutrition with calories and minerals.

Teachers in the lower grades bring in lots of materials for the girls to experience to help them make connections. They are given the opportunity to build on what they know, ask lots of questions, experience trial and error, and come to their own conclusions. Teachers show how the subject is useful and help them link this new knowledge to prior knowledge. One teacher makes lots of KWL charts. Her students love this and she goes back once a week to answer their questions. Teachers in the lower grades feel that to keep the girls interested they should not use textbooks. It is all about the hands-on experiences.

Recently the school hosted a STEM summit for students in grades 7-12. Eight female participants were invited to the panel to discuss their careers in STEM fields and their experiences. Students were invited to ask questions of the panelists in various breakout sessions. Several girls posed questions about the ease or difficulty in managing a marriage and raising children while pursuing a career in a STEM field. This is a topic Dr. Coelho discussed as being a major stumbling block for women. The panelists all answered honestly that it is possible, but takes a lot of work and effort. The students also asked questions about the ease of finding good jobs upon college graduation. These women all responded enthusiastically that there were definitely lots of good jobs for women in STEM, and they had all had offers to choose from. One woman even reported that there was a shortage of women in her field and as long as one was qualified, there would definitely be jobs. Questions about jobs and well-paying careers are

commonly asked of the high school science teachers from their junior and senior year students. These girls are already contemplating potential majors in college and where those could lead them on their future career path.

In answer to the question about how to promote girls' interest in science, many teachers interviewed suggested introducing positive role models to the girls. They wanted women in STEM fields to come speak to their class or to the school to get girls excited about the field of science. These guests should be women who are successful or who are making a difference in the world. This question was asked of the teachers prior to our STEM summit, which did exactly that. One thing the high school already does is host a college panel the first Monday in January each year. College freshman come back to share with juniors and seniors on a wide range of topics from college. One high school teacher commented that she has noticed a growth in science majors, but she would like to see more girls come back to talk about science. Another high school teacher felt strongly that the school should offer an engineering class. This teacher also would like the high school girls to be more involved with the elementary school girls. He thinks that if they worked together more, more girls would be interested in science. He has already set up one program where the third grade girls are invited to shadow his high school girls during their cow's eye dissection labs. This is a memorable day for the young girls and definitely excites them about high school biology. It also provides an opportunity for the older girls to share their knowledge with the third graders.

Chapter 5 Discussion

Summary of Major Findings

This on-site research has confirmed that girls are able to focus on a subject such as science when they are in small classes in a single-sex environment. They are comfortable working in small groups of girls and are confident in their discoveries and in posing questions. The hands-on approach promoted by teachers at this school serves them well. Labs are well structured to ensure their benefit to students. Most girls at this school enjoy science all the way through high school and take more than the required number of science courses. They do well on assessments and many are studying science in college. Teachers at the school all agree they could do more to promote girls future success in science by inviting female professionals in the STEM fields to campus. The first STEM summit was held just a few weeks ago, after this research was conducted, and its success predicts there will be many more to follow.

Comparison of Major Findings to Previous Research

The major findings in this research are similar to previous research. Girls learn best when they have high self-esteem and confidence. If they are not distracted by boys or compared to boys, they can focus on learning science. At this school site, boys are not a consideration during class and all girls are engaged in science. All teachers are in agreement that a hands-on approach is the best way to experience science. Teachers make great effort to make the subject matter relevant to the girls and build on their connections. Girls are given opportunities to collaborate and work in small groups without competition. These are all recommendations found in the literature reviewed.

Limitations/Gaps in the Study

This study was limited in that it only focused on one school. Most of the teachers who teach science at this school in grades 2-12 were interviewed, but there were three who were not. It would have been ideal to have held focus groups in the middle form and at the high school to collect feedback from the students to find out their opinions on science and their science education at this school. This school is not ethnically diverse and 100% of graduates attend college. It would be interesting to compare the results found here to those from a school with a more diverse student population or to a school where students do not attend college.

Overall Significance of the Study

This study confirms that it is more important than ever for girls to have be encouraged and given opportunities to work in STEM fields. This background begins when girls are first learning about science. Even though Title IX was passed 40 years ago, girls still lag behind boys in science. It is important for me to know that at the school where I work, the school and the teachers are utilizing instructional strategies and presenting science in a manner that is appealing to girls. Girls at this school are engaged and successful in science.

About the Author

The author lives in San Francisco and made a career change into education eight years ago. She has been teaching elementary school age children and has worked at an independent all-girls school for the past four years.

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