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Counting Girls In - Gender Issues in Science and Mathematics: An Examination of the Research Concerning Innate and Socio-Cultural Gender Differences in the Fields of Science and Mathematics in an Effort to Promote More Female Participation

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Counting Girls In: Gender Issues in Science and Mathematics

An examination of the research concerning innate and socio-cultural gender differences in the fields of science and mathematics in an effort to promote more female participation.

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Abstract

In today's world, there is an increasing demand for people in the technological fields. Fewer females than males pursue careers in physical sciences, engineering, and computer science in the United States presenting a loss of needed mathematicians and scientists. Gender differences related to mathematics and science is a complex arena of study, involving both innate biological differences combined with socially constructed ideas about gender in society. Through an in-depth investigation from educational, cognitive, and social psychology perspectives one will be able to determine how innate and socio-cultural factors contribute to the shortage of needed mathematicians and scientists in the United States. The research presented in this thesis paper examines the factors essential to the reasons why women in the United States are not entering careers in science and mathematics, namely physics, engineering, and computer science at the same rate as males. Moreover, suggestions for achieving a more gender equitable education that will *Count Girls In* when it comes to pursuing science and mathematics career opportunities serve as a guide for educators in the future.

Counting Girls In: Gender Issues in Science and Mathematics

America is a nation that stands behind the idea of equality. Yet, this does not necessarily mean that everyone is the “same.” In fact, the suggestion that men and women develop differently is not a new idea. The role of women in society has been a topic of interest since Eve in the Garden of Eden. Plato (c. 428 B.C.-c. 348 B.C.) dedicates Book V of his Dialogues to this issue and addresses the question that if women are to have the same duties as men, then they must have the same nurture and education.

Salve Regina University promotes a community that seeks wisdom and promotes universal justice. In keeping with the traditions of the Sisters of Mercy, the university encourages students to work for a world that is harmonious, just, and merciful. Additionally, the Pell Scholar’s Program expands on the university mission by preparing students to serve the community, seek peace and justice in the world, and be responsible citizens of the world. The experiences of being a Pell scholar at the university’s and a student of mathematics and education inspired research involving gender and mathematics. Living Salve’s mission and upholding the themes of service, justice, and citizenship as a Pell scholar are interwoven throughout the paper.

As a nation, society is lacking needed mathematicians. Fewer females than males are pursuing careers in physics, engineering, and computer science. In addition, women constitute half of the United States workforce, but only twenty six percent of the science and engineering workforce (Halpern et al., 2007, p. 3 see graph). The research in this paper will examine the socio-cultural and innate biological factors that contribute to fewer females in the United States pursuing math and science related fields, namely physical sciences, engineering, and computer science. The following questions are addressed: (1) Are innate gender differences the reason why fewer women pursue these fields? (2) Are there socio-cultural reasons why fewer women pursue these fields? Furthermore, the study suggests better gender equitable practices and advice for teachers on encouraging girls in science and mathematics by answering the question (3) What gender equitable educational practice would promote additional interest in these fields? Socio-Cultural factors, as opposed to innate differences, are the key determinant of U.S. women pursuing advanced study and careers in science and mathematics. Promoting a curriculum that is gender responsive with an awareness of the differences in learning patterns, is the only way to alleviate the gender gap.

Innate Differences

Presently, there is a great amount of evidence supporting the notion that boys and girls learn differently based on biological differences. In other words, there are differences in the brain that influence how males and females construct knowledge. Gender differences are evident and expand at each stage of development due to innate biological factors. Many researchers take an evolutionary perspective to gender roles basing their epistemology around the hunter and gathering societies prominent in human history. Historians feel that current gender typical behavior developed from domestic “ideas” in which male and female roles follow currently. Laura Berk (2005), author of *Infants, Children, and Adolescents,* explains the historical approach taken by evolutionary psychologists. Historically, men are hunters and providers, therefore males are genetically wired for “dominance and competition” (2005, p. 392). Women on the other hand are the nurturers and caregivers and therefore females are geared towards “intimacy and responsiveness” (2005, p. 392). In addition to the great cultural influence, gender typing is influenced by “biological” and “adaptive functions” for human history (2005, p. 392).

Innate biological differences can help answer the question of why females do not pursue math and science career fields. Females tend to score higher on reading and writing assessments and males tend to score higher in mathematics and science. Scholars feel this is due to a biological advantage in the development is centered, areas of the brain. For example, the cerebral cortex of the female brain, where language centers, develops earlier in females than males. Furthermore, according to Berk (2005) girls, "depend more on concrete manipulative ways to solve basic math problems, whereas boys can mentally represent numbers and rapidly retrieve answers from memory" (Berk, 2005, p.575). Depending on the mathematical ability test, the types of questions asked will determine the disparity of gender differences in scoring. Males and females approach problems differently and exhibit various strengths and weaknesses.

Additionally, biological differences influence behavior among boys and girls. The differences in sex hormones lead to differences in play, presenting a greater interaction between same-sex playmates because they exhibit similar needs during early childhood (Berk, 2005, p. 392). Differences in motor ability become more evident as the child grows as well. Boys are more advanced than girls in areas involving "force and power." According to Laura Berk, "by age five boys can jump slightly farther, run slightly faster, and throw a ball about five feet farther…girls have an edge in fine motor skills and in certain gross skills that require a combination of good balance and foot movement, such as hoping and skipping"(2005, p.317). The differences in motor ability result in parents having different expectations and beliefs about their children.

According to Leonard Sax (2005), biological sex differences influence how boys and girls learn. Sax argues that many teachers and parents are unaware of innate differences. Sax explains what the critics have to say in his book:

> Not only do most of the books currently in print about girls and boys fail to state the basic facts about innate differences between the sexes, many of them promote a bizarre form of political correctness, suggesting that it is somehow chauvinistic even to hint that any innate differences exist between females and male. (Sax, 2005, p.6)

There is merit in the research studies that evaluate biological sex differences in males and females and how these differences affect a child's learning and development.

Herbert Lansdell instituted the beginning of modern research on gender differences when he reported the existence of anatomic sex differences in the organization of female and male brains. Sax (2005) summarizes the research explaining that the left hemisphere of the brain is specialized for language functions in men, but that distinction is not as clear in female brains. In addition, from studies of people with strokes, evidence shows that functions are more compartmentalized in male brains and more globally distributed in female brains. By the mid 1980's it was clear from the research that compartmentalization of left-brain verbal and right-brain spatial applies less or not at all amongst females. Norm Geschwind and other neurologists suggested that male hormones were responsible for the hemispheric specialization of male brains. (Sax 2005, p 12) A recent study conducted by a team of neurologists in 2004 including fourteen neuroscientists from the University of California, the University of Michigan and Stanford University found that female brain tissue and male brain tissue are intrinsically different. Females get more from their X chromosome than males do, and the males Y chromosome is directly responsible for the differences in the brain. Scientists still connect differences in the brain to sex hormones but this recent study suggests that differences on brain tissue are directly linked to sex chromosomes therefore are genetically programmed and present at birth. It is still unclear whether this research tells us anything about the sex differences in brain function and if it is significant enough to affect how boys and girls learn. (Sax, 2005, p.15) Professor John Corso from Penn State demonstrated that females hear better than males, during his research conducted in the 1950's and 1960's. Sax claims in his book that the fact that males cannot hear as well as females is partially the problem of why boys are labeled as attention deficit more often than girls are. Could the problem be that boys just cannot hear soft-spoken female teachers, not that they cannot pay attention in class? (Sax, 2005) Studies conducted by pediatric audiologists Barbara Cone-Wesson, Glendy Ramirez, and Yvonne Sininger showed that baby girls had an acoustic brain response about 80% greater than the response of the average baby boys. These built in gender differences have implications in later life. For example, music therapy works for baby girls but not baby boys. In addition, a little girl may feel that her father is yelling at her even though it seems to be at a normal decibel.

Moreover, research has shown that boys and girls eye anatomies differ, which some argue is the reason behind women interpreting facial expressions better than most boys do. Researchers have tried to answer the question of whether or not understanding facial expression was innate or linked to social factors such as parents encouraging girls "to interact with other girls while the boys shoot each other with ray guns," states Sax (2005, p.19). One study concentrated on newborn babies the day they were born. Researchers gave babies a choice between looking at a mobile or a young woman's face. Researchers who were unaware of the newborns sex analyzed their eye motions. Baby boys were more than twice as likely to prefer the mobile to the woman's face. Researchers concluded from this study that, "they had proven beyond reasonable doubt that sex differences in social interest are in part biological in origin" (Sax 2005, p.19). The results suggest that girls are born prewired to be interested in faces while boys are interested in moving objects. Sax claims that the reason for that difference has to do with the anatomy of the eye. The retina, which is the part of the eye that converts light into a neurological signal, is made up of cells responsible for different tasks. Magnocellular ganglion cells (M-cells) are wired to primarily rods, which are colorblind with little input from cones, which are sensitive to color. M-cells are simple motion detectors and they are distributed throughout the retina, tracking objects anywhere in the visual field. M-cells collect information regarding movement and direction and can be thought of as the cells that answer the question "Where is it now and where is it going?" Parvolcellular ganglion cells (P-cells) are connected to all three varieties of cones, with much less input from rods. In addition, P-cells are much more concentrated towards the center of the field of visions (fovea). P-cells gather information about texture and color answer the question "what is it?"

P-cells and M-cells send information differently. P-cells utilize a part of the brain (thalamus) that is specialized for analysis of texture and color whereas M-cells send information through a region that is specialized for analysis of spatial relationships and object motion. Additionally Sax explains, "Every step in each pathway, from the retina to the cerebral cortex is different in females and males" (2005, p.20). From studies or microscopic analyses of the eye, scientists have concluded that the retina is full of receptors of sex hormones. Anatomist Edwin Lephart found that the female retina is significantly thinner than the male retina. This sex difference is because males have more M-cells. (2005, Sax, pp.18-21)

Leonard Sax, in light of all the recent research on the differences in eye anatomy, explains why boys and girls when given crayons draw different things. Boys and girls see the world differently. Girls tend to draw people and places and prefer red, orange, green, and beige that are colors associated with P-cell sensitivity. Boys, on the other hand prefer to simulate motion in their pictures using colors such as black, gray, silver, and blue; colors that M-cells are sensitive to. Furthermore, girls demonstrate a better understanding of what objects are whereas boys are better at object location. Sax goes on to explain how the differences of the eye can also explain sex differences in the toys boys and girls play with. It should not be a surprise that girls prefer dolls over trucks since dolls are richly textured or that girl babies look at faces compared to mobiles. (Sax, 2005, pp. 21-25) Sax later on in the chapter explains how social learning and gender schema theories cannot explain toy preference in totality because studies have shown that girls choose dolls while boys choose trucks long before either group has any idea to which gender they belong. Child psychologists Lisa Serbin and Anne Campell both performed studies that proved that boys and girls show gender-typical toy preferences long before they understand gender. (Sax, 2005, p.27)

Along with the organization of female and male brains, geometry and navigation is another topic of difference in the functions of the female and male brain. Researchers have found that males and females approach problems involving location differently. For instance, women tend to use landmarks such as the McDonalds or the house painted blue to explain directions. Males on the other hand will use directions such as north and south and exact distances such as two miles to describe location. Males and females use different strategies for navigation that correlate directly with different regions of the brain. Women use the cerebral cortex and males use the hippocampus.(Sax, 2005, pp.25-26) George Grön (2000) and his colleagues at the University of Ulm in Germany created virtual reality goggles that allowed volunteers to play a video game inside a MRI brain scanner. The video game was a simulation of a maze. The experiment shows that females and males use different areas of the brain for spatial tasks. Women use the cerebral cortex, the area for understanding, talking, and most of our interactions in the outside world in order to find a way out of the maze. Conversely, males used the hippocampus, an area of the brain prewired for spatial navigation. (Sax, 2005, pp. 99-102)

Scientists have studied laboratory animals and found the same results as in humans. The gender differences exhibited from animal navigation experiments posses a case against gender as culturally constructed. Rather the experiment points to the fact that there are genetically programmed differences as well. These differences have implications in the field of education, especially in teaching mathematics and geometry. Since boys use the hippocampus to solve geometry type problems, it can help explain why boys are more comfortable and engaged with mathematical material, even at an early age. Girls can cover the same material, but since they use the cerebral cortex of the brain, they benefit when education is connected to the real world and tied to higher cognitive thinking. (Sax, 2005 pp.100-106)

How boys and girls process feelings and emotions are also different. Deborah Yurgelun-Todd and her associates at Harvard used MRI Imaging to examine how emotion is processed in the brains of children ages seven to seventeen. The research showed that negative emotional activity associated to unpleasant visual images were localized in the parts of the brain that do not change over the course of evolution, more specifically in this case the amygdala. For instance, this is why seven-year-olds have difficulty describing their feelings. The cerebral cortex facilitates speech and it has little direct connection to the area of the brain where emotion occurs. As a child matures and reaches adolescence, the brains procession of negative feelings moves from the amygdala to the cerebral cortex, where higher cognitive functions take place. This movement allows a child to explain, if they want to, in great detail why they feel the way they do. This change ONLY occurs in girls, though; boys' negative emotion remains in the amygdala. According to Sax (2005), in recent talks there has been a push to increase the "emotional literacy" of boys, which shows a lack of awareness between basic sex differences. This difference in brain functioning can explain why some boys are disengaged in English classes when asked to put feeling into their writing. The fact that boys and girls process emotions differently can affect their learning negatively if a teacher is unaware of the emotional gender differences. (2005, Sax, pp. 29-30)

Differences in the nervous system can help explain why males are more likely to engage in risky behavior. Psychologist Barbara Morrongiello interviewed injured children ages six through ten. Her study shows that boys are more likely to attribute injuries to bad luck verses a lack of ability or foresight. In addition, boys are less likely to tell their parents and are around other boys at the time the injury occurs. Risky and dangerous behavior according to gender triggers a "fight or flight" response that gives a charge of excitement that boys find irresistible that is not as apparent for girls. For example, women often times on interviews do not ask for more money since they are not likely to be risk takers. According to Sax (2005), that is a factor in explaining why a gender gap in pay still exists even when one eliminates occupation as a determining issue. Some argue that the media typically shows the male as the lifesaver and risk taker, and that is partially to blame for boys' overestimation of ability and a likeliness of getting hurt. (Sax, 2005, p.42) Sax (2005) claims that the male risk taking has been observed in primates which disputes the idea that sex differences derive primarily from cultural influences. Martin Seligman(1967) who is well known for the development of the theory of learned helplessness found that the more you experience new situations, face fears and master them, the more likely you are to deal with new challenges and conquer them as well. (Sax, 2005, pp. 40-54) The knowledge of gender differences related to risk can benefit the environment in which a child learns and grows by allowing parents and teachers to encourage children to look for the challenges in life and teach perseverance in the face of failure.

Additionally Sax (2005) claims that differences in hormones are the reason boys and girls respond to aggression differently. Studies of girls with Congenital Adrenal Hyperplasia (CAH), which result in girls having high levels of male hormone in the mother's womb, suggests girls with CAH are more likely to engage in masculine behavior and toy preferences. Researchers found no evidence of parental influence in the study; even those parents who encouraged their girls to play with dolls and feminine toys had no effect on the behavior of the child. Studies of laboratory animals produced the same result and showed that male primates were six times more likely to engage in rough and tumble play than female primates. The concept of aggression as fun comes naturally to boys but girls do not see aggression as useful to building friendships. This difference is natural and should be acknowledged for educational purposes when developing lessons. For example, females may want to work cooperatively to build friendships whereas boys may benefit more from friendly competition. (Sax, 2005, pp. 56-64)

Moreover, sex hormones are attributed to the reason why boys are better at geographic navigation and envisioning a three-dimensional object spinning in space, whereas girls are better at remembering object location and landmarks. The study published by Sarah Glazer, explains that sex hormones have been shown to influence the ability for envisioning objects moving in space. Females tend to do better on tests with three-dimensional rotation when estrogen levels are low and better on verbal fluency tests when estrogen levels are high. Information from studies on sex hormones can help explain why females have more difficulty at a level higher than in high school due to the increased demand to visualize mathematics. Levels of testosterone are tied to greater levels of confidence, which translates into better decisions on tests and higher scores. (Glazer, 2005, p. 454)

Professor Tracey Shors and her colleagues demonstrated that stress improves learning in males, but not in females. She demonstrated by studying laboratory animals that exposure to stress enhances the growth of the neural connections in the male hippocampus while it inhibits growth of connections in the female hippocampus. Sax connects Shors' study to explain why boys are energized by time constraints and confrontation, but girls are debilitated by high pressure all or nothing classrooms. Differences in dealing with the effects of stress could be contributing factor as to why females' standardized testing grades do not correlate with their class grades. (Sax, 205, pp. 89-90)

Socio-Cultural Differences

Even though women have made strides in bridging the achievement gap, there is still concern for females' lack of interest in math and science, as well as shortages of women in technological, engineering, sciences, and advanced mathematical fields. (Cavanagh, 2008) The cultural myths that are so prominent in our society largely influence males' outperformance of females in math and science test scores and explain why men have more opportunities to pursue careers relating to those fields despite growing female college attendance and women's higher achievement in the classroom.

Gender differences have existed for many generations and are evident before the birth of a child. Once parents know the sex of their child, they decorate their child's room and buy their child toys and clothes that match stereotypical gender ideas. Traditionally, boys are associated with blue or green colors and girls are associated with purple and pink. From the time children are born, their parents encourage differences that further push their sons to be "physically active" and their daughters to seek help and “physical closeness.” Furthermore, children’s toys resemble the common stereotypes, and parents have a more positive reaction towards gender-typed play. Trucks and footballs are common toys for boys while dolls and tea sets are common for girls. (Berk, 2005, pp.265, 285)

Gender-typed behavior increases more during early childhood. Parents, as well as social pressures, continue to separate children into gender based physical activities. Fathers typically tend to play catch with their sons and buy them sports related toys. Girls on the other hand are encouraged to play with jump ropes and to play house with related toys like sewing machines and cooking sets. Once a child begins schooling, gender typing intensifies. In classrooms, girls tend to spend time with housekeeping, arts, and reading corners. Boys on the other hand enjoy activities such as blocks, woodworking, and active play. As children develop a sense of gender identity at around age two and describe themselves as “boy” and “girl,” they tend to make an association that gender differences exist and act in a certain manner. Children’s gender beliefs match their actions and ultimately influence their personality as they grow. Berk defines personality traits among boys, “as active, impulsive, assertive, and overtly aggressive.” In contrast to boys, girls tend to be, “more fearful, dependent, compliant, considerate, emotionally sensitive, self-controlled, and skilled at understanding emotions” (2005, p. 391). Many scholars suggest that the way parents raise girls promote learned helplessness because they shield girls from risky behavior and respond to injury differently. Parents often tell their sons to suck it up and praise them for risky behavior like riding a bike with no hands. Girls avoid future risks when they fail, which has implications that are carried into the future. (Sax, 2005, pp.49-51) Many of these differences continue into middle childhood further deepening the ideas of gender stereotyping.

As children progress through schooling, separate achievement areas for boys and girls become evident. Academic subjects take on “masculine” and “feminine” skill areas. Berk claims that, “reading, spelling, art, and music” are better for girls whereas “mathematics, science, athletics, and mechanical skills” are for boys (2005, p. 504). A child’s preference toward certain subject areas is often due to the attitudes of parents and teachers that promote gender differences. In middle childhood, males tend to identify with their “masculine” traits and girls identification with their female characteristics decline. Girls have a tendency during middle childhood to associate with the “other-gender,” often experimenting with a wider range of activities. Many believe this is due to societal factors that depict masculine characteristics as having higher status than female ones. (Berk, 2005 p. 504-505) Furthermore, boys tend to spend more time with computers and tend to use them for writing computer programs, analyzing data, and graphing software. Girls on the other hand use the computer for instant messaging and homework (Berk, 2005, p. 576).

Laura Berk describes adolescence, “as a period of gender intensification—increased gender stereotyping of attitudes and behavior, and a movement toward a more traditional gender identity” (Berk, 2005, p.615). As children reach puberty, their concerns about how people view them intensifies. Girls at this stage are less likely to experiment with cross-gender ideas and become more concerned with social pressures. As friendship among girls becomes more important, they develop a greater emotional closeness by often getting together to “just talk.” In contrast, boys focus more on accomplishments and spend more time involved in sports and competitive games. In early adolescence, it is also more common for boys to have more friends of the opposite sex than girls. At this stage, boys and girls deal with conflict differently. For example, males often brush off conflict as “no big deal” minimizing the importance of the problem. Girls on the other hand tend to "coruminate" or mull over a problem and keep negative feelings (Berk, 2005, p. 621). Furthermore according to Berk, girls are more prone to depression due to stressful life events and gender-typed coping (2005, p. 627). Boys on the other hand tend to be more delinquent accounting for more of the serious violent crimes in society (Berk, 2005, p.631). In addition, recent research shows girls having a greater graduation rate and college enrollment than boys.

Gender differences also continue into adulthood. Emerging adults try to develop a sense of identity. According to Berk, "the vocational realm is more challenging for woman than for men. During college, woman's career ambitions decline due to concerns about combining work with motherhood" (2005, p.649). Some women pursue male-dominated careers such engineering or finance but tend to have "masculine traits." Even if they have the drive to succeed in a field dominated by men, they are more likely to be seen as less efficient. (Berk, 2005, p. 649) Cultural pressures today still demand women to uphold the caregiver role and the male to be the breadwinner, which strongly influences the careers that people choose to enter.

Discussion: Gender Equitable Educational Practices

Despite efforts of Title IX and pushes for equal education, achievement gaps are still evident between males and females, and stereotypical ideas of gender roles are prevalent. Math and science are traditionally viewed as masculine subjects and many women are absent from the male dominated career fields associated with the subject. The attitudes of parents, teachers, and culture as a whole intensify the stereotypical gender roles evident in our society by hindering the opportunities available to all people. In 1994 Mattel created a Barbie doll that said, "Math is hard." The media publicized that case after *The Barbie Liberation Organization* criticized Mattel for gender stereotyping. Does Barbie's frustration exhibit a world in which females more than males find math to be hard? It is hard to escape gender stereotypes when they shape the environment in which we live. (Ben-Zeev et al., 2005, p 190)

One cannot totally understand gender unless he or she views it in light of Vygotsky's socio-cultural perspective. Vygotsky argues that society and culture are important in promoting development. Socialization and gender identity are essential for students as they progress through schooling. Dr. Gerard Duveen (1993, p. 1) focuses on ontogenesis or "the process through which children's thinking, acting, and feeling come to be structured in terms of the social representations of their community"(p.1), in order to explain that a child is born into a world already structured by social representations. The social representations help shape a child's identity, which is imperative for the future. Gender marking is a big part in the socialization of a child and as previously described, begins before birth. Children orientate themselves to fit into a collective system of meaning based on their social world. Duveen summaries this idea further:

> Within sex groups, social representations of gender offer a variety of possible gender identities, enabling individuals to position themselves in a number of different ways. Each type of social identity provides a certain version of femininity or masculinity, and for the child, different types of social gender identity prove both a means for orienting themselves in a social world of a classroom and a pathway towards the development of their gender identity in later years. For the positions, which children adopt also structure their experiences in the classroom and beyond. (Duveen, 1993, p. 3)

Gender then is not a question of individual response to situating themselves in the world but rather an adoption of positions clearly marked by social representations of gender. Often there are exceptions to the normal gender roles, such as a girl who develops the position of "tomboy," a girl who engages consistently with boys in masculine marked activities. This is a viable identity for a girl and most people feel that a tomboy will grow out of this identity once she reaches puberty. The reverse, a boy engaging consistently in feminine activity receives the label “sissy,” which has a much more negative connotation and becomes a focus of concern for teachers and parents. Duveen explains the idea of the “tomboy” and “sissy” more in his research:

> To return to the tomboy and the sissy, these are roles, which have a clearly specified career path into the future. The tomboy is more tolerated because there is an expectation that eventually puberty will intervene to reorient the girl into an identity, which will enable her to take an appropriate position within the adult world of gender. The anxieties aroused by the sissy are precisely focused on what playing with things feminine signifies for the future sexual identity of the boy. Whether or not children are aware of the temporal dimension of their identities, each of these positions points a child along the path of a gender career. (Duveen, 1993, p.4)

It is evident that society’s expectations play a huge role in the development of a child’s identity.

There is a commonly held belief that men have the upper hand in visual-spatial reasoning and mathematical reasoning and females are better at verbal skills. These gender differences, though, are quite small and getting smaller. Recent data points to the fact that girls perform as well as boys in mathematics and sciences despite the “masculine” nature of the classes. Robert Sanders (2008) reflects on males and females performance the same:

> Girls now equal the performance of boys on standard mathematics assessment tests, probably because girls now match boys in the number and level of math courses they take in elementary and high school, according to a new study by researchers at the University of California, Berkeley, and the University of Wisconsin, Madison. That was not the case

> 20 years ago, when studies showed nearly identical performance at the elementary school level but girls lagging boys at the high school level. Since then, girls' participation in higher level mathematics classes has risen to the same level as boys', with predictable results, according to study co-author Marcia Linn, UC Berkeley professor of education. (Sanders, 2008, para. 2)

Although this may or may not be true, schools have a major challenge in overcoming gender stereotypes held by teachers, parents, and the girls themselves. Sander explains that the research does not change the attitudes of society:

> Study leader Janet Hyde, a psychology professor at UW-Madison, noted that, despite the fact that girls now take just as many advanced high school math courses as boys, and women earn 48 percent of all mathematics bachelor's degrees, the stereotype persists that girls struggle with math. Not only do many parents and teachers believe this, but scholars also use it to explain the dearth of female mathematicians, engineers and physicists at the highest levels, Hyde said. (Sanders, 2008, p.1)

If the educational system is to benefit all students, one needs to break the stereotypical attitudes of society and provide a more gender equitable education in the future.

Ann Gallagher (1998) takes an in-depth look at why there still is a difference amongst test scores, but not classroom grades. Some researchers feel that differences that exist are the result of socialization practices or physiological indicators. Other researchers recognize that societal and biological factors interact systematically. Halpern’s model suggests that, “learning is both a socially-mediated event and a biological one. Individuals are predisposed to learn some topics more readily than others...determined by prior learning experiences” (Gallagher, 1998, Abstract, para. 5). Gallagher follows this model and focuses on patterns of socialization ultimately affecting performance on tests through reflection of cognitive processing differences. (Gallagher, 1998)

By examining the three domains of psychology: educational factors, cognitive factors, and socialization factors, one can see how they interact to produce gender differences in performance on standardized tests. Educational factors such as course-taking patterns, classroom experience, and motivation greatly influence how well a female student will perform on a standardized test. Cognitive factors influence performance beyond the classroom that ultimately creates a gender gap in testing. Analyses of mathematics content of questions on standardized tests have failed to identify specific mathematics content that consistently favors males over females, yet general patterns of performance are evident. (Gallagher, 1998)

According to the Cavanagh (2008), females are not entering math and science related fields not because of an inability to, but because it does not suit her interests because they are male dominated careers. An interesting statistic further shows gender differences surrounding subject interest. More than eighty percent of students taking the AP Spanish exams are female compared to the seventy-five percent of students taking the AP physics exam are males (Sax, 2008). Recent studies show that more females are going to college than males and are completing an equal number of bachelor's degrees in certain sciences. Bachelor's degrees that are of interest to the nation's economic health such as engineering, computer science, and physics are still male-dominated. (Cavanagh, 2008)

Leonard Sax takes a similar approach and argues that the question we should be addressing is not what males and females can do, but what they WANT to learn, and HOW they want to learn it. Sax claims that there is a real gender gap and it is growing. Rapidly, this gap is not in ability but in motivation. An issue he points out in his article, *Where the Girls Aren't*, "the absolute number of young women studying computer science and physics has fallen by more than fifty percent in the past twenty years." (Sax, 2008, p.29) Girls approach the same subjects as boys but with different interests and teacher's need to structure their classroom to address those interests.

A recent analysis of contemporary data published on June 1, 2009 in the Proceedings of the National Academy of Sciences includes researchers from the University of Wisconsin-Madison reporting that, "the primary cause for gender disparity in math performance at all levels is culture not biology" (Devitt, 2009, para. 3). Janet Mertz, a UW-Madison professor of oncology says, "There are countries where the gender disparity in math performance doesn't exist at either the average or gifted level. These tend to be the same countries that have the greatest gender equality" (Devitt, 2009, para. 4). If there was a biological math gene that allowed men to be more math and science inclined, then it would exist cross-culturally and societal changes could not eliminate that disparity. Wisconsin researchers documented a pattern of performance that suggests that gender disparity in math is correlated to socio-cultural factors. Specifically, in the U.S. girls have made great strides in eliminating the gender gap. Girls at all grade levels now perform at par with boys on standardized math tests and are now taking calculus in high school. Additionally the percentage of U.S. doctorates in the mathematical sciences has climbed thirty-percent in twenty-first century. However, there is still disparity in the amount of girls being identified as mathematically gifted and in the science and math career fields but the gap is narrowing and will continue to narrow as more gender equity measures are addressed. (Devitt 2009) Mertz claims:

> If you provide females with more educational opportunities and more job opportunities in fields that require advanced knowledge of math, you're going to find more women

> learning and performing very well in mathematics…U.S. culture instills in students the belief that math talent is innate; if one is not naturally good at math, there is little one can do to become good at it…in some other countries, people more highly value mathematics and view math performance as being largely related to effort. (quoted by Mertz, Devitt, 2009, para. 11)

If women, as Harvard professor Lawrence Summers claimed in 2005, did not have the “intrinsic aptitude” for scientific inquiry, women would not have had the ability to close the gender gap in math and science. Wisconsin researchers have contradicted Summers’ assumption claiming girls’ math scores are as variable as boys’ in some countries and among some ethnic groups in the U.S., with as many girls as boys scoring above the 99^{th} percentile in some cultures. Additionally, the ratio of girls to boys excelling in math correlates quite well with measures of a country’s gender equity. Mertz, along with another professor of psychology at the university, Janet Hyde, caution, “The United States may fall further behind other nations in math performance as tests mandated by No Child Left Behind include almost no questions requiring complex problem solving” (Devitt, 2009, para. 13). Neglect of problem solving skills can hurt the future of the U.S. economy and as a society; America needs to be “doing a better job of identifying and nurturing mathematically talented youth, regardless of gender, race or ethnicity” (quoted by Hydge, Devitt, 2009, para. 14). Today’s world is one in which technology is necessary and strong mathematicians and scientists are essential to America competing globally. America needs to be on the brink of innovation and looking for ways to encourage the mathematics and science fields.

Women-rights groups argue that summer ignores the fact that sex discrimination and the way girls are taught to view math as a male territory are large factors in women’s avoidance of mathematics and science fields. Critics blame male hiring committees for being bias against women and argue that there is a lack of family-friendly policies. Women now earn thirty-one percent of chemistry doctorates and twenty-seven percent of math doctorates, but only constitute twelve percent of faculty positions in chemistry and eight percent of math positions at the nation's research institutions. Advocates for women's rights claim a "steel ceiling" keeps women's participation trapped at less than twenty percent of engineering, computer science, and physics careers. Many accept the notion that there are biological innate differences between males and females related to math and science, but it is the overwhelming social differences that is deterring women from those careers. Jocelyn Samuels, vice president of education and employment at the National Women's Law Center blames, "a chilling environment when the atmosphere of culture sends the message 'Women don't belong.' She contends that female graduate students and faculty tend to receive less lab space, less mentoring by senior faculty and fewer invitations to participate in research grants" (Glazer, 2005, p.456). There are hard-wired biological differences but the differences do not determine whether a woman can succeed in a math or science career and the attitude that women are not genetically programmed to do math needs to change; the societal factors are what America needs to do something about. (Glazer, 2005, p. 447)

Historically, women were very much a part of the sciences. Sarah Glazer (2005) in her article *Gender and Learning* published by the C.Q. Researchers claims, "The question is not why there haven't been more women in science, the question is why have we not heard more about them." Girls need role models; women like themselves who have accomplished great things motivate them. Some examples are Ada Byron who founded scientific computing and Marie Curie who discovered radium. In many early 19^{th} century schools, more girls than boys studied science and girls were known to outperform boys. During that period, much emphasis was placed on learning the classics, Latin and Greek. Knowing the classics resulted in higher status and was necessary for college. At that time, many colleges barred women from attending so girls tended to focus on the sciences instead. With the rise of coeducational schooling, it was clear boys were failing behind and that girls were excelling. Often feminism was blamed and the educational system was ridiculed for its feminine influence of teaching science by telling stories. By the end of the 19^{th} century, there was a negative reaction towards female science teachers and a gradual decline of women in the sciences began. After the civil war, there was a push to make schooling more “practical,” in other words geared more towards what would prepare students for real life. This resulted in recommendations for girls to be taught home economics. In addition, since colleges were beginning to accept girls, girls also began taking classes in Latin. A combination of girls learning classics and acceptance to college drew girls away from enrolling in math and science courses. At the turn of the 20^{th} century, women became interested in the nature study movement, which provided opportunities for women as science teachers, amateur collectors, and museum and lab assistants. This movement received criticism for its spiritual nature and for being too sentimental and feminine to appeal to boys. In response to the movement during the first couple of decades of the 20^{th} century, male science teachers began to dominate. Additionally textbooks and curriculum were changed with the goal of encouraging more boys into math and science. With the launch of the Soviet satellite *Sputnik* in 1957, the American government reacted out of fear and promoted initiatives to provide funding for gifted science students, which they associated with boys. By 1955, the proportion of girls taking physics dropped from twenty three percent in 1890 to two percent. (Glazer, 2005, pp 458- 459)

Ann Gallagher in her article, *Gender and Antecedents of Performance in Mathematics Testing* (1998), explains the differences between the natures of standardized tests and classroom tests as well as she explains the difference in how males and females approach problems. Sex-role socialization influences a child as it grows and develops; behaviors are either rewarded or sanctioned by social norms that dictate the attitudes of parents, teachers, and peers. It is quite clear that a divided culture exists amongst males and females and that different expectations become reinforced by society. Societal factors influence a difference in personality, attitudes, and friendships. It is evident that changes in policy issues and suggestions for improvement should be on the forefront of educator's minds. One should not dismiss the idea of changing standardized testing, nor changing education to reflect a more problem solving approach. Another imperative move is to educate our teachers on sex-role stereotypes for teachers. (Gallagher, 1998) Once aware of the "myths" that surround gender difference one can move towards a better curriculum and environment for ALL to learn.

The gender gap does exist and is an issue not just in math and science but also in the school system as a whole. Males are more likely to be enrolled in special education classes, have discipline issues, and drop out. Societal factors relating to gender and the expectations of the gender straight jacket negatively influence learning for both boys and girls. Leonard Sax states:

> Today we know that innate differences between girls and boys are profound. Of course, not all girls are alike and not all boys are alike. However, girls and boys do differ from one another in systematic ways that should be understood and made use of, not covered up and ignored (2005, p.28).

Although there are innate biological differences amongst males and females, it should not impede girls' participation in science, technological, engineering, and mathematical careers. As a citizen, one has a responsibility to ensure equity in schools and demand that educators are meeting the needs of all students. Differences are differences; they are not to be interpreted as inabilities. Sax summarizes it best with an analogy:

> The bottom line is that the brain is just organized differently in females and males. The tired argument about which sex is more intelligent or which sex has the "better" brain is about as meaningful as arguing about which utensil is "better" a knife or a spoon. The only correct answer to such a question is" "Better for what?" …If your child has a spoon but no knife you'll give your child beef stew. If your child has a knife but no spoon, then you'll give your child some meat loaf. Likewise, the differences between what girls and boys can do are not large. But the differences in how they do it can be large indeed…You can make math appealing to girls by teaching it one way. Or you can make it appealing to boys by teaching it another way. Boys and girls can both learn math equally well if you understand those gender differences. (2005, pp.34-35)

Societal factors and the belief that women cannot do mathematics is what hold women back. Scientists and researchers tend to look towards statistics to solidify the belief that males have the advantage in math and science when instead the research should allow both genders to excel. Teachers should implement different teaching strategies and encourage males and females. How well one performs on a high-level mathematics exam does not accurately predict the ability of that person to excel in a mathematics career; it is simply one factor that can be impacted by societal pressures. Males and females may approach mathematical problem solving differently, but they are both equally capable of finding the answer. Any biological shortcoming that may exist can be strengthened and a woman can adapt for it with the proper encouragement and guidance. Women are said to have great networking, problem solving, and creative skills that would benefit any mathematical team. University of California, Davis sociologist Kimberlee Shauman claims, “What it takes to be a successful scientist is much more than math achievement…We need people who are creative, who have good communication skills, are good managers...skill more likely to be found in women”(2005, Glazer, p.449). In addition, women who participate in mathematics and science tend to choose fields that characterize gender typical roles of caring that deal with people not things. For example, fields in the life sciences involving biology and medicine. Sciences such as physics and engineering deal more with things demonstrating a more masculine nature are still male dominated. It is difficult to assert if this is due in large part to a biological preference or societal pressures of gender characterizing that determine what field of work women chooses.

As whole students in the United States are losing interests in math and science, and we need to *Count Girls In* to continue advancing the sciences in a demanding global world. Sax summarizes this issue in the afterword of his book:

> At the graduate level, there has been a significant drop in the number of American men earning Ph.D.s in math and science, and American women have not stepped in to fill the breach. Looking at men and women combined, the number of Americans earning degrees in engineering has dropped 8 percent since 1990, despite the rising demand for engineers; the number of Americans earning degrees in math has dropped 22 percent over the same period. The gap is being filled by foreign students…James Gallagher in an essay suggesting that the decline in the number of Americans studying advanced math and science may adversely affect national security. (Sax, 2005 p.261)

In order to move beyond the gender gap, all students need to be motivated and the attitudes of society need to be altered to be accepting of both genders and not so gender-typical. Schools across the country have introduced “girl friendly” curriculum relating to math and science. Ruta Sevo, who directs the National Science Foundation’s research program on gender in science and engineering claims, “We found if we taught science differently with hands on inquiry-based approach, it sustains girls’ interest in science.” She goes on to say, “Girls like to work in cooperative teams, previously a lot of science was taught in a competitive mode” (Glazer, 2005, p. 454). Creating a climate that is more encouraging, combined with a curriculum that meets the needs of gender has helped shrink the gender gap in schools, but some argue it has cost too much and believe it is a fabricated myth that girls are shortchanged in mathematics and science.

Teachers and parents believe “myths” about gender differences shape the interactions that exist between males and females. As a teacher, one should make a concentrated effort to develop and structure curriculum to reduce gender stereotypes and represent both genders in a positive and competent light. Boys and girls alike focus on careers that are stereotypically “appropriate” for their gender in part because they have greater self-confidence about their ability to succeed in such careers. (Ormrod, 2008, pp. 124-132) One key to improving academics is to improve girls’ perceptions of their abilities, also known as self-efficacy. Huebner (2009) suggest strategies backed by research to encourage girls and improve self-efficacy, including teaching students that academic ability is not fixed but expandable, exposing girls to role models, and provide informational feedback. A student’s confidence improves when feedback praises effort and is specific to problem solving strategies and centers on the student’s strength and weaknesses. Research shows that students who receive genuine praise and feedback specific to performance were more likely to ask for assistance and have greater self-efficacy. (Huebner, 2009)

The United States Department of Education expanded on Huebner's suggestions and published an Institute of Education Sciences Practice Guide on *Encouraging Girls in Math and Science.* The study guide outlines five recommendations to count girls in:

1) Teach students that academic abilities are expandable and improvable.
2) Provide prescriptive, informational feedback.
3) Expose girls and young women to female role models who have succeeded in math and science.
4) Create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science.
5) Provide spatial skill training. (2007, Halpern, p.9)

When teachers contribute success to effort rather than ability, self-efficacy improves. Teachers need to understand that abilities can be improved through consistent effort and learning. Research shows that even bright students who view their abilities as fixed and unchangeable are more likely to experience greater discouragement, poorer performance, and suffer from learned helplessness. (2007, Halpern p. 11) Moreover, teachers should provide feedback that is prescriptive and should focus on strategies, effort, and the process of learning. This type of feedback, although it overlaps with formative assessment feedback, centers more on the beliefs about why students did or did not perform well on a given task. According to Halpern, prescriptive feedback enhances students' beliefs about their abilities and improves persistence, ultimately advancing the level performance on tasks. (2007, p.15) In addition, research has shown that negative gender stereotypes create problems for females on spatial reasoning and mathematics tests. Teachers should expose females to positive female role models. By providing examples for girls that invalidate gender stereotypes, test performance improves and allows for greater success in mathematics. (2007, Halpern, p. 19) When establishing a classroom the first thing a teacher should do is establish relationships. In order for that to be possible, it is necessary to discover out the needs and interests of the students. Halpern suggests building off the initial interest of students in specific math and science activities to build a long-term interest in math and science content. According to Halpern, research indicates that students' interests are linked to academic performance and choices for boys and girls. In other words, if students are interested in the material they tend to get better grades, take more advanced courses in that field, and pursue a career. (2007, p. 23) Additionally, researchers have found that spatial skills are associated with performance on math tests and can be improved with practice. If teachers provide spatial skills training, women will be able to perform better, which will increase their confidence related to mathematics and ultimately they will pursue their interests further. (2007, Halpern, p. 27) If teachers implement the five recommendations previously listed for encouraging girls in math and science it will provide females will the tools necessary to choose careers in math and science related fields as well as foster a better learning environment.

If a teacher is aware of gender differences and structures his or her classroom to meet the needs of both girls and boys, interest in math and science will increase and so will the level of academic success. For instance, differences in hearing suggest different strategies teachers should implement in the classroom. For instance, psychologist Colin Elliot demonstrated that girls are often distracted by noise levels about ten times louder than noise levels that boys find distracting. Additionally, if you are teaching girls it is beneficial if you do not raise your voice and try to keep a classroom free of outside noise. (Sax, 2005 pp. 17, 18) When teachers are aware of gender differences surrounding hearing, they can adapt the classroom to meet the needs of both genders.

The educational system in America needs to achieve a gender equitable curriculum with administrators and teachers to recognizing biological differences in male and females approach to education. The educational system is not just shortchanging girls when it comes to math but there is a true gender gap that exists across curriculum. Boys are more likely to be in special education classes, involved in alcohol and drug abuse, drop out of schools, and perform at a lower reading level. Sax (2005) claims that boys are becoming increasingly alienated from schools. According to the U.S. department of education, the average eleventh-grade boy now writes at about the same level as the average eighth grade girl. In addition, the U.S. department of Education projects by 2011 there will be a 60/40 ratio of females-to-males amongst college graduates. (Sax 2005, p. 8) Sax urges educators to build enthusiasm for learning in both boys and girls in light of sex differences stating:

> Many educators and policy makers stubbornly cling to the dogma of “social constructionism,” the belief that differences between girls and boys derive exclusively from social expectations with no input from biology. Stuck in mentality that refuses to recognize innate, biologically programmed differences between girls and boys, many administrators and teachers do not fully appreciate that girls and boys enter the classroom with different needs, different abilities, and different goals. (Sax, 2005, p. 9)

Sax, along with many educators, is proactive in promoting single sex education. In 2001, Republican Senator Kay Bailey Hutchison joined with Democratic Senator Hillary Clinton to construct new legislation legalizing single-sex education, in American public schools. There are many positive and negatives associated with single sex education but this law makes the opportunity for those that want it the option of same sex classrooms. Same sex classrooms allow teachers to differentiate the class to the needs of gender differences. In *Why Gender Matter,* Sax says, “I will suggest that for at least some children in some circumstances, single-sex activities offer unique opportunities and may even serve to ‘inoculate’ girls and boys against some of the societal ailments that now threaten children and teenagers” (Sax, 2005, p.9).

Elizabeth Weil (2008) looks at gender differences in a school setting in her article, *Should Boys and Girls Be Taught Separately?* The article takes the idea of single-sex education and debates both the benefits and the potential consequences of separation by gender. The belief that boys and girls be should be taught separately is not a new idea and can be seen in a number of private and parochial schools through the country. The debate of single-sex education has recently taken storm in the world of education due to the increase in research showing how it increases learning for both genders. A number of public schools across the nation are now experimenting with constructing single sex classroom and have been highly successful. There is a wide array of benefits to switching to a single-sex school and it is one possible solution to promote an interest in learning, especially math and science by appealing to the needs of gender. There is a great amount of research showing that girls and boys learn differently and respond to different emotional and cognitive responses. Classrooms structured to certain genders increase learning, confidence, and self-motivation. (Weil, 2008, pp. 40-45)

Possible explanation for why more women are not entering certain fields may be explained by the lack of female role models in math and science. Girls may be discouraged by the isolated “geek” stereotype often portrayed in computer science and engineering. Females also appear to prefer careers that center on helping others. Lisa Damour (2009), author for *Education Week* offers another explanation “girls don’t tinker” in other words girls are not commonly found taking things apart or figuring out how things work (para 4). The American Association of University Women commented in its 2000 report *Tech-Savvy:*

> Boys see computers as toys interesting in their own right, while girls see them as tools for accomplishing tasks. By approaching computers and other mechanical devices as toys, boys are able to learn how they function from the inside out. When tinkering with programming, they develop an intuitive understanding how computers work. When tinkering with machines, they develop their mechanical reasoning, an arena of cognitive skill that boasts one of the largest of all gender gaps. (Damour, 2009, para. 5)

Damour explains further that girls are just not encouraged to tinker with and teachers often intrude sooner when girls struggle, causing girls to be "afraid of doubt, investigation, and experimentation" (2009, para. 6). These resulting fears are essential components of problem solving necessary in math and science. Damour encourages teachers and parents to be patient and look for opportunities to promote tinkering. Some examples include woodworking, having after school Lego Leagues, and having a workspace at home with broken appliances. When asking girls to tinker, it is important to give them plenty of time, space, allow them to work with partners, and set meaningful goals. Damour concludes by saying:

> To engage in these critical fields (computer science and engineering) girls need compelling role models and an appreciation for the collaborative nature and human applications of engineering and computing. Moreover, from their earliest days, girls need to tinker. (Dam our, 2009, Para. 11)

If tinkering were built into the curriculum, it would increase the motivation and interest not just for girls but all students, especially the kinesthetic learners.

Sheila Widnall (2000), former Secretary of the Air Force and professor of aeronautics and astronautics at the Massachusetts Institute of Technology takes a stand against gender bias in her field by stating, "If women don't belong in engineering, then engineering as a profession is irrelevant to the needs of our society…Engineering must welcome women or risk being marginalized as other fields seek out and make a place for them" (p. 1). In order to help students it is necessary to know students individually. Widnall offers a list of effectors to encourage women as leaders in math and science fields:

> 10. Effective TV and print material for high school and junior high girls about career choices.
>
> 9. Engineering courses designed to evoke and reward different learning styles.
>
> 8. Faculty members who realize that having a women in a class improves education for everyone.
>
> 7. Mentors who seek out women for encouragement.
>
> 6. Role models—examples of successful women in a variety of fields who are treated with dignity and respect.
>
> 5. Appreciation and rewards for diverse problem-solving skills.
>
> 4. Visibility for the accomplishments of engineering that are seen as central to important problems facing our society.
>
> 3. Internships and other industrial opportunities.
>
> 2. Reexamination of admissions and evaluation criteria.
>
> 1. Effective and committed leadership from faculty and senior administration. (2000, p. 4)

Promoting a curriculum that follows effectors similar to the ones listed above and teaching educators to be aware of gender differences are the only ways to eliminate the gender gap as it stands today.

Conclusion

The debate surrounding gender differences and mathematics should not be centered on whether there are innate hard-wired differences that give males a mathematical advantage. The debate should be concentrated on how best to educate America's children. If there is a biological hard wiring for men in math and science, America should be asking 'why do women outperform men in other countries?' Females are closing the gender gap in math and science at such a great rate and if they really were not "programmed" for scientific inquiry then this would not be possible. The biological differences previously discussed are not what hold females back in male dominated careers. What holds females back is the sexism that exists at the implicit level. Laurie Rudman, professor of psychology at Rutgers University, New Brunswick, New Jersey speaks out on the topic:

> There has been a sea of change in employment for women, what people haven't changed is attitude at the implicit levels like the association of masculinity with leader like qualities and assumptions that warm communal females lack the rigor for scientific inquiry. (Moore, 2008, p.2)

America has a responsibility to promote a curriculum that is gender responsive to meet the needs of all learners. Educators should have an awareness of how males and females learn differently and alter teaching practices to meet that demand. Students who express an interest in math and science should have all the opportunities possible to excel. As citizens in a society that strives for equality, there is a possibility of breaking gender stereotypes, but only if people are willing to overlook preconceived ideas about gender and mathematics. Promoting motivation for all students should be the central focus of American education, especially in the increasing technological world where careers in science and mathematics are in such high demand.

References

Berk, L. (2005). *Infants, children, and adolescents* (Fifth ed.). Boston, Massachusetts: Pearson Education Inc.

Ben-Zeev, T., Carrasquillo, C., Ching, A., Kliengklom, T., McDonald, K., Newhall, D., et al. (2005). "Math is hard!"(Barbie, 1994): Responses of threat vs. challenge-mediated arousal to stereotypes alleging intellectual inferiority. In A. Gallagher, & J. Kaufman, *Gender Differences in Mathematics: An Integrative Psychological Approach* (pp. 189-219). Cambridge, United Kingdom: Cambridge University Press.

Cavanagh, S. (2008, August 27). Stereotype of mathematical inferiority still plaques girls. *Education Week*, 28 (1), 9.

Damour, L. (2009, November 9). Teaching girls to Tinker. *Education Week,* 29 (11), 25.

Devitt, T (2009, June 1). Culture, not biology underpins math gender gap. *University of Wisconsin-Madison News.* Retrieved from http://www.news.wisc.edu/16786

Duveen, G. (1993). The development of social representations of gender. *Papers on Social Representations, 2 (3), 1-177*

Gallagher, A. (1998). Gender and antecedents of performance in mathematics testing. *Teachers College Record*, *100 (2),* 297-314.

Glazer, S. (2005, May 20). Gender and learning. *The C.Q. Researcher*, 15 (19) Retrieved from http://chem.ou.edu/~djn/diversity/ScannedRefs/CQResearcher20May05.pdf

Halpern, D., Aronson, J., Reimer N., Simpkins, S., Star J., & Wentzel K. (2007). *Encouraging Girls in Math and Science* (NCER 2007-2003). Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ncer.ed.gov

Huebner, T. (2009, September). Encouraging girls to pursue math and science. *Educational Leadership*, 67 (1) 90-91 Retrieved from http://www.ascd.org/publications/educational_leadership/sept09/vol67/num01/Encouraging_Girls_to_Pursue_Math_and_Science.aspx

Moore, K (2008, November 28). Rutgers plan targets faculty gender gap. *Asbury Park Press* Retrieved from http://sciencewomen.rutgers.edu/pdf/asburyparkpress112808.pdf

Ormrod, J. E. (2008). *Educational psychology* (Sixth ed.). Upper Saddle River, New Jersey: Pearson Education Inc.

Sanders, R. (2008, July 24). Girls' and boys' math performance now equal, *UC Berkley News.* Retrieved from http://berkeley.edu/news/media/releases/2008/07/24_math.shtml

Sax, L. (2005). *Why Gender Matters.* New York, New York: Broadway Books.

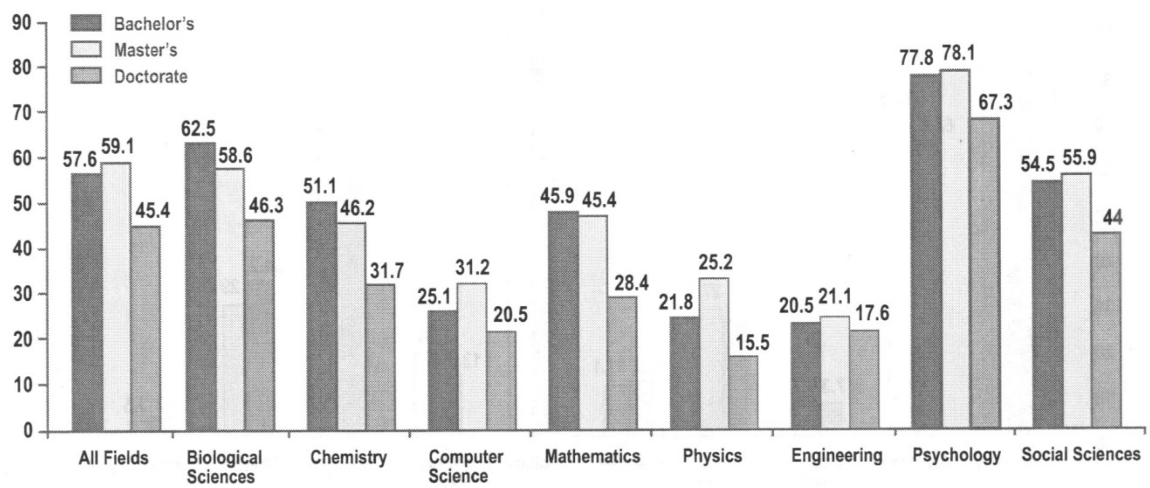
Sax, L. (2008, June 18). Where the girls aren't. *Education Week*, 27 (42), 36.

Weil, E. (2008, March 2). Should boys and girls be taught separately. *New York Times Magazine*, 38-45, 84-87

Widnall, S. (2000, April 26). Digits of pi: barriers and enablers for women in engineering. Retrieved from http://gos.sbc.edu/w/widnall5.html

Appendix

Figure 1: Percent of degrees awarded to women by major field:



SOURCE: National Science Foundation, *Science and Engineering Degrees: 1966-2004.*