Gender differences in science

David Harbaugh

University of Northern Iowa

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Gender differences in science

Abstract
This literature review examines the research that was available about the trends and the status of gender differences in science. The major factors identified by researchers and educators that contribute to this gender difference are discussed. Suggestions are presented which may minimize the gender differences and provide specific practices that can help improve the situation. The results of this review indicate that although a difference exists, there are ways that educators, parents, and students can make changes to decrease the difference.
Gender Differences in Science

A Graduate Review
Submitted to the
Division of Elementary Education
Department of Curriculum and Instruction
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Education

UNIVERSITY OF NORTHERN IOWA

by
David Harbaugh
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This review by: David Harbaugh
Titled: GENDER DIFFERENCES IN SCIENCE
has been approved as meeting the research requirement for the
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Donna H. Schumacher
Graduate Faculty Reader

\[7-31-97\]
Date Approved

Rick Traw
Graduate Faculty Reader

\[7-31-97\]
Date Approved

Greg P. Stefanich
Head, Department of Curriculum and Instruction
Abstract

This literature review examines the research that was available about the trends and the status of gender differences in science. The major factors identified by researchers and educators that contribute to this gender difference are discussed. Suggestions are presented which may minimize the gender differences and provide specific practices that can help improve the situation. The results of this review indicate that although a difference exists, there are ways that educators, parents, and students can make changes to decrease the difference.
Many students take science at the secondary level only because it is required. Of those students who do like science or have a more positive attitude towards science, most of them are males (Simpson & Oliver, 1985). This commentary peaked my interest and I decided to investigate why females don't seem to “get into science” or take science classes. The general purpose of this review is to investigate the relationship between gender and enrollment, and gender and achievement in science. The following questions will guide my research:

1. Does research indicate there is a difference in science achievement based on gender?
2. What are believed to be the external factors which influence females and their entry into science courses and careers in science?

As a science teacher it is of importance to me to try and understand my students. What can be done to help more girls enroll in science courses? The results of this review might be helpful in understanding why there are discrepancies and what I, as a science teacher, can do to help increase the number of girls enrolled in science courses and selecting science related careers.

Methodology

An Educational Resources Information Center (ERIC) search at the Donald O. Rod Library at the University of Northern Iowa was the initial method for identifying sources. Terms used as descriptors for the ERIC search included: science, girls, and elementary school. Another search using the terms science and women was also done. From these initial sources found as a result of the ERIC search, additional references, such as journal articles and books, were
identified in the bibliographies of these articles. References more than twenty years old were not used unless the study was a landmark study.

Literature Review

There have been many books and journal articles written about gender differences in science in the last two decades. What do experts in the field have to say about this trend in education? The results of this review might provide some insight into this educational phenomena.

Is There a Difference in Number of Girls Entering the Science Field?

According to statistics (National Science Foundation [NSF], 1990) women constitute nearly 30 percent of all scientists. This has increased, but women still are vastly under represented in science. Observers in elementary, junior high, and senior high school science classes see progressively less active involvement by girls as their age increases (Klein, 1989). The lack of science experiences along with an increasingly poor view of science results in poor attitudes about science, about their science capabilities and affects their career choices (Kahle & Lakes, 1983). In response to “recognition of equipment” questions on the Minnesota Assessment Test, fourth grade boys answered the questions correctly only 1.2 percent more frequently than did girls. The boys answered correctly 5.6 percent more frequently in eighth grade. By the eleventh grade, boys recognized science equipment 12.5 percent more frequently than did the girls (as cited in Klein, 1989). In most parts of the world, women are not pursuing careers in the science areas. This trend has been noted for years by educators and researchers.

Shakeshaft (1995) noted that “recent state mandates that increase the
number of years of science required for high school graduation have increased female science participation" (p. 74). In the past there has been a major discrepancy between the percentage of females that enter the physical science fields and those that enter the life science fields (National Science Foundation [NSF], 1982). The physical sciences are seen as more masculine than are the biological sciences (Klein, 1989; Reyes & Padilla, 1985; Vocknell & Lobonc, 1981). Klein (1989) stated, "Physical science is seen as masculine because of its perceived emphasis on industrial and military applications. Biology may be more acceptable because of its involvement with living things and protection of the environment" (p. 29). Klein (1989) also suggested that in biology there is more of a lecture and directed laboratory approach, which girls like. The open ended problem-solving approach of physics is less appealing to girls. Research has shown that there are areas of science that are under represented by females. What can be done about this is discussed later.

**Is There a Difference in Achievement in Science?**

Research has shown that girls do not achieve as high in science classes as do boys. A report from the American Association of University Women reports that girls in high school science don't do as well as boys (1992). The National Assessment of Educational Progress (NAEP) data from 1973 to 1992 shows that as students get older, the difference in science proficiency becomes greater between boys and girls (NAEP, 1994). As girls get older they don't do as well in science as boys (NAEP, 1992). The next section will demonstrate what research has suggested as to what the reasons for these differences are.

**Reasons for Differences**

A gender difference has been documented. Statistics and studies have shown that there is a gender difference in the area of science. What are some of
the reasons research has suggested to account for these differences? Why do so few females choose science as a career? What are the forces that influence the path chosen by girls and women? The following reasons were identified in the literature review.

**Nurture.** Research suggests that there is a difference in spatial abilities between girls and boys that might be due to the environment the child was brought up in. Most boys grow up making models, working on cars, and using telescopes. Boys' toys usually include chemistry sets, mechanical toys, and puzzles which are usually portrayed with male figures (Kerr, 1994; Klein, 1989). Boys have grown up using the tools and materials of the science laboratory. Girls are still for the most part playing with the toys that society doesn’t view as science related (Shakeshaft, 1995). This is one reason that could explain why girls don’t do as well in the area of science. A student is going to do a better job if they are using familiar skills and equipment.

**Stereotyping.** Sex-role stereotyping is another reason that has been attributed to causing gender differences in science. Many times science is seen to be a masculine area. Researchers in one study asked children, grades kindergarten to five, to draw a scientist. Less than one percent of almost 5,000 drawings, were that of a female scientist (Chambers, 1983). In another study, only 135 out of 1654 respondents pictured female scientists (Fort & Varney, 1989).

Cultural biases have been found to have an effect on a girl’s performance in science. Many of these biases begin when girls are young (Peltz, 1990). A study of children's educational science television programs showed that the females on these programs were often portrayed as pupils or assistants. Very few women were portrayed as scientists or in responsible positions (Steinke &
Long, 1996). They stated,

In conveying information about the world of science to children, media practitioners should carefully consider the messages conveyed through the images of science they construct. For example, what message is being conveyed to viewers when twice as many male scientists as female scientists are shown or when girls are shown acquiescing to the wishes of a male scientist or when girls and young women typically are shown assisting with science experiments rather than supervising them or when a male scientist is shown physically pushing a female assistant aside after she has just completed an experiment. (Steinke & Long, 1996, p. 110).

Females in science should be presented in the same manner as males.

Biology is one science course that more girls take and more women go into (NSF, 1990). Biology is often considered to be a helping science, people oriented, and more feminine (Kelly, 1982; Vockell & Lobonc, 1981). A girl, who believes that science is for boys and all of her life has been told that, will not be inclined to pursue or excel in the area of science.

**No female role models.** Lack of role models is another influence that discourages a girl from going into the science field. Much of a girl’s picture of herself is determined by the adult examples to which she is exposed. Attempting a career in which one has no role models to follow is very difficult (Jones & Wheatley, 1988). The absence of women in science in textbooks and media help perpetuate the masculine image of science (Koch, 1992).

**Biased teachers.** Teachers' perceptions also may have an influence on a girl deciding whether or not to go on in science. Many teachers perceive that science is a male domain (Jones & Wheatley, 1988). Shepardson and Pizzini (1992) proposed that one reason for the differential educational treatment of
girls and boys is that teachers possess a gender-bias in their perception of the scientific ability of their students. This bias may cause a differential treatment of girls, which contributes to the discrepancy in the development of their scientific ability. Research has shown that it is likely that teachers do have different expectations of students based on gender (Jones & Wheatley, 1990). Teachers tend to overrate the work of a boy compared with that of a girl (Spear, 1984). Male students receive more attention from teachers than do female students. Female students are not given as much time to talk in class as are their male counterparts and teachers tend to spend more time with boys in the classroom (Sadker & Sadker, 1986). Teachers, either consciously or subconsciously, provide different treatment of boys and girls in science (Shepardson & Pizzini, 1992).

Counselor and teacher advisement on course selection. Along with the teacher perception in classroom treatment, there is the influence of teachers and counselors as to a career path a student will follow. Counselors must convey to students the idea that class and curriculum choices early in high school can eliminate science career choices later on (Matyas as cited in Kahle, 1985). If girls don't take the proper prerequisite science or math courses, they aren't going to be able to take the upper-level science courses (Jones & Wheatley, 1988). Teachers and counselors must inform their students and help them to understand that by not taking basic or advanced high school math courses, they are limiting their career choices. They are limiting their options not only in science, but also in business, computer science, management, technology, and other fields (Sells, 1978). Sells found in a survey:

Among the top 12.5 percent of high school graduates admitted to the University of California at Berkeley, 43 percent of the entering men and
92 percent of the entering women did not have the second year of algebra and pre-calculus trigonometry background required to prepare for the standard calculus sequence. Thus, 92 percent of the women in this class were effectively relegated to five fields: the humanities, music, social work, elementary education, and guidance and counseling. (p. 28)

Teachers and counselors whose training and background are built on traditional male/female roles, may not give the best guidance. They may guide into careers or place students in courses, using sex and gender instead of talent and motivation (Lee, 1984).

**Competition.** Girls in single sex schools are more likely to choose physical science subjects in high school than those in coed schools (Vockell & Lobonc, 1981). The social interaction between boys and girls may have an influence on a girl's choice in science. Vockell and Lobonc (1981) stated that:

Girls in coeducational schools may have learned that it is socially unwise to succeed in fields where boys are expected to dominate. Girls in coeducational schools who do elect to take physics and/or chemistry are aware of the disproportionate enrollment of males, and this would lead to the perception of these sciences as masculine. Girls who stay out of such classes may do so because of their awareness of male dominance and unwillingness to compete. Non-coeducational girls attend physical science classes consisting entirely of girls and are not presented with this class enrollment discrepancy. (p. 217)

The Horner Effect, or Fear of Success syndrome says that women under-achieve when competing with men (Horner, 1972). Even though a woman may be intellectually superior to a man, the woman will allow the man to win.

Barbara Kerr (1994) wrote:
I first encountered the Horner Effect in college in my general psychology lab. He [her psychology professor] purposely had assigned us to an even number of mixed-sex and same-sex partnerships, and involved us in two competitive games, one intellectual and one physical. .... the trend was clear: women's scores were much lower when they competed against men than when they competed against women. (p. 160)

In a head to head competition with a male, many females don't push themselves to win.

Many ideas and theories about the gender differences in science exist. Underachievement and under representation of girls in science is a fact. The gender differences are a result of the previous many factors. After reviewing these factors, there are things that can be done to close the gender gap.

Recommendations

Many suggestions have been made about what can and should be done to help even the playing field. In addressing all of the previous factors identified there are practices and procedures which can be done at home and at school. The home is the first place where changes can be made. The years before school are a time when foundations are laid. Parents are the key to making sure that the factors which can begin to lead to a gender difference in science are eliminated or minimized. After the young girl has entered school the parents and educators need to work together to provide the opportunity for all students to reach their potential. Jane Butler Kahle (1985) stated:

One general conclusion from the classroom observations, the past and present student surveys, the teacher reports, and all the analyses is that good teachers make a difference. Each teacher successful in encouraging girls as well as boys to continue in science courses and
careers was also a successful teacher. (p. 70)

Well informed parents and educators that are meeting the needs of all their students working together will narrow the gender gap that exists in science.

**Nurture**

In response to the different environments that girls are brought up in, there are certain steps that can be taken at home. Encourage parents to get involved and provide more opportunities for their girls in science. Barbara Kerr (1994) listed numerous things that parents can do to guide their gifted girls. Her suggestions included dressing preschool daughters in clothes that allow them to be active. Don’t dress daughters in lace dresses every day. Choose toys that are nonsexist, encourage toys that allow for problem solving and manipulation. Choose child care that allows boys and girls to play together. Another author recommends that if a daughter comes home from school discouraged or saying that science is boring, parents can work with the daughter to make it fun. Suggestions include: doing puzzles together, watching science programs on TV, going to science museums, taking things apart, and discussing science in the news with the student (Campbell, 1992).

Another recommendation that would help young girls in their spatial development is playing with blocks. Shakeshaft (1995) suggested that:

Playing with blocks, an activity related to early spatial development, is rarely assigned to the formal curriculum in early childhood programs. Instead, it is an elected activity allowed in free play or recess. Boys, who come with more experience in block play than girls, choose blocks in free time. Girls do not. Thus, girls are deprived of an opportunity to learn an important critical thinking and organizing skill, while boys expand their skills by electing an activity that adds to the formal curriculum. (p. 78)
A parent that would encourage their daughter to play with blocks at home would be strengthening them to do better in school. The home is where the foundation is laid. Lee (1984) stated, “Parental impact on children, which precedes school influences and extends beyond them, cannot be underestimated as a powerful educative force, which should be more formally acknowledged and systematically utilized” (p. 333). Parents hold the key to see that their daughters get started on the right track. Teachers need to help them stay on the track.

**Stereotyping and lack of female role models**

In addressing the problem of stereotyping and no female role models, parents again are crucial. Allow young girls to see women in leadership positions (Campbell, 1992; Kerr, 1994; Koch, 1992; Wygoda, 1993). After a daughter is in elementary school, parents should provide books that portray women in many different roles (Kerr, 1994). Campbell (1992) also discusses the attitudes of parents towards their daughters:

In studies of women engineering, math, and science students, parents were most frequently mentioned as the most important influence in young women's decisions to go into science or engineering.

Encouragement doesn't have to be financial or informational (although those don't hurt). You don't have to be a scientist or an engineer to give your daughter confidence.

Today, most girls know women can be scientists and engineers, but many have been told that they wouldn't be able to do it and not to try.

Whether it's staying in science, working with computers, or doing a science fair project, having you, their parent, say “try it, you may like it” can make a difference. (p. 4)

Parental encouragement can be a key factor in helping a girl decide whether “to
Parents also can help reduce the stereotypes that girls face in school. Letting girls see real women as scientists can help reduce the stereotype that is present in so many girls (Campbell, 1992). Finding a mentor can also be important in helping a girl go on and be academically successful (Kerr, 1994).

Educators need to be brought into the equation. If girls are getting one message at home and another at school, this will cause confusion. Teachers need to address the stereotype problem as well. Versey (1990) stated, Don't use society stereotyping as an excuse. We cannot avoid the fact that we have stereotyping in society. This is not the fault of science teachers, but we do not need to reinforce it. We need not distort the real world picture; but we should seek out those examples of science which will engage the interest and enterprise of our girl pupils, and place them more visibly at the forefront of our curriculum offerings. (p. 12)

Teachers should evaluate their textbooks and curriculum materials for sex-bias both in the illustrations and text sections of their materials (Klein, 1989; Nobles & McDonald, 1996). Women scientists are traditionally left out of many reference books. In Asimov's Biographical Encyclopedia of Science and Technology there are 1,195 scientists listed. Only 10 are women (Nobles & McDonald, 1996). Administrators can also be instrumental in having textbooks and other curriculum materials reviewed (Lee, 1984). Teachers and parents need to work together to help dispel the stereotypical image of women and science that exists. As a team they can help change this image that society has.
Teacher bias

The teacher bias factor need also be addressed. Parents should also be supportive of their daughters and fight the educational system if they see something that is not in the best interest of their daughter or girls and science in general (Campbell, 1992). Parents need to watch for and be aware of teacher bias. Educators need to do the same. Self examination is important in the teaching profession. Sadker, Sadker and Thomas (1981) stated that unintentional teacher bias is present many times.

Obviously, teachers are not consciously and intentionally sex stereotyping students. Most teachers work very hard and are extremely conscientious; they try to treat both boys and girls fairly and equitably; they want all children to develop their full potential. However, educators, like members of other professions, have been raised in a society where sexism is prevalent. From parents and counselors, books and television, and a whole myriad of social institutions, teachers have been taught one set of jobs and behaviors that is appropriate for girls and another set is appropriate for boys. When teachers are able to recognize the subtle and unintentional behavior sex bias in their behavior, they can make positive changes in their classrooms- and in the lives of their students. (p. 33)

Teacher bias does exist, and through training and self examination teachers can reduce or eliminate this sex bias that they have (Jones & Wheatley, 1990). Elementary science methods courses can also help train new teachers in ways that will reduce sex bias in the classroom. Koch (1992) stated the following about elementary teachers needing to show their students how to get messy.

Elementary teachers frequently project their own early squeamishness
about science to their female students, thus preventing their active engagement in many science experiences. The discomfort many girls and young women feel about getting messy is inconsistent with the chores for which adult women have traditionally been responsible. The women of the world mess about as they maintain the fabric of daily life. Women are frequently the caretakers of the household, garden and nursery, where cleaning out the Thanksgiving turkey, pruning plantings, and changing diapers require a great deal of "messing about." Elementary teachers, especially women, need to own their right to getting messy, to showing the girls and the boys what it is like to explore, take apart, build, construct, mix, spill, and -yes- sometimes, make a mess. (p. 68)

There also needs to be support from the school administration. Principals need to monitor their staff and be aware and take a role in helping address this bias (Sadker & Sadker, 1986). Teachers need to be sensitive to the needs of all their students.

Course selection advice

As well as bias in the classroom, counselors, teachers and parents need to be aware of how they advise their female students on course selection. The female student needs to continue to take science and math courses during the middle and high school years. Taking these courses will provide opportunity for her later on (Campbell, 1992; Jones & Wheatley, 1988; Kerr, 1994; Sells, 1978). Campbell (1992) notes that there are two key "math decision-making times" in most schools. These are the eighth grade, when the decision of taking algebra in ninth grade is made and the eleventh grade when the requirements for college are met in the mathematics area and the decision about whether to continue taking math courses is made. Parents should be aware of these
decisions and should be involved. Working together parents, teachers and counselors need to consider what is best for the individual student.

**Competition**

When addressing the effect of competition on gender differences in science, a couple of recommendations surfaced. For educators in the elementary school, teachers should do science in single-sex groups to provide girls enough experience to be confident in taking an active role in the science lab (Klein, 1989). When a girl reaches high school age, parents should consider an all-female school (Dyche & Ceperich, 1996; Kerr, 1994). The elimination of male/female competition will allow a female to be more open in course choice and thus provide more opportunities for her future. If a girl gains confidence in the elementary school and middle school a single sex school would not be necessary. Until that point is reached, the option of an all girl school is one that should be considered. There will always be competition in schools. Helping girls be more prepared for this competition is an important aspect of narrowing the gender difference in science.

**Conclusions**

The gender difference in the area of science cannot be attributed to one single reason. The reasons are, however, tied together. Girls are faced with these factors from birth. Beginning in the home where parents fail to address the gender differences that they and society present to girls and continuing on through elementary school, middle school, and high school where stereotypes and biases are present and even in college where women face challenges because they are women. Having society recognize this is an important step. Parents and educators won't change unless they see the need for a change. The home is where the foundation is laid. Parents need to pay close attention
to what they are presenting to their children and to what society is presenting.

Educational is the next crucial point in a young person's life. Teachers, counselors, and administrators must be on constant guard against a sex bias creeping into their lives and thus their teachings. In describing a successful teacher Peltz (1990) said that:

What is necessary is a teacher who is sensitive to the needs of all students in the classroom, who wants all students to have equal opportunity to achieve their fullest capacity. These teachers successfully encourage all students, fostering them in such a way that they do not feel that they are taking risks, or that they are threatened. Everyone is made to feel comfortable asking questions, offering hypotheses, and working in labs. Successful teachers maintain well-equipped, well-organized and stimulating classrooms. They use non-sexist language, avoid practices that reinforce male stereotypes, and confront bias in texts when they find it. Information on women scientists and technologists is provided in their classrooms, and they value creativity. They present a clear sense of direction in their lessons, stress the use of math and encourage students to take further course work. They help girls develop spatial abilities. (p. 49)

The gender differences in science do exist. With some forethought families, education, and society can help reduce or eliminate these differences.
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