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ABSTRACT

The literature is rich with studies investigating gender differences in math, science, and technology. While some inequities have been evidenced and studied for years, we are still finding out many new sources of gender bias in the classroom. That girls think and learn differently as well as interact with equipment differently from boys is a major key to beginning to understanding how best to educate girls in math, science and technological areas in order to encourage their continuation in these areas as career fields. Suggestions for strategies and interventions for rethinking gender biases in the classroom and professional organizations are presented. (Contains 29 references.) (Author/YDS)

Psychological Foundations of Education for Pre-Service Teachers
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Gender Differences in Learning and Achievement in Mathematics, Science, and Technology and Strategies for Equity

A Literature Review

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Abstract

The literature is rich with studies investigating gender differences in math, science, and technology. While some inequities have been evidenced and studied for years, we are still finding out many new sources of gender bias in the classroom. That girls think and learn differently as well as interact with equipment differently from boys is a major key to beginning to understanding how best to educate girls in math, science and technological areas in order to encourage their continuation in these areas as career fields. Suggestions for strategies and interventions for rethinking gender biases in the classroom and professional organizations are presented.

Introduction

Much research and discussion (American Association of University Women [AAUW], 1992; Mangione, 1995; Mark & Hanson, 1992; Mael, 1998; Marino, Ames, Johnson, & Bodey, 1997; Mark & Hanson, 1992; Matthews, Binkley, & Crisp 1997; Reinen & Plomp, 1994; Rogers, 1995; Silverman. & Pritchard, 1993; Sofia, 1998) have gone into investigating gender differences in students at all grade levels in learning and achievement in the areas of mathematics, science and technology. A major concern is that women are underrepresented in the professional areas associated with these disciplines. This "underrepresentation" is evidenced as soon as females begin choosing classes in the middle school years (Silverman and Pritchard, 1993). Girls become uncomfortable and disinterested in math, science and technology early in the educational process. Unfortunately, one of the main reasons for this disinterest is that girls are not encouraged to achieve in these areas and are not given the same opportunities to learn as the male students (AAUW, 1992). Girls are sometimes overlooked and ignored by their teachers in the classroom because girls are more anxious to please and are generally more compliant than males of the same age (AAUW, 1992). Gender gaps in achievement in math appear to be narrowing but they are still very real.7 While females make equal or better grades on average as compared to males at all levels of academic endeavor, girls are discriminated against in college admissions and scholarships because of lower standardized test scores (AAUW, 1992). Women are still not applying to graduate and professional schools in computer science and other professional fields in numbers even close to their proportion in the population (Kirkpatrick and Cuban, 1998).

International data were collected from ten different countries in 1992. (Twenty countries were surveyed in 1989.) The data collected were part of the Computers in Education Project (Comped) to investigate "cross-national factors" that account for students1 computer know-how (Brummelhuis, 1994). Reinen and Tjeerd (1994) used this same data to "study the state of the art with respect to gender and computer use". These data were collected via questionnaires given to principals, computer coordinators and teachers. Student data were collected from a "functional information technology test" (FITT) that included attitude and background questions (Reinen and Plomp, 1994). The data showed "substantial achievement differences" between male and female students in the area of information technology (Brummelhuis, 1994). Brummelhuis (1994) reported that "sex of the student is the only factor with a substantial influence on student achievement in all countries." Consistently across all countries, female students reported "having more difficulty in understanding or using programs" and enjoyed using the computer less than males (Reinen and Plomp, 1994). Another fact that surfaced in this study is that most schools do not consider the gender issue in terms of computer use to be a problem and have no plans to investigate the issue (Reinen and Plomp, 1994).

An explanation of why girls might have more problems than boys in using programs is presented by Mangione1s study (1995) that reviewed previous studies on educational software from 1983-1993. Software was found to be gender specific – male software was "game oriented and action oriented", while female software was "tool-oriented". Girls enjoy "maintaining harmonious relationships" in their computer activities while boys preferred to argue about the rules continuing to quarrel while they played their games. Girls would stop the game if too much controversy was involved and switch to more non-confrontational activity (Sofia, 1998). More importantly Mangione1s study found that non-gender specific software looked more like the software created for males (Mangione, 1995). It was suggested that using software designed for the other sex could result in "anxiety producing" scenarios. That is, because the software created for males and females seemed more male oriented, girls would not feel as comfortable using the "male" software. The author further suggested that the reason more girls don1t take programming courses is that the approach and computer itself is male oriented. Mangione cites Turkle1s work in 1984 that examined male/female ways of programming. Boys are rewarded by using the technique that is both more natural to them – top-down design and considered the "right" approach while girls prefer to program in what Turkle calls a "soft mastery" approach. While both approaches get the job done, the top-down approach is the accepted paradigm in the male dominated computer science area.

A study by Kirpatrick and Cuban in 1998 found that "when females and males have had the same amounts and types of experiences on computers, S females1 achievement scores and attitudes are similar to those of males in computer classes and classes using computers (in primary through higher education levels)." Females just stop taking the computer classes as well as the math and science classes.

Attitude toward technology was measured in Boser1s et al. (1996) study of selected instructional approaches in technology. His findings using seventh grade students showed that girls said they felt that technology was more difficult and less interesting than the boys in the study. Boys held very stereotyped ideas about girls1 ability with technology. These attitudes did not change in a post survey (Boser et al., 1996).

Another study that examined student use of computer-mediated communication software – e-mail, usenet news, Notebook (a local listserv package) - found significant gender differences only in the male dominance in number of posted articles to news (Fishman, 1997). Girls read lots of articles on news but didn1t feel a need to post as many as the males. This is reminiscent of the male behavior exhibited in the early grades – boys forever raising their hands to answer questions even if they don1t know the answer!

The math and science areas have noticed the dirge of women entering the workforce in math and science as well as the technology areas. Research by Jewett in 1996 considered the reasons that women have "negative or ambivalent attitudes toward science." His study indicated that "parental and societal perceptions and teacher behavior and expectations" are the main reasons that girls turn away from science and thus don1t compete for the technical jobs. He quotes Pogo: "We1ve met the enemy, and they is us." That is we are passing our biases onto our children thus perpetuating our biases to the next generation. Teachers and parents pass on their likes and dislikes in very subtle ways. A teacher who may have disliked math or science in their own schooling is responsible for teaching these subjects to K-5th graders. Jewitt cited a 1981 study (Manning, et al) that found that elementary teachers spend less than two hours a week instructing science. Are these science, math phobic teachers, who are generally female, passing these fears onto their students – especially the female students who are seeing their female teachers as role models?

Girls from birth are encouraged to be less independent and adventuresome and to be more passive than their male counterparts (Jewitt citing The Cinderella Complex, 1981). It should come as no surprise that boys then take the lead in science lab actually using the equipment while the girls only write up the experiments. The girls then become watchers and not participants in science. It1s difficult to just watch and become competent with the hardware. "Because of their socialization and lack of experience in manipulating objects, many girls do not feel comfortable in the science classroom, thereby inhibiting, physiologically, their ability to excel" (Jewitt, 1996). Technology classes have experienced very similar findings as the class involves using equipment that may seem unfamiliar and different to the girls.

Jewitt cites a study by Hanson in 1992 that found that boys and girls have already identified math and science as "male" in the second grade. As the students move from elementary to middle and high school peer pressure plays a role in discouraging girls from becoming more involved in math, science, and technology classes. A study by Silverman and Pritchard in 1993 in three middle schools in Connecticut showed that strong gender-career stereotyping –begun as noted above in one second grade - had not changed in the minds of these young girls and boys. While some girls enjoyed the technical classes and were confident about their abilities in this area they felt discouraged from continuing because of peer pressure and their own preconceived beliefs about the type of career a girl would pursue after graduation. By the time these middle school girls reached high school, they were exhibiting less confidence in their abilities to be successful technically and were not choosing to take technology classes (Silverman and Pritchard, 1993).

The instructional technology field – as opposed to most math, science and technology areas – is not disproportionately male dominated in terms of numbers. In fact in a study conducted in

1993 conducted a survey of sixteen of the major colleges and universities with IT programs and showed that 60.1% of the students in the programs were female. However in a further review of the professional IT literature less than 40% of the published articles had female authors (Foley, Keener, Branch, 1993). While the authors did not attempt to explain this disparity it is interesting to note it1s similarity to the findings in the 1997 Fishman study where the female students did not post as many articles to Usenet news as their male colleagues. Do females not feel a need to voice their research and views to wider audiences?

A survey of colleges and universities degrees by gender produced some very interesting results. Women account for more of the associate1s, bachelor1s and master1s degrees than do males. However, at the doctorate and professional degree level men accounted for more of the recipients than women (Gloeckner, 1997). There are many traditional female degree areas – nurses, teachers, psychology, languages – which are dominated by women. The author suggests that male and female dominated fields are missing out on the "other perspective" – incites from the other sex. Gloeckner wonders "Do our children really have the opportunity to become whatever they want?" (1997).

The media is responsible for much of the gender bias that we observe today. Commercials on television are divided between male and female commercials. Male commercials are fast-paced and picture aggression while female commercials are slower paced and picture females as sensing and submissive. Because the technology and math areas are so male dominated these stereotypes infiltrate the mainstream philosophy of most professional offices and organizations making it difficult for women to feel comfortable and valued (Knupfer, Rust, and Mahoney 1997).

While the above suggests more societal, parental, and teacher influences on students, a startling longitudinal study by Fennema and Carpenter in 1998 found that by the third grade boys, while equal to girls on solving number fact and other routine math problems, outperformed girls on solving extension problems. In addition there were definite gender differences in problem solution strategies indicating that boys "tended to use more abstract solution strategies." (Fennema and Carpenter 1998). These abstract solution strategies used by the boys were techniques devised and extended from those used in solving problems sessions introduced by the teacher. The boys were able to more readily adapt and develop a new technique to solve a problem that went beyond the techniques learned. Is there a sex-linked gene for abstract thinking? Hyde and Jaffee are quick to question the Fennema et al. findings by suggesting that the sample was very small (32 girls and 37 boys) and needs to be replicated before we consider changing the way we teach. However Fennema et al. rejoin that there is no simple explanation as to the gender differences found in their study. While they warn that it is imperative to continue to investigate gender differences as it relates to our ways of knowing, they pose the question "Is it possible that we are doing a major injustice to females by pursuing issues related to gender and mathematics?" thus devaluing more traditional and perhaps more appropriate female career choices.

Gender Bias Overrides: Approaches to Equity

In a study of 5th grade students by Matthews, Binkley, Crisp, and Gregg (1998) the students were given pre and post questionnaires surrounding gender discussions. What does it mean when someone says "boys will be boys" and other guided questions about observing gender differentiated treatment in the classroom. The discussions that followed were rewarding for the students as well as the teachers who also struggle to overcome traditional biases (Matthews, Binkley, Crisp, and Gregg, 1998). Open discussions with students are an excellent way to make students and teachers aware of the subtle ways in which gender differentiation invades our classrooms.

One science teacher felt that single-gender labs were the best way to avoid the problem of boys handing the equipment and girls being the secretaries (observers) for the activity (Rop, 1998). This approach could be used in the technology areas as well – especially in computer lab sections. In a lengthy article Mael reviewed the single-sex education literature – both pro and con - and found that, while additional research is necessary, for some students a single-sex (SS) classroom is beneficial. He found that women in SS post-secondary institutions were more likely to "(a) have greater roles in student leadership, (b) complete bachelor1s degrees, and (c) aspire to higher degrees" than females in co-educational institutions (Mael, 1998). Again, further research is necessary. It would be difficult to run a true experiment randomly dividing your subjects between SS and CE colleges!

Other researchers argue that co-educational classrooms are important to help students learn to work together modeling the behavior they1ll need as adults (Knupfer, Rust, and Mahoney 1997). Isn1t it important to get a "common ground" for the sharing of ideas from both sexes to get the best thinking on an issue? Gloeckner (1994) posed the question: don1t both men and women have different perspectives and experiences bases that would help these professions grow and mature?

Girls need to be encouraged early on in their formal education to be high achievers (Knupfer, Rust, and Mahoney, 1997). Summer institutes and academic camps have become popular instruments to give girls additional encouragement and opportunity. These summer activities can be single-sex and provide lots of female role models for career exploration (Marino et al., 1997).

Because continued use of computers is highly correlated with positive initial experiences with computer, it is important to provide the proper sex-differentiated introductory session with computers. Girls think of computers as tools and problem-solving devices (Gunn, 1994). Providing them with age and gender appropriate software will increase the likelihood that they will develop positive feelings toward the hardware (Mark and Hanson 1992). In a study on gender preference in imagery, Rogers found that "Girls like colors, boys like action" (1995). Designing software with Rogers suggested guidelines would be helpful in insuring a positive computer experience for females. In a 1994 study on gender differences in software use, Gunn outlines key issues that teachers should consider as they incorporate technology into the classroom: (a) provide sufficient help and introduction to the software and hardware to be used, (b) supply additional on-going support as necessary, (c) check for sex-fairness in the software to be used, and (d) avoid sex-stereotyping in all educational activities. Jakobsdottir and Krey (1993) offer guidelines for gender-specific software design that follows Rogers1 findings: girls like people, plants, and animals and boys like action. Choosing gender based appropriate educational software will allow girls to be successful on computers, be comfortable with the equipment, and encourage them to continue using them.

A key issue in overcoming gender inequities is that the teachers themselves need to be aware of the issues and how to address them (Gunn citing Whiteside, 1992). Workshops and in-service programs are the best avenue to increase teacher awareness of gender issues and their ramifications. Based on the Comped project most teachers are not even aware of gender problems in their classrooms (Brummelhuis, 1994). Required coursework in education curricula would serve to make our future teachers aware of the importance of gender bias problems in teaching.

An interesting study by Rothschild in 1986 investigated gender-biased language and the influence that it has on resulting discussions in the classroom. Gender-free language can be awkward at times but is necessary in most circumstances to insure that neither sex is excluded from the discussion. The language is only awkward because we1ve become so accustomed to the use of male pronouns to identify either sex. However, gender sensitive language is important to reveal the very different and important contributions by both sexes to the intellectual experience (Rothschild, 1986). "A language and style that includes both sexes, and differentiates where called for, is consistent with and integral to an inquiry that probes the complexity of human-machine interactions" (Rothschild, 1986). Rothchild further suggests that teachers develop a "gender critique" of literature to be used in the classroom and that this critique be honed on classroom assignments – papers and projects – as well. The class then can discuss gender issues and "develop tools of gender analysis."

Conclusions

Women are not choosing careers in math and technology (and science) fields in proportion to their population. Based on grades women have obtained in school women have exhibited the ability to achieve and be successful in these technical careers. To meet the needs of a growing technological society we must have the best work of all of our citizens – including the women. How best to encourage women to become involved in these areas is an important area of research in education and should be given special emphasis.

Specific Items for Consideration

1. Given that men and women have very different ways of thinking and learning it is important that we know as much as possible about those differences to be able to provide appropriate gender based educational situations.
2. Teachers need to be aware of gender biases and how they can negatively impact the learning process – especially for females. Workshops and in-service training for current teacher and required courses for pre-service teachers on gender issues would help in the awareness process.
3. If women do have a different way of knowing than men, then this should be capitalized on and cultivated in order to produce a more complete and well thought-out approach to problem solving.
4. Women need to feel comfortable within their learning environment. This should be one of the by-products of further gender-based education for teachers. (Further research will tell us whether single-sex education is more appropriate in the short term in the technical areas until the traditional gender stereotyping is overcome.)
5. Educational software needs to be developed that follows suggested gender specific guidelines.
6. Women need to be encouraged to reach their potential in the technical areas and to pursue further study as well as careers in math and technology.
7. In the learning environment, attention must be paid to the materials being used – textbooks and software - to insure that they are gender appropriate.
8. Professional organizations need to reevaluate their structures to insure that the current (or previously) male dominated managerial hierarchy has not organized their structure and evaluative mechanisms in such a way that precludes women from being active, productive,

and valued members of the organization.

9. Gender specific language and approaches to problems should be maintained when appropriate.
10. The differences in the value systems of men and women can produce different and valuable approaches to problem solving and should be considered together to produce the best solutions.

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