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AUTHOR Caporrimo, Rosaria
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ABSTRACT

In the area of school mathematics, research has repeatedly indicated that males are far more likely than females to participate in and excel at the highest levels of achievement. Given the supposition of innate differences between the sexes in mathematical ability, as well as the existence of sociocultural differences, none of these variables appears readily amenable to intervention strategies. A study investigated those variables upon which the mathematics education community can exert some influence. Considered as a possible explanatory factor for gender-related differences in mathematical abilities was autonomous learning behavior, which is both characterized as mediation between internal and external influences and performance on high-level cognitive tasks, and hypothesized to be the result of environmental and societal factors. Analyses were conducted to examine the relationship of standardized mathematics achievement scores, problem-solving strategies, self-report scores, and Confidence in Learning Mathematics survey scores among 122 eighth-grade students, 70 females and 52 males, representing all levels of mathematics achievement. Among the findings, no gender differences were evident on any of these scores; however, the Confidence scores functioned differently for the sexes. When consideration was focused upon average scores on the problem-solving strategies measure, males exhibited a direct relationship between routine problem scores and Confidence scores, whereas females showed an inverse relationship. (22 references) (JJK)

GENDER, CONFIDENCE, MATH: WHY AREN'T THE GIRLS "WHERE THE BOYS ARE?"

Rosaria Caporrimo
Center for the Study of Women and Society
Graduate School and University Center
City University of New York

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INTRODUCTION

Gender Differences in High Level Math Achievement

Popular discourse would have us believe that the gender gap has decreased in most areas that once plagued education. However, in the area of mathematics study, research has repeatedly found that males are far more likely than females to participate in and excel at the highest levels of math study (e.g., de Wolf, 1981; Wise, 1985; Chipman and Thomas, 1985). This persistent gender difference has been the focus of much research over the last 15 years.

While some researchers have implied innate differences between the sexes in mathematical ability (Benbow and Stanley, 1980; 1983), many more have found a variety of sociocultural variables to be related both to mathematics achievement and enrollment in advanced mathematics courses (e.g., Sherman, 1981; Armstrong, 1985). While these variables appear to exert a powerful influence on both math persistence and achievement, they are not readily amenable to interventions that produce behavioral changes. Thus, it has become necessary to investigate those variables upon which the educational community may have some influence.

Problem-Solving Strategies

Fennema and Peterson (1985) talked about autonomous learning behavior as a possible explanation for gender-related differences in mathematics. The behaviors that characterize autonomous learning behaviors are viewed as mediators between internal and external influences and performance on high level cognitive tasks and are hypothesized to be the result of external and societal factors. Their conceptual model views specific differential problem-solving behaviors to be an important explanation of gender differences in math achievement. If during the process of general development, males learn behaviors that ultimately serve to their advantage in the study of mathematics, then these behaviors should be evident in their problem-solving strategies. Moreover, one would expect that females and males would exhibit differences in their approach to problem-solving and to behaviors in the math classroom.

In an effort to identify autonomous learning behavior in the classroom, several researchers have conducted studies examining classroom process and teacher-student interaction. The present research developed a measure of problem-solving strategies and math classroom behaviors by drawing on teachers' working knowledge and the literature on problem-solving, including self-regulatory and metacognitive strategies. Further, student self-reports on this measure were obtained and related both to scores on a standardized math achievement test, and a measure which included both routine and non-routine math word problems. If, indeed, females and males engage in different math classroom behaviors and problem-solving strategies, one would expect that males' strategies would be more useful during problem-solving if they had developed superior strategies.

Fennema and Peterson partially define autonomous learning behavior as working independently on high level tasks and persisting at these tasks. Thus, one method of viewing good problem-solving strategies is to consider self-regulation of math learning.

Bandura defines the subfunctions of self-regulation as self-observation, judgmental processes and self-reaction, and asserts all three are necessary to successful regulation of one's own behavior (Bandura, 1986). Individuals not only change their own behavior during self-regulation but also shape their environments in the process. This may be particularly important as it relates to the behaviors and achievement of females in the typical mathematics classroom. In one study (Zimmerman & Pons, 1986), the use of self-regulated learning strategies was found to differentiate high and low achievers and to be a better predictor for the Math section of a standardized achievement test than were either gender or SES.

The metacognitive viewpoint stresses that good problem-solvers do not necessarily possess more knowledge than do poor problem-solvers, but they possess superior use of specific strategies and an awareness of their thinking processess (e.g., Flavell, 1976; Peterson, 1988). This focus on thought processess is stressed by all metacognitive researchers and is summarized by Schoenfeld (1987) who asserts that good problem-solvers test and reject ideas, are aware of their thinking processes, make tentative explorations, generate approaches and try new approaches when warranted. Additionally, good problem-solvers efficiently use available information and spend more time thinking about the problem-- analyzing and making sense of it before actually working on details and "doing" the problem. In a comparison of an average and an above-average problem-solver, Lester and Garofalo (1987) found that although both students persisted in their attempts to solve the problem, the above-average student monitored her activities, "sat and thought" about the problem before actually attempting to solve it, exhibited confidence in her actions, and checked her answer by estimating.

Leinhardt and Putnam's work on strategies used by students in the math classroom (1986) helps researchers focus on possible classroom behaviors that may contribute to learning. These include capabilities such as recognition of behaviors and situations that are routinized, anticipation of varying components of math lessons, assimilating or distinguishing new information from existing knowledge, and selecting and focusing skills.

Attitudes Toward Math

There is a long history of research on the relationship between gender and attitudes toward mathematics. Carey (1958) found attitudes toward math to be strongly related to performance and found that females both performed less well in math and exhibited poorer attitudes toward the subject. Since Carey's research, many studies have found attitudes toward math to be positively related to math achievement (e.g., Hilton & Berglund, 1974; Boswell, 1985; Ethington & Wolfle, 1988).

Various manifestations of interest have been measured and gender differences favoring males are still found on a variety of math attitude measures. The attitude of interest for the present study was confidence in learning math, since recent research continues to find this an important variable in females' math achievement (e.g., Lantz, 1985; Lester & Garofalo, 1987). Also, there has been an assumption since females have less confidence in math and do less well in higher level math courses, that efforts to boost confidence in females should help increase their math performance.

The present research investigated the relationship between gender, confidence and use of specific problem-solving strategies to math achievement in three contexts. It was expected that males would exhibit greater math achievement and greater confidence in math scores and that this confidence would be an important predictor of achievement when considering the use of specific problem-solving strategies. Further, males were expected to exhibit higher scores on the problem-solving strategies questionnaire.

METHOD

Measures

Word problem-solving strategies. The questionnaire measuring problem-solving strategies evolved through several phases of construction, and was adapted from the Math Assessment Project

Questionnaire (MAPQ) (Tittle & Hecht, 1988). The MAPQ was designed to assess students' awareness of their behaviors in math class and when solving a non-routine word problem. The items included in their measure were gleaned from the research on metacognitive and self-regulatory strategies in the problem-solving literature and the work of Leinhardt and Putnam (1986) on strategies used during math lessons.

The first phase involved obtaining teacher-generated characteristics of good problem-solvers and possible autonomous learners. An open-ended questionnaire was administered to 10 seventh- and eighth- grade math certified teachers in four different suburban New Jersey school districts. These teachers were asked to think of a student whom they considered to be a good problem-solver or an autonomous math learner and list specific characteristics and behaviors they had seen exhibited by this student.

Thirteen of the characteristics identified by teachers in the first phase did, in fact, reflect those identified in the math metacognition and self-regulation literature and were represented in the original MAPQ. However, 24 behaviors and characteristics generated by the pilot teachers were not included in the MAPQ. These 24 items, the 13 items identified in phase I and already included in the MAPQ, and an additional 20 items selected from the MAPQ, were integrated into a questionnaire.

Twenty-five math teachers, representing three private and five public schools, participated in phase II of the study.

These teachers were presented with the items discussed above and were instructed to indicate for each item whether the behavior was characteristic of an autonomous math learner by checking "no," "maybe," or "yes" next to each item.

In the final phase of instrument development, the student self-report use of strategies questionnaire was constructed. Teacher-generated items to which 30% or more of the teachers checked "no" were eliminated from the measure, while all items selected from the MAPQ were included, for a total of 51 items These 51 items were divided among four sections describing different stages of problem-solving- "before," "during," and "after" solving a non-routine problem, and a "classroom strategies" section. In accord with the procedure followed by Tittle and Hecht, a non-routine word problem preceded the presentation of the ALB items. The problem read:

> Eight pennies are arranged in a row on a table. Every other coin is replaced with a nickel. Then, every third coin is replaced with a dime. Finally, every fourth coin is replaced with a quarte-. What is the total value of the coins on the table?

This problem gave the students a specific stimulus on which to reflect when responding to items regarding strategies/behaviors used before, during, and after solving a non-routine problem.

An example of an item from the "before" section read:

> I tried to put the problem into my own words.

Students indicated whether or not they had engaged in this behavior by checking "no," "maybe," or "yes."

An example of an item from the "during" section read:

> I drew a picture or diagram to help me understand the problem.

An example of an item from the "after" section read:

> I thought about a different way to solve the problem.

An example of an item from the "math classroom" section read:

> I usually ask questions of the "what if" and "why" type.

Scoring for responses to individual items was as follows. For items that were positively weighted , NO = 1, MAYBE = 2, YES = 3. For items negatively weighted, NO = 3, MAYBE = 2, YES = 1. An example of a negatively weighted item read:

> I would have liked the teacher to check each step as I worked it.

Other Measures

In addition to the questionnaire, students also completed the Confidence in Learning Math Scale, a subscale of the Fennema-Sherman Mathematics' Attitudes Scales (Fennema & Sherman, 1976). The scale consists of 12 items and subjects indicate their degree of agreement on a Likert-type scale, with each statement ranging from strongly agree to strongly disagree. Six items are positively weighted and six are negatively weighted.

Scores on the math section of the Iowa Test of Basic Skills were obtained from the cooperating school and used as the standardized math test score. The subtest scores-- computation, concepts and problem-solving-- as well as the overall score, were obtained.

A word problem-solving measure was constructed consisting of six routine and six non-routine word problems. The subjects' math teachers were consulted to provide information as to the "routineness" of the problems. Only those agreed upon by the two cooperating teachers as "routine" and "non-routine" for their students were used in the instrument.

Subjects

One hundred twenty-two eighth-grade students-- 70 females and 52 males-- were used as subjects. The subjects represented all levels of math achievement, with students tracked in specific math classes according to this achievement.

Procedure

Data collection was conducted on two days in two consecutive weeks for each of the two teachers' classes, for a total of four days. This was done to avoid any possible confounding effects between the questionnaires and the word problem-solving task. All subjects completed the problem-solving task on Day 1. This task was presented first in order to avoid the possibility the the problem-solving strategies questionnaire itself would encourage the use of problem-solving strategies not previously employed by the students. The Confidence in Learning Math scale was completed prior to the strategies questionnaire to avoid the possibility that solving the problem presented at the beginning of the strategies questionnaire would affect students' confidence in such a way as to affect responses on the Confidence scale.

RESULTS

Analyses were conducted to examine the relationship of standardized math achievement, problem-solving strategies score, and Confidence in learning math, to gender. Two-tailed T-tests were performed to assess the relationship between these variables using all sub-tests, as well as the overall math score, on the Iowa Test of Basic Skills, scores on the student self-report strategies measure and the Confidence in Learning Math questionnaire. No gender differences were found on any of these variables (see Table 1). It was expected that males would score higher on the standardized test score, particularly on the problem-solving sub-test. The findings did not support this hypothesis. Further, males did not score higher on the problem-solving strategies measure as had been expected. Although the *t*-test for confidence and gender revealed a significant difference in favor of the males, this result may be due to the fact that eight *t*-tests were performed. A more conservative approach, based on the Bonferroni inequality, revealed this gender difference to be insignificant.

The results of Pearson correlation analyses revealed significant correlations between problem-solving strategies score and standardized test score ($r = -.19$, $p < .04$). Thus, strategies score is a significant, although negative, predictor of standardized test score. A significant correlat on was found for the interaction term gender*problem-solving strategies and the Confidence measure ($r=.22$, p,.01).

In the multiple regression analysis predicting standardized test score the addition of gender and confidence, individually, to the regression equation did not significantly increase the multiple R . However, the inclusion of the interaction term gender*confidence resulted in a rise in the multiple R from .24 to .30, a significant increment of .06.

The same pattern was found in the regression equation predicting routine problem score. That is, the addition of the gender*confidence interaction term resulted in a significant rise in the multiple R from .14 to .30.[1]

Thus, Confidence functioned differently for females and males. In the prediction of the routine problem score for males, when considering an average score on the problem-solving strategies measure, higher scores were related to higher Confidence scores. For females, an inverse relationship exists. That is, high routine problem scores were related to lower Confidence scores, although at the mean Confidence score the routine problem scores are almost identical (see Figure 1). In the prediction of the standardized test score for males, when considering an average score on the problem-solving strategies measure, higher scores are related to higher Confidence scores. For females, regardless of the Confidence score, the standardized math test score remains in the range of 80 to 85 (Figure 2) indicating a relatively weak and inverse relationship between Confidence and the Iowa score.

Table 1

Means, standard deviations and results of t-tests performed on gender for math achievement measures, confidence in learning math and problem-solving strategies score

Variable	No. cases	Mean	S.D.	T	2-Tail Prob.
IOWA MATH CONCEPTS					
MALES	51	78.7	19.2	0.17	NS
FEMALES	69	78.1	18.9		
IOWA MATH PROBLEMS					
MALES	51	73.5	19.6	-0.03	NS
FEMALES	66	73.6	19.9		
IOWA MATH COMPUTATION					
MALES	51	76.5	17.2	-1.45	NS
FEMALES	70	81.2	17.8		
OVERALL IOWA					
MALES	52	79.2	16.7	-0.47	NS
FEMALES	68	80.6	17.2		
ROUTINE PROBLEMS					
MALES	52	74.7	23.3	1.13	NS
FEMALES	70	70.0	22.1		
NON-ROUTINE PROBLEMS					
MALES	52	66.4	26.0	0.23	NS
FEMALES	70	65.3	26.3		
CONFIDENCE IN MATH					
MALES	52	49.3	7.8	2.68	<.01
FEMALES	70	45.6	7.5		
* ALB SCORE					
MALES	51	80.7	10.7	-1.37	NS
FEMALES	70	83.1	8.3		

* = strategies

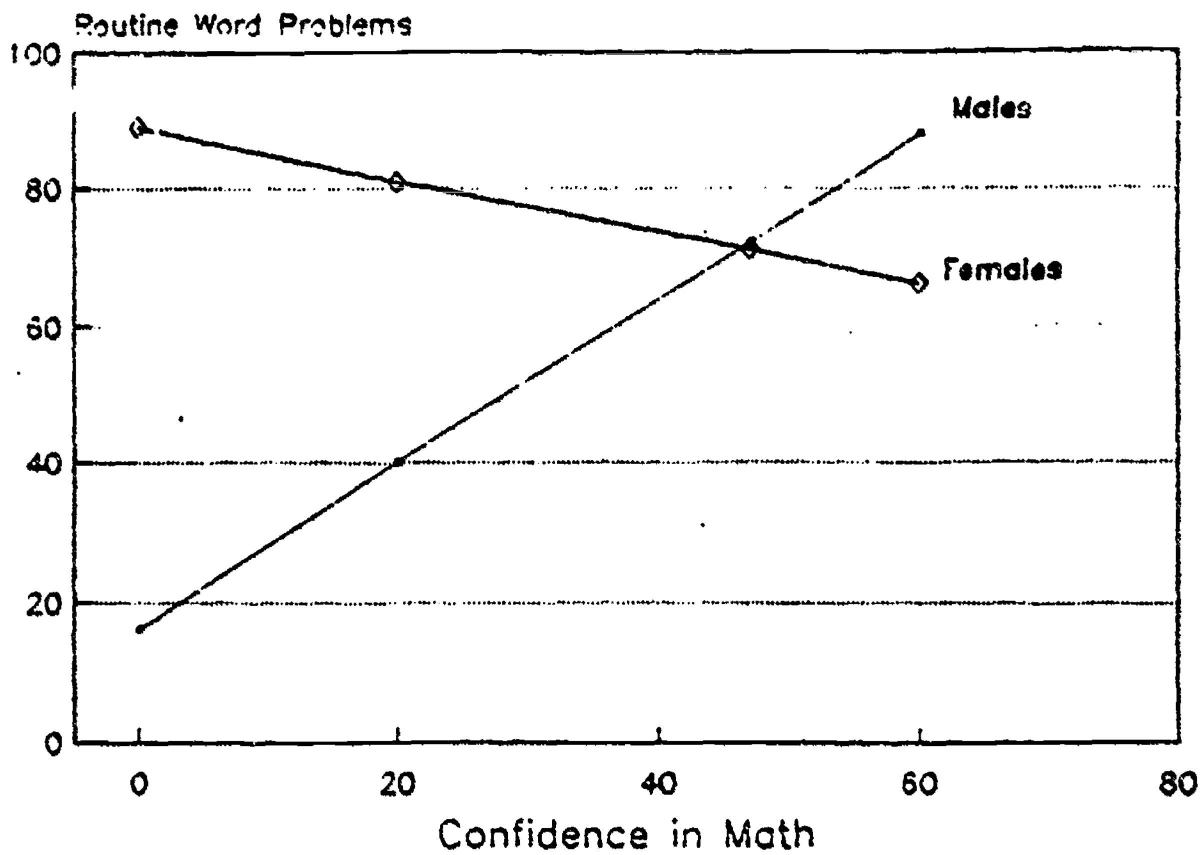

Figure 1

Regression lines for females and males of the relationship between confidence in learning math and routine word problem score when considering problem-solving strategies

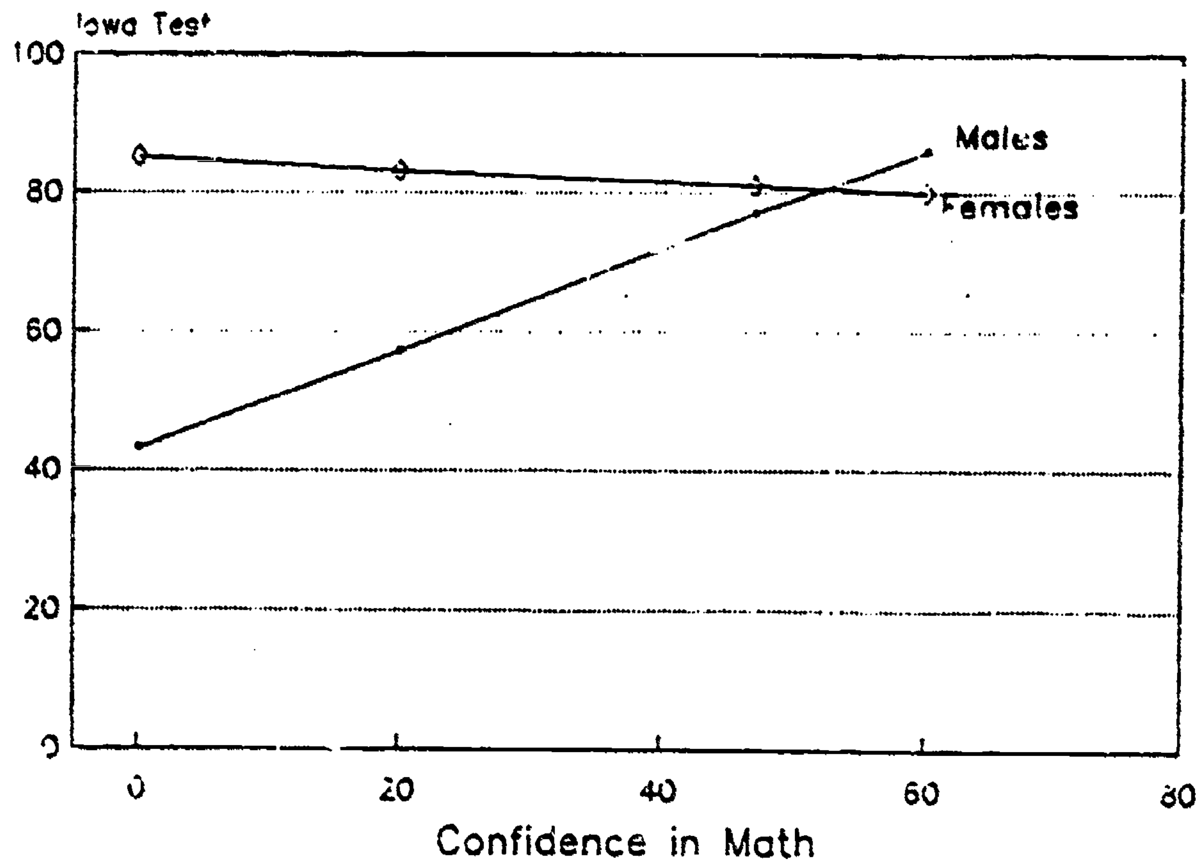

Figure 2

Regression lines for females and males of the relationship between confidence in learning math and standardized math test score when considering problem-solving strategies

DISCUSSION

Results suggest that at the eighth grade level, math problem-solving strategies are similar for females and males. That is, at this level, the notion of specific autonomous learning behaviors supposedly exhibited in problem-solving strategies appear not to differentiate between female and male students. Nonetheless, it is possible that at the highest levels of math study, perhaps in advanced calculus or high school honors math classes, gender differences in problem-solving strategies may exist. Future research should focus on the most advanced courses in an effort to discover if indeed males and females engage in different strategies when solving difficult math problems.

The study served to elucidate other issues regarding problem-solving strategies, gender, confidence and math achievement. In the problem-solving strategies measure, the section on the "math classroom," with items drawn heavily from the work of Leinhardt and Putnam (1986) appears to best describe how researchers may conceptualize autonomous math learners. Items such as "when my math teacher makes a mistake, I say something about the error;" "I like to do new word problems by myself, even before the teacher explains them;" and "I usually ask questions of the "what if" and "why" type" appear to describe students who are willing to take personal responsibility for their *learning*. Thus, it may be important to expand on research conducted in the math classroom, specifically by interviewing students in an effort to discover cognitive processes and strategies used during the *learning process* rather than exploring strategy use during actual problem solving *performance*.

Another issue which merits exploration is the finding that the strategies score is *negatively* related to standardized math test score. Although there was a variety of item types, many from the first three sections fall into a broad category describing a meticulous problem-solver, a "careful worker." Given the time factor involved in the standardized testing context, it is likely that meticulous, step-by-step problem-solvers would not do as well as those who skip steps and take chances. Thus, skills that serve students well in the math classroom and are indeed endorsed by teachers, may be counter-productive in the standardized testing context. The skills that are seen as important in the math classroom and by problem-solving researchers may help students to better understand and enjoy the nature and process of problem-solving. Unfortunately, these skills appear not to be valued by those who construct and monitor procedures of standardized tests.

The finding that Confidence in learning math is related to standardized math test scores differently for females and males, warrants further discussion. It has been assumed that Confidence in learning math is important in that it may impact on student math achievement. Thus, one approach to increasing math achievement for females has been to attempt to increase their confidence. These results indicate that a different explanation may be appropriate. For males in this sample, the higher the math achievment level, the higher the score on the Confidence in learning math measure. There is no way, however, of suggesting the causative relationship of these variable. For females, the relationship between Confidence level and achievement level suggests that confidence in learning math may not be an important variable. Past research conclusions have suggested methods to increase females' confidence in their ability to learn and perform well in math. However, one may also conclude that regardless of past achievement, females remain less confident than males in their ability to achieve highly in math.

This final result is disturbing since it indicates that females continue to be less confident in their math performance than are males achieving at the same level. So, why aren't the girls "where the boys are" when it concerns their confidence to continue achieving in mathematics? Two possible explanations are explored here.

First, it is possible that females are simply reluctant to voice their confidence in an area that has been traditionally defined as "male." Perhaps if they "sound too confident" and then fail, they believe they have supported the status quo, that is, that they just cannot "do math." Indeed, the sizeable literature on females' attributions for success and failure suggest that as a group, females are less likely than are males to attribute success to ability and more likely to focus on effort. In a small research project I conducted several years ago, the high school sophomore females whom I interviewed felt they could achieve as well in math (and indeed did) as their male cohorts, yet they believed that it would require great effort for them to continue to do well. The issue of effort did not appear to affect the considerations of the male students interviewed.

Another possible explanation is that perhaps females "buy into" the predominant value system and cultural belief that females cannot or should not achieve as well in math as should males. Thus, to be confident in an area in which they simply happen to achieve well is to go against a belief system that has defined "proper" behaviors and interests for females and males. Certainly, we see many more males occupying careers in which the study of high levels of math is necessary. According to feminist beliefs, the lack of females in these careers cannot be explained by an innate lack of ability, but a reaction to the prescriptions and proscriptions of society. While "buying into the system" may allow math talented females to feel "safe" by not "making waves," these behaviors serve to reinforce stereotyped notions of appropriate choices for women.

While the girls may not be "where the boys are" in terms of their confidence to achieve well in math, they certainly should be supported by math educators who recognize their abilities and allow them to expand their notion of available choices. Instead of working on increasing females' confidence, perhaps intervention programs can stress existing strengths, help girls to focus on the positive, stop using boys as the comparison group, and truly allow females to experience their successes in math as real accomplishments of which they can be proud.

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