Classroom Influences on Girls' Interest and Performance in Math and Science

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Researchers interested in sex differences in students' performance and interest in math and science have looked at three types of classroom influences: differential treatment, general teaching practices and classroom climate, and general classroom and school cultures. Today, I am going to talk briefly about each, citing example research studies. Since I believe all of these processes are important, I will not attempt to either compare their relative importance or the evaluate the research underlying each type. I will note, however, that there has been a historical trend toward less and less differential treatment. Consequently, many classrooms today do not show all, or even most, of these differences. Nonetheless, differences are still sufficiently common that most children will experience some or all of these differences over the course of their elementary and secondary school education. In addition, while the differences have declined, we still find little evidence of teachers actively intervening in such a way as to facilitate the interest and involvement of girls and women in math and science.

Differential Treatment within the Classroom

The classic orientation on classroom influences has focused on the issue of differential treatment within the classroom.Typically, these studies have looked three types of issues: (a) differential instructional time or opportunities to acquire skills (e.g. Leinhardt, Seewald and Engel, 1979, (b) differential teacher responses or requests linked to teacher expectations and gender-role stereotypes such as the level of question asked, response to student errors, and responsiveness to students' who raise their hands (e.g. Eccles and Blumenfeld, 1985; Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon 1985; Sadker and Sadker, 1985), and (c) differential treatment linked to praise and criticism (e.g. Eccles and Blumenfeld, 1985).

While the finds across studies are not always consistent, when differences emerge in math and science classes, the differences generally favor males. For example, teachers spend more time teaching boys math and science than girls (Leinhardt et al., 1979). Teachers are more likely to assign boys to head a laboratory team (Kahle and Lakes, 1983; Wilkinson & Marrett, 1985). Teachers are more likely to call on boys and to allow boys to monopolize classroom interaction (Eccles and Blumenfeld, 1985; Sadker and Sadker, 1985). Boys, especially high ability are more likely to receive praise for their correct answers than girls (Parsons, Kaczala, and Meece, 1982). As a result of these patterns, boys, in general, are getting more instruction in math and science and high ability boys are getting more positive feedback and more opportunity to practice their math and science skills than girls in general and high ability girls in particular.

There is one other differences in treatment: Boys get more criticism than girls (e.g. Brophy and Good, 1974; Eccles and Blumenfeld, 1985). This difference has two possible consequences. First, criticism of poor performance can convey a strong message regarding teacher's high expectations for high ability children. To the extent that teachers are more comfortable giving this type of feedback to high ability boys, the boys are getting a stronger message than the girls that the teacher has high expectations for their performance in math and science. For the other boys, the pattern of high teacher criticism usually results from conduct criticism. Boys, especially low and average ability boys, are more likely to be yelled at for misconduct than girls (Eccles and Blumenfeld, 1985). Years of such experiences may innoculate boys from adult criticism and allow them to discount negative feedback from the teacher more easily than girls can discount such feedback. As a result, boys, especially low and average ability boys, may be able to maintain high expectations for themselves despite negative feedback.

Before leaving this section, it is important to discuss briefly whether differential treatment reflects sexists attitudes on the part of the teacher or differential patterns of behavior on the part of the children. The answer to this question is not clear. Several recent studies suggest that much of the differential treatment reflects teachers reactions to differential behavior on the part of the children: For example, boys get yelled at more because they act out more and boys get called on more because they volunteer more and engage in other behaviors that demand the teachers attention (Eccles and Blumenfeld, 1985; Lockheed et al., 1986). Other data indicates that at least some teachers do over react to differential behavior in their students, leading to greater differences in teacher treatment than one would predict based just on student differences in their behavior patterns (Eccles and Blumenfeld, 1985; Sadker and Sadker, 1985). Both of these accounts are probably correct. But whatever the origin of the differences in treatment, it is clear that most teachers are doing very little to actively try to change the sex differences in their students' behaviors and attitudes toward math and science.

General Classroom Teaching Practices and Climate

The second strategy to studying classroom influences on sex differences in students' performance in and attitudes toward math and science is quite different. Researchers in this tradition identity a set of characteristics that makes some classrooms special and then observe and compare these classrooms to more typical classrooms. For example, both Pat Casserly (1975) and Jane Kahle (1983a,b) have identified "superb" teachers and then compared how these teachers teach their classes with the techniques used by more "average" teachers. Casserly and Kahle used criteria such as average student achievement level to define these "superb" and "average" teachers. Following a similar strategy we identified classrooms in which these were few sex differences in the students' attitudes toward math and compared them to classrooms in which there were large sex differences, favoring males, in the students' attitudes toward math.

Even though researchers have used a variety of criteria to define their classroom types, there has been reasonable consistency across studies regarding the distinguishing characteristics of good, and/or non-sexists, classrooms. In our study, for example, we compared classrooms in which the boys and girls had similar self-perceptions and similar confidence in their mathematical ability to classrooms in which the boys had substantially higher confidence in their math ability than the girls (Eccles, MacIver, and Lange, 1986; Parsons, Kaczala, and Meece, 1982). Classrooms in which there were no sex differences were more orderly, less effective and more business-like. The teacher also maintained tighter control over student-teacher interactions, making sure that all students participated by calling on everyone rather than focusing on the small subset of students who regularly raised their hands. In contrast, in the classrooms that had sex differences in the students' attitudes, student-teacher interaction tended to be dominated by a few kids. Essentially these teachers appeared more reactive; only students who raised their hand were called on. Consequently, a running dialog emerged between the teacher and the two or three students who both sat in the front of the room and regularly raised their hands. Other students rarely raised their hands, and were never called upon to participate. They sat out of the teacher's view, and as long as they didn't cause a disturbance or get into trouble, they were allowed to be non-participants. The latter group of students included both the boys for whom the teacher had low expectations and most of the girls.

We found one more difference: The classrooms in which boys and girls had similar views of their abilities were less public and more private. Essentially,. these classrooms were characterized by more dyadic interactions between the teacher and the student and less whole class public drill. Consequently, the students spent less time waiting to be called on and competing for public attention, and more time working on problems and consulting individually with the teacher when help was needed. This teaching style appears to have beneficial effect on girls, perhaps because it induces a less competitive environment. It's an environment in which you can work and get feedback without that feedback having to be public.

We have just completed a second study using a similar approach (Eccles, MacIver, and Lange, 1986). In this study we gathered information on 110 mathematics classrooms rom the students and the teacher and compared the classroom in which the girls had more favorable attitudes than the boys (girl-friendly classroom) with classrooms in which the boys had a more favorable attitude towards mathematics than the girls (boy-friendly classrooms). The girl-friendly classrooms were characterized by less social comparison and competition amongst the students, by more teacher stress on the importance and value of mathematics, and by a warmer, fairer teacher.

Pat Casserly, using a different criteria of excellence, found a very similar pattern of results (Casserly, 1975, 1979). She identified the 20 school districts in the United States that had the most favorable record of girls going on to take Advanced Placement courses in math and science.[1] She then observed and interviewed these teachers in an effort to identify their particular teaching skills and strategies. Five characteristics emerged with great regularity. These teachers were more likely to use either cooperative learning strategies or individualized learning strategies than public drill. They were less likely to use competitive motivational strategies; that is, they didn't try to pit the students against each other in order to get them motivated to study mathematics. They used more hands on learning. They used more practical problems with the possibility for creative solutions; that is, rather than treating math and science as subjects in which there is a right or wrong answer, they would pose problems like -- Build a bridge that can bear a maximum amount of weight -- and then would put the students into teams. These teams could solve that problem in a variety of ways. These teachers also engaged in a great deal of active career guidance in the classroom, stressing the importance and the usefulness of math and science for the students other courses and for their future directions.

Jane Kahle (1983a,b) has done a similar study in science classrooms; she found a very similar cluster of techniques to be characteristic of teachers who have been labelled as outstanding science teachers. These teachers tended to use multiple texts and to carefully supplement their texts with information about the involvement of both males and females in math and science and with pictures of scientists of all nationalities, races, and both genders. They were careful to avoid the use of sexist or racist materials and they provided a lot of active career guidance during class time.

When they used hands-on experience (which they did a lot), they were careful to make sure that everyone participated actively. Use of computers in the classroom provides an excellent example of the importance of this type of teacher control. Too often when computers are introduced into the classrooms, especially in elementary school, the pattern of a single male dominating its use emerges especially when the students are allowed to control access to the computers. A similar pattern often emerges with other types of scientific or laboratory equipment. Kahle's "good" teachers made

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[1] These districts also had the best record with boys. Apparently, techniques that work for girls also work with boys.

sure everyone participated that everybody had a chance to be the "boss" in the laboratory group, that everyone got to work with the equipment, and that everyone had equal time on the computer. This is not easy to do, it requires a very organized teacher who is committed to everyone having a change to work with the equipment. Instead, all too often, a few students, usually white males, take over and other students, usually girls, watch. This is especially true of computers particularly when the teacher is uncomfortable with this new technology. These teachers often find a confidant in the classroom who knows something about computers and then put this person in charge of the computer. This person then monitors who gets access to the computer, and how long they get to use it. More than likely this person is a white male who has had the privilege of someone buying him a computer at home or sending him to computer camp.

What can we conclude? It appears that there are certain kinds of learning environments that may not be particularly conducive to most girls' motivation to study math and science. These characteristics seem to be competition, social comparison, high use of public drill, and domination of student-teacher interaction by a few students. In contrast, there are certain kinds of learning environments that appear to be more beneficial to girls, and maybe to minorities and to boys who are having trouble as well. These appear to be controlled hands-on experience, use of non-sexist and non-racist materials, cooperative or individualized learning formats, and active career counselling.

Jane Kahle has labelled this latter type of classroom a "girl-friendly" classroom. These classrooms have the following characteristics: The teachers use multiple texts, they don't use sexist humor, sexist material, or sex=stereotyped examples, and they give regular non-competitive tests to assess the students progress. The classrooms are neatly decorated with pictures of both female and male scientists of all races. The teachers use individualized instruction, hands-on laboratory work, and small group discussions; they involve everyone, making sure that everyone (both boys and girls) actively participates, that no one can opt out of participating in the classroom just be being a quiet, non-intrusive student; and they don't rely on competitive motivation strategies. In particular, they don't use competition between the sexes to motivate boys. Finally, they provide a lot of career education and educational counselling.

Classroom and School Culture

Classroom culture. Boys' and girls' experiences in school differ in other ways. Several investigators (e.g. Delamont, 1980; Kahle and Maytas, 1987; Klein, 1985) have pointed out a variety of subtle forms of classroom interaction that reinforce gender-stereotyped behaviors. For example, teachers often use competition between boys and girls as a means of motivating and controlling the boys: Boys are admonished for letting the girls excel them and teased if they do not conform to the teacher's expectations; girls, on the other hand, are often excused for poor performance because it does not really matter whether they excel or not, particularly in math and science. Teachers also tend to assign classroom tasks in a sex-stereotyped manner: girls are asked to be class secretary and boys to be team captains or laboratory work group coordinator. Boys and girls are also often segregated for a variety of activities, including lining up to go outside and being assigned to special projects and athletic teams.

Each of these forms of differential treatment reinforces traditional stereotypes of the appropriate behaviors and roles of boys and girls. Consequently, they convey the message that one ought to engage in sex-appropriate behaviors and ought to aspire to sex-appropriate adult jobs. Sex segregation in the children's activities also denies boys and girls the opportunity both to see children of the opposite sex performing non-traditional activities competently and to interact with each other in a variety of settings. As a result, sex stereotyped notions of competence and appropriate interaction patterns remain unchallenged and are likely to persist into adulthood. Finally, differential task assignment insures that boys and girls have different opportunity to practice leadership and problem solving skills. This is especially critical in mathematics and science where girls are likely to doubt their leadership and problem solving skills.

The propensity to reinforce traditional aspirations and choices is exacerbated by the sexist materials typically used in American elementary and secondary schools and by the absence of non-traditional role models. Textbooks and supplementary curricular materials such as posters and films are biased against females in two ways: women are portrayed less frequently than men and in a much narrow range of activities and occupations than men. These differences are especially marked in the upper grades and for science, math, and traditionally male-typed vocational education courses (Wirtenberg, Murez, and Alepektor, 1980). Similarly, male and female school personal typical occupy sex-stereotyped jobs: Principals are usually male; elementary school teachers and secretarial staffs are usually female; math and science teachers are quite likely to be male while English, foreign language, and social science teachers are likely to be female. Thus, it is unlikely that females will be exposed to many examples of women engaged in non-traditional activities in their academic classrooms, especially their math and science classrooms. What about in their counseling experiences?

Counseling. Like teachers, school counselors tend to reinforce traditional occupational aspirations. In many cases, they discourage nontraditional course selection and occupational choices -- if not actively, at least passively -- by questioning the wisdom of such a decision, and by pointing out the potential dangers associated with being in a nontraditional field (Tetenbaum, Lighter and Travis, 1981; Thomas and Seward, 1971). School counselors also tend to have a restricted view of occupations appropriate for women (Medvene and Collins, 1976), to suggest different occupational choices for gifted males and females (Donahue and Costar, 1977), and to view the traditionally feminine occupations as more appropriate for females (Thomas and Stewart, 1971). Furthermore, counselors in general, and male counselors in particular, are often ill informed both about the probability that a girl will have to work a major portion of her adult life and about how traditional job choices affect her earning potential (Bingham and House, 1973). As a result, girls are often given inadequate career counseling. They are not encouraged to translate their talents into careers or occupations that will maximize their earning potential. Too often this means that girls with a talent for math and/or science are not encouraged by their counselors to consider careers or special educational opportunities in math and science.

Girls are also often given poor advice about course selection by their school counselors. For example, it is not uncommon for girls to be allowed to drop twelfth grade math without being told the number of college majors that require four years of high school math or the range of careers that require advanced math training. As a result they graduate from high school with inadequate background for many college majors.

Sex Composition in the Classroom. The last type of classroom culture variable I'd like to discuss is sex composition. Again, while the evidence is mixed, when effects of sex composition emerge, the results suggest that girls do better in, and maintain more interest in, math and science in single-sex schools and classrooms (Delamont, 1980; Hamilton, 1987; Lee and Bryk, 1986; Tidball and Kistiakowsky, 1976). Females in single-sex schools in both British Commonwealth countries and the USA are more likely than females in co-educational schools to major in math and science and to enter non-traditional occupations including math and science-related fields. They also score better than their females at co-educational institutions on A-level exams in mathematics and science. But a wide spread shift to single-sex schools is unlikely in the USA, especially at the secondary school level. What are the alternatives? First, we can have special classes or programs for females even in co-educational programs. Second, we can make sure there are a critical number of females in all math and science classes. Data from intervention studies suggest that at the very least, we should be sensitive to the sex composition of the classroom and the work group and should make sure there is a critical mass of females in the group (Fox et al., 1980; Stage et al., 1985). Females do better and are more likely to maintain their interest in math and science when they are not part of small minority group in their classroom.

Conclusions

In this paper, I have reviewed the major findings on classroom influences on females' performance and interest in math and science. The findings suggest three types of classroom influences: differential treatment, general teaching styles, and classroom and school cultures. Processes associated with all three of these influences discourage girls' participation in math and science.

What can be done? Even though most teachers do not actively work to increase girls' interest in math or science, teachers are uniquely situated to do this. One of the ways that "superb" teachers produce such positive outcomes is by active career counselling and value resocialization. They change the girls' views of who they are and who they can become. And, by making an enjoyable experience for both the boys and the girls, and by engaging in active career counselling in the classroom, they also change the values that girls attach to mathematics. By providing students with a reason for studying math and/or science, and by telling them how these subjects relate to the occupational world, these teachers give students a reason for wanting to learn math and science. In essence they provide an answer to the question "Why should I study more mathematics or science?" for those students who don't find math or science especially interesting or enjoyable. I have always loved mathematics and never had any trouble learning it. Consequently I was one of those students who took mathematics because of intrinsic interest. I found it an aesthetically pleasing activity. But this orientation is not typical of most high school students. And most of the math classes I have observed are not very interesting. Consequently, if a student doesn't find math or science aesthetically pleasing, then they probably find them either boring or very anxiety provoking. When teachers do something "special" to make the math or physical science classroom an enjoyable place to learn or when teachers do something "special" to make the relationship between the math and science they are doing in class relate to "real" world problems or future job choices clear, students, especially females, respond more positively to the subject matter and appear to gain in confidence as well.

Teachers are also in a unique position to identify, on the spot, talented, motivated students, women and minorities especially, and to communicate their confidence in these students to the student. Females and minority children appear less likely than males to label themselves as math or science talented. Females are more likely to say, "I'm doing well because I'm a hard worker" than "Gee, I must really be good in mathematics, I ought to think about going on and studying more mathematics." The teacher can make this assessment and provide this feedback. The teacher can go one step farther; she or he can call home and let the parents know their child is very good in mathematics and/or science. The teacher can provide the parent with information about educational and vocational options appropriate for their child. Most parents want the best for their children but since they were raised in a sex-typed culture and have had little exposure to non-traditional models or information, they often overlook non-traditional career possibilities for their children. With information from the schools, from a recognized expert, telling them that their child has math or scientific talent, parents may be more likely to encourage their daughters to think about careers in math or science related fields.

Finally, teachers are in a unique position to expose students to non-traditional role models -- in print, in pictures, and in person. Evidence from a variety of source document the power of role models to both make new options salient and increase the probability of non-traditional choices (see Eccles and Hoffman, 1984). Exposing young women to female models in various math and science-related professions should make these professions seem more attractive, especially if the models are successful in those personal and familial aspects of their life that are central in young woman's life goals.

All of these recommendations require very active involvement on the part of the teachers. Such involvement is easier not that there are good curricular material packets available for women students. These materials provide teachers with films and posters that will expose the students to minority and female role models in fields associated with math and science. Such materials can open up new options for the students by providing information about jobs they may not have thought of or may not be aware of. They can also provide new images of professions the students think they are familiar with. For example, not all engineers wear hard hats and live on an Arabian desert. Engineers do many different things, many of which involve helping people. By pointing these options out to girls, the teachers can get girls to entertain the possibility of such occupations.

In closing, it seems evident to me that at this historical point, in this culture, equal treatment in schools is not enough if our goal is to increase the probability that young women will seriously consider non-traditional educational -- or vocational options. It certainly is the minimum we must aspire to. But since children are exposed to a heavy dose of gender-role socialization outside of school, they come into the classroom with well-formed, gender-role stereotyped beliefs about what is appropriate for them to think about in terms of their long-range vocational goals and in terms of their view of their own competencies. If we are to get women involved in math and science, and if we are to change the impact of gender-role beliefs on females' self-perceptions, then we must use the classroom and the school to counteract the years of socialization messages the children have received from the t.v. and from the culture at-large. Only such active interventions will get students to reconsider their view of themselves, of math and science, and of the options that they should consider as they move towards adulthood.

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