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While studies that show lower achievement for girls often receive wide publicity, studies that show the opposite may not. Research on the International Educational Association (IEA) mathematics results from 20 countries at the Grade 8 level (age 13) shows that boys and girls are about equal in achievement, and that the differences among countries are much larger than any differences within countries (Hanna, 1989).

Another study which challenges the popular notion of girls and lower mathematics achievement is one by Alan Feingold (1988). In reviewing the research results on cognitive gender differences for a period of 30 years in the United States, Feingold shows that differences had actually declined over the three decades preceding his study. Clearly the research message is that the problem of gender differences and mathematics achievement, and on gender-based inequities in mathematics-related careers, is a socially constructed one.

At the same time numerous studies have been done which indicate what can be done at the level of societies and of education systems to counteract the development of gender inequities. This discussion paper is an attempt to summarize key questions in one segment of the literature on retaining girls and women in mathematics and science — namely, analyses of gender issues in mathematics education. It is hoped that the identification of the relevant questions will focus attention on key gender-related issues in mathematics education for the 1990s and beyond.

## 2. FACTORS GENERATING GENDER INEQUITIES IN MATHEMATICS

### ATTITUDES

Femininity and masculinity are socially developed constructs which are reinforced by the interactions of children with each other and with adults. Implicit and explicit assumptions and messages about female and male intelligence, needs, and inclinations seem to affect attainment in mathematics. To a certain extent, gender differences in mathematics performance might be a reflection of differences in attitudes towards mathematics.

Girls tend to avoid mathematics courses when they are no longer compulsory. It appears that the attitudes females have towards mathematics, their feelings as learners of the subject, and the values that shape their attitudes determine whether or not they persist in mathematics course-taking. Girls who are aware that mathematics will be relevant to their lives and useful in their future careers are far more likely to remain in mathematics courses.

The larger question in this context pertains to socialization. What is its role in the observed differences in attitudes towards mathematics? More specifically, the following questions are helpful:

- Is there an implicit message in society that competence in mathematics is more important for the attainment of boys' career ambitions than it is for girls?
- How can we increase the confidence of females in their ability to do mathematics?
- Do specific teaching approaches and learning modes lead to more positive attitudes to mathematics?
- How does understanding the similarities between male and female achievement and attitudes help practitioners establish a basis for resolving inequities?

## CULTURE

Ethnomathematics recognizes the influence of sociocultural factors on the teaching and learning of mathematics. Documentation exists that emphasis placed within schools on the application of mathematics differ markedly within countries and from country to country and that this emphasis affects student performance. We have much to learn from this research, especially if we include consideration of the following additional questions:

- How informative are, or what do we have to learn from, international performance comparisons?
- Are there cultural patterns, such as social customs, family customs, customs in our educational system, and customs specific to mathematics, that discourage girls and women from pursuing mathematics?
- What difficulties in mathematics do males and females from minority groups face?
- What methods of encouraging, recruiting, and retaining women and minorities are used by different cultural and national groups?

## MATHEMATICS AS A DISCIPLINE

Recently, the existence of gender biases in the practice of mathematics has been studied extensively from several different perspectives including a feminist one. The questions emanating from this line of research are worth examining. Some essential questions are:

- What are the consequences in the theory and discourse of mathematics of the fact that it was constructed in predominantly patriarchal societies?
- Does the nature/structure/language of mathematics have a bias that promotes gender imbalances?
- What is the nature of the different areas of mathematics that appears to encourage (or not, as the case may be) students to persevere?
- What features of mathematics as a discipline (e.g. the contribution it can make to developing creativity and enjoyment, and its value in developing reasoning powers) can be emphasized to make it more relevant to both genders?

### 3. MANIFESTATIONS OF GENDER INEQUITIES

#### JOBS AND CAREERS

Historically woman have been seriously underrepresented in mathematics and related fields. This does not appear to be due to lower levels of achievement. Gender-related differences in mathematics achievement, when they are found, are very small and thus do not account for these large participation discrepancies. Even though more women have chosen to pursue careers in mathematics and science in the last decade, there is still a concern over their low representation in mathematics, engineering, and the natural sciences.

Educators need to pursue an understanding of the factors that account for the discrepancies in involvement in higher level mathematics courses and to develop strategies that will help both genders stay in mathematics courses and thus keep open the full spectrum of career and job options. Research still needs to be done around the following questions:

- Do social perceptions (media, publicity, etc.) discourage girls from choosing careers that require mathematical skills?
- How can (female) students be helped to see that mathematics can also contribute to the solution of problems which they will meet out of school and to job opportunities?
- Should the privileged position of mathematics as a screening device for professions be challenged?
- Why hasn't the preparation in mathematics translated into greater numbers of female science and engineering majors?
- How can the visible proportion of women in mathematics and related fields be increased so that these options and occupations become part of female students' accepted range of choices?