1. Rationale for the study

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GENDER AND MATHEMATICS EDUCATION

KEY ISSUES AND QUESTIONS

DISCUSSION DOCUMENT FOR AN ICMI STUDY

1. RATIONALE FOR THE STUDY

The study proposed in this discussion paper is based on a simple premise: there is no physical or intellectual barrier to the participation of women in mathematics, science, or technology. Having said this, we must ask ourselves: why don't they participate more? Here there is no simple explanation. For if there are no physical or intellectual barriers, there must be social and cultural barriers that account for their underrepresentation. For the most part, these barriers have not been raised intentionally. They are an integral part of a social order that carries with it discrimination. The perspective of this study is that discrimination on the basis of gender is no longer acceptable. Judge Rosalie S. Abella, an advisor to the Ontario government, has posed the problem as follows:

> Systemic discrimination requires systemic remedies. Rather than approaching discrimination from the perspective of the perpetrator and the single victim, the systemic approach acknowledges that by and large the systems and practices we customarily and often unwittingly adopt may have an unjustifiably negative effect on certain groups of society. The effect of the system on the individual or group, rather than its attitudinal sources, governs whether or not a remedy is justified.
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> Remedial measures of a systemic and systematic kind are meant to improve the situation for individuals who, by virtue of belonging to and being identified with a particular group, find themselves unfairly and adversely affected by certain systems of practices (CAUT, 1991, p. 12).

Statistics on the participation of women at the tertiary level in general and in mathematics, science, and technology in particular strengthen the case for a social, systemic viewpoint. We have to ask why women specifically avoid mathematics and sciences. Taking Canadian data as an example, we note that

while women are attending universities in unprecedented numbers (and earning more than 50% of all bachelor's degrees in Canada), they are overrepresented in the humanities and underrepresented in mathematics and science. The proportion of women undergraduate students in the mathematical and physical sciences increased from 19.4% to 28.5% in the years 1971-1987, and in the engineering and applied sciences it increased from 1.2% to 12.2%. This constitutes very modest progress, when one compares it to the progress women have made as students in other traditionally male-dominated professions. Over the same period (1971-87), the proportion of women among those obtaining a bachelor's degree in law increased from 9.4% to 46.7%, while the proportion in medicine went from 12.8% to 41.7%. At the doctoral level, though women have increased their participation they are still underrepresented in mathematics and science.

Two decades of research on the problem of gender imbalance in higher mathematics, and in mathematics-related carriers, have consistently found that when gender-related differences in achievements are present they are rather small. Or put in other terms, achievement *per se* does not account for the large discrepancies in enrolment in higher level mathematics courses and in the election of mathematics-related carriers. This finding is perplexing in light of what we find in the media on girls and mathematics and science.

In the United States and Canada, and in other countries as well, a lot of publicity has been given to girls' supposed inferiority in these subjects. Articles have appeared in popular magazines claiming that women are inferior in what they have referred to as "cognitive abilities", "spatial skills", or "aptitude for mathematics". It has also been claimed that women are incapable of grasping mathematics or science because they are "emotionally minded". It is hardly surprising that such messages in the popular press influence girls to believe in their inherent ability to succeed in mathematics, and thus discourage them from taking up mathematics or other branches of science.

Such claims are usually based upon studies of achievement. Yet, as stated above, most studies that have found achievement differences in favour of boys have found very small differences that are not educationally significant. The more important point is that the popular press, and indeed many of the researchers, have confounded achievement with aptitude, ignoring other factors. The truth is that we do not really know how to measure aptitude, or even whether aptitude alone is a determining factor in achievement. Some research suggests that learner's attitudes towards learning and their career aspirations are powerful determinants of achievement.

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.