COMMISSION INTERNATIONALE DE L'ENSEIGNEMENT MATHÉMATIQUE (THE INTERNATIONAL COMMISSION ON MATHEMATICAL INSTRUCTION)

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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.

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?

— How can women's opportunities for careers in scientific and technical professions be expanded? Conversely, should women go into mathematics-related fields given the nature of the present system?

Girls and technology

The technological environment can, and does, affect student attitudes and their conceptions of what comprises desirable knowledge and understanding. In 1990, Ursula Franklin noted that the practices used in technology define its content and "when certain technologies and tools are predominantly used by men, then maleness becomes part of the definitions of those technologies". As a result, many female students do not appear to hold a worldview which includes technology as relevant to their lives or as appropriate for them.

Few educators would disagree that schools must be more responsive to the science/technology thrust of our contemporary world and to the related educational needs of all students. However, international investigations have noted consistent gender inequalities in the technological education. Important questions for educators to discuss include:

— How does the considerable and growing impact of technology on schools and its changing role affect the education of females?

— How can we foresee and influence how technology changes their education?

— Can we influence the designers and producers of technology, and hence how girls are educated, by setting technological goals (e.g. development of technical hardware for educational purposes)?

— How are the areas of computer studies and mathematics to be made more relevant/accessible to girls?

— How can the computer be used as a learning and teaching aid? What are the effects of certain implementations on the cognitive development of the learner?

— What are the epistemological changes due to the use of computers?

4. Foci for change

Curriculum

To achieve gender equality in mathematics education, educators need to look at the development, content, and presentation of the mathematics curriculum within its general educational context.

In this regard it is helpful to find examples of success in teaching mathematics to all students (and to be aware of criteria used to denote the term "success") and to learn from these successes. Some worthwhile questions for consideration are:

— Given the pattern of lower rates of female participation in elective mathematics courses, and the fact that mathematics is critical to careers at technical, professional and managerial levels, to what extent would it be appropriate to make mathematics a compulsory subject in schools?
— What would a gender neutral curriculum and pedagogy look like?
— Would single-sex education benefit students who tend to opt out of mathematics?
— Should different mathematics curricula be provided for different groups of students?
— Does the mathematics curriculum fail to deal with topics of particular concern to girls and women?
— Why do specific mathematics topics seem easier to one group of students than another?
— What are the essentials which must be contained in mathematics curricula?
— How can different components of curriculum — instructional methods, assessment programs, and resources produced by teachers and by publishers — be designed so that the development of mathematics skills and knowledge becomes a prime aim for all children?
— How can the pace and range of work in the mathematics classroom be adapted to allow for increased understanding by all students?
— Does the mathematics curriculum necessarily have to be so overloaded that the quantity tends to control the pedagogy?

ASSESSMENT

Assessment is a crucial component of mathematics education. It generally functions to provide information to assist in decision making about individual students, classes, teachers, programs, or institutions. The kind of information sought, how it is gathered, and the form in which it is reported, all have a bearing on mathematics education.

Major challenges and questions exist within the realm of assessment as it relates to gender issues. A critical question, for example, is whether mathematics is taught equally well to different groups of learners. Important queries within this larger question include:

— What is mathematical ability and how can it be measured?
— What kinds of mathematical tasks are being assessed (short technical exercises, long tasks, extended problems, etc.)?
— Are the methods of assessment used more favourable to certain groups of students?
— How can we ensure that classroom materials and exam questions properly reflect gender equity? Should they include a wider range of human activities and interests than traditional materials and examinations?
— Is the range of experiences provided in the mathematics classroom (or elsewhere in the school) biased in favour of one group of students to the possible detriment of others?
— Are there examples of assessment practices which are known to have a positive or negative influence on instruction? What aspects should be maintained and encouraged?
— Are there examples of assessment practices which negatively influence instruction; for example, by focussing instruction on assessment and tests rather than on more general goals?
— How do different assessment modes influence the social environment in the classroom?

TEACHERS AND THE SCHOOL

Teachers are one of the most important educational influences on students' learning of mathematics. The school environment or social context in which students learn mathematics is another critical factor, influencing how they learn, their expectations, their perceptions and misapprehension of mathematics and of schooling in general. More research is needed on how the ethos of the school and individual teachers shape or alter student attitudes towards mathematics.

With respect to teacher education, the general question remains of how to make teachers at all levels aware of, and hence how to eliminate, any gender bias in their current practices. More specifically, we need to ask the following questions:

— Do we need to improve in-service training? Should we increase incentives to groups to participate and the amount of time we spend on the topic of gender awareness?
— Should more research be focussed on teachers — their conceptions of their roles both in the classroom and in society, their understanding of the educational process, their methods and teaching aids?

Research has been done on the critical factors in the school environment which reduce retention of females in mathematics courses. We need to continue to ask:

— How can pupils' (particularly girls') self-confidence in mathematics be increased?
— How can the learning climate for girls be improved?
— Does the learning climate for girls improve within single-sex settings?
— How can modes of classroom organization and teacher-pupil interactions be encouraged and developed which would benefit all children?

Working with parents

Sex-role stereotyping begins at birth, a fact alluded to in the earlier discussion of attitudes and the different socialization patterns of girls and boys in our culture. This stereotyping is reinforced as the child progresses through school by the differential expectations and treatment of boys and girls by teachers, counsellors, parents, peers, and also through instructional materials and the media. It is known that parents and educators can intervene to modify the influence of sex-role stereotyping and to provide an equitable education for all students.

As well as working at the gender factor, researchers have studied how parental educational and occupational level affects their children's mathematics learning. And so the basic public and community issues pertain to how the dual disadvantage of sex-role stereotyping and social class can be overcome. More specific questions include:

— How can parents be sensitized to ways they can encourage and support their children in mathematics/science fields?
— How can public awareness be increased, especially among parents, teachers, counsellors, of the advantages of mathematics-related careers for women and their achievements in mathematics?
— How can schools take responsibility for informing the community about the importance of girls' participation in mathematics?
— How can the commitment of national and local governments to supporting mathematics education for girls and women be increased?

5. Call for papers

The ICMI Study on Gender and Mathematics Education will consist of two components, a *conference,* and a *publication* to appear in the ICMI Study series and based on the contributions to and the outcomes of the conference.

The exact site and dates of the conference have not been finally determined yet, but it will almost certainly take place in the Southern part of Sweden in October 1993.

Against the background presented above, the International Program Committee for this study invites individuals and groups to propose or submit contributions to be study for consideration by the Committee no later than *1 February 1993*. Contributions should be related to the problems and issues identified in this document but are not required to be limited to addressing these only. Participation in the conference is *only by invitation* of the Program Committee, but those who submit a contribution are encouraged to apply for an invitation.

Contributions and suggestions concerning the content of the study and the conference program should be sent to

Professor Gila HANNA, MECA
Ontario Institute for Studies in Education
252 Bloor Street West,
Toronto, Ontario M5S 1V6, Canada
Tel.: +1 416 923 6641 Fax: +1 416 926 4725
e-mail: g_hanna@utoroise.bitnet

The International Program Committee consists of:

Gila HANNA, Ontario Institute for Studies in Education, Toronto, Canada (Chair)
Geoffrey HOWSON, University of Southampton, UK
Hans-Georg STEINER, Universität Bielefeld, Germany
Heleen VERHAGE, Freudenthal Instituut, the Netherlands
The Secretary of ICMI, Mogens NISS, Roskilde University, Denmark, is a member ex-officio.

6. REFERENCES

CAUT (Canadian Association of University Teachers) (1991): *Status of Women Supplement.*

FEINGOLD, Alan (1988): Cognitive gender differences are disappearing. *American Psychologist 23 (2),* 95-103.

FRANKLIN, Ursula (1990): *The Real World of Technology CBC Massey Lectures.* CBC Enterprises, Toronto and New York.

HANNA, Gila (1989): Mathematics achievements of girls and boys in grade 8: Results from twenty countries. *Educational Studies in Math. 20,* 225-232.