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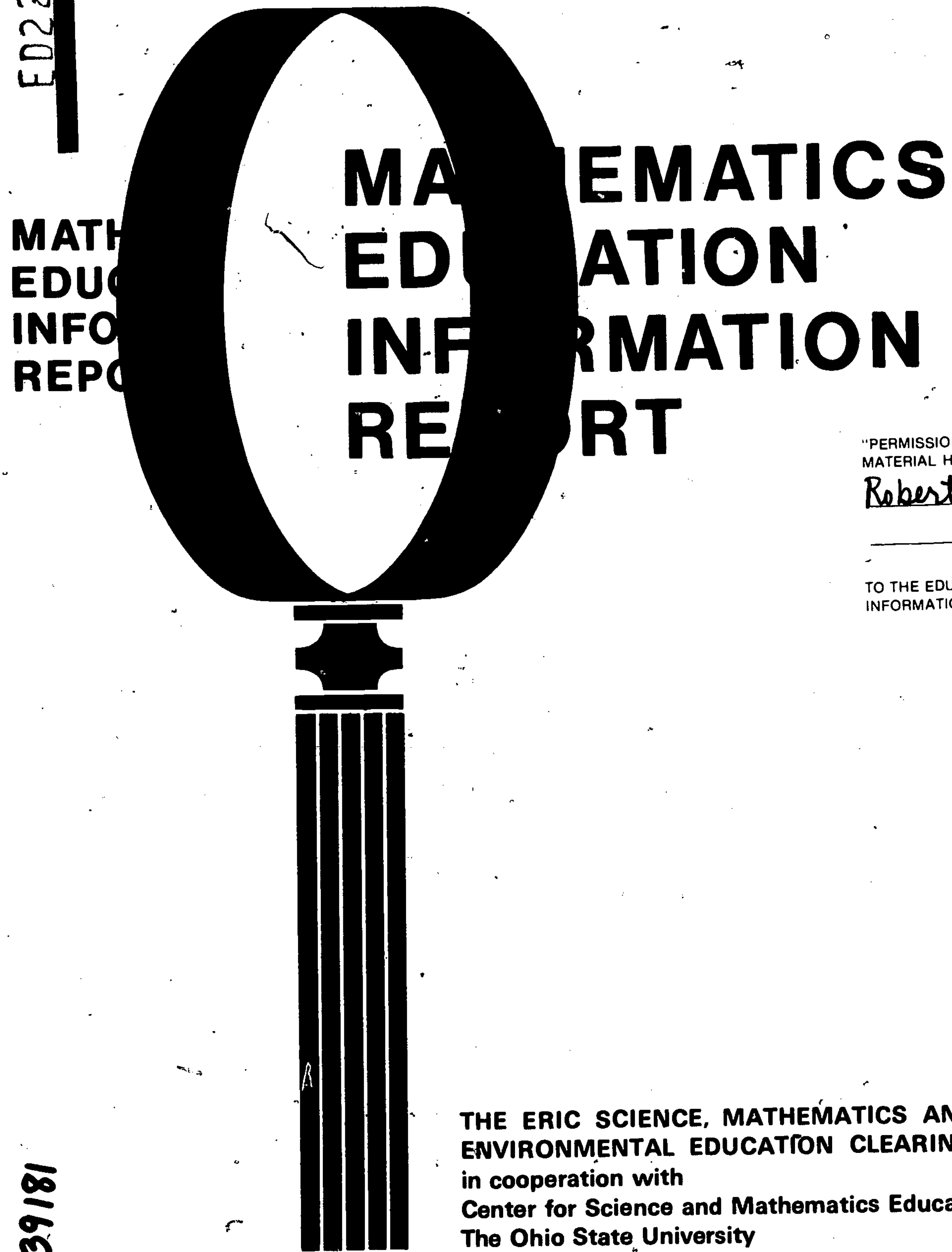
ABSTRACT

Because mathematics and gender(sex) is a research area of increasing international interest, a worldwide survey about research concerned with special problems of girls and women when learning mathematics was conducted. Reports included in this document were submitted from Australia, Canada, Dominican Republic, England and Wales, India, Ireland, Israel, New Zealand, and the United States. Points considered in the reports include the general interest in the topic in each country, research concerns (variables other than sex examined, theoretical frameworks of the research, activities resulting from the research such as programs to increase females' achievement/interest), discussions/developments on the topic, and situations unique to each country. Highlighting information received, it appears that: (1) in most countries the topic is not a central subject of empirical research, although there are some indications that as interest arises, its importance is recognized and leads to research; (2) the United States, followed by England/Wales, is far ahead of other countries in research on mathematics and gender; and (3) that different research strategies are used to understand sex-related achievement differences as explained by sex role perceptions, personality traits, and differentiated interaction processes. References, including articles and documents published in countries participating in the survey, are included. These include background papers, research reports, project information, and teaching suggestions. (Author/JN)



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Second International Mathematics Study

International Association for the Evaluation of Educational Achievement (IEA)

prepared by

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Universität des Saarlandes
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Second International Mathematics Study
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A NOTE OF THANKS . . .

. . . to each of the persons who so painstakingly prepared the national reports for this publication. The wealth of information will be of benefit to many others, providing an understanding of the basis for the need to consider the role of gender in mathematics education, information on its status in each of nine countries, and useful sources of additional information. We appreciate the insight these authors share with us.

. . . to Erika Schildkamp-Kündiger, who struggled long-distance with the task of collecting and editing these reports. She coped with it admirably, as the review testifies. We appreciate her willingness to develop this publication for us.

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Kenneth J. Travers
International Mathematics Committee

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An International Review on Gender and Mathematics

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I. Introduction*

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Mathematics and gender is a research area of increasing international interest. This is one of the outcomes of the 4th International Conference of Mathematics Education (ICME IV) in Berkeley, August 1980. Moreover, the conference showed that there are great differences between countries in regard to the theoretical background of empirical researches and in regard to their quantity. It appeared necessary to have a worldwide survey about research concerned with special problems of girls and women when learning mathematics.

Encouraged by Kenneth J. Travers, Chairman of the International Mathematics Committee for the Second IEA Mathematics Study, University of Illinois and by Marilyn N. Suydam, Associate Director, ERIC Clearinghouse for Science, Mathematics and Environment Education, Ohio State University, I started to prepare this survey. I thank both of them for their support in gathering the information and publishing this survey.

Research workers from more than 20 countries were asked to send reports about the situation in their countries. Nine reports were received from the following countries:

- Australia
- Canada
- Dominican Republic
- England and Wales
- India
- Ireland
- Israel
- New Zealand
- United States of America

This is not an overwhelming number of replies. The correspondence shows one main reason for this fact: in many countries there are no researches of interest on the subject. This was reported specifically by:

C. Brusselmans-Dehairs, Rijks University, and G. Henry, University of Liège, for Belgium,

Paavo Malinen, University of Jyväskylä, for Finland,

W. J. Pelgrum, Technische Hogeschool Twente, for the Netherlands.

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*Parts of this article go back to presentations at the 4th International Congress on Mathematical Education, Berkeley, U.S.A. 1980 and at the conference: Comparative Studies of Mathematics Curricula - Change and Stability 1960-1980, Osnabrück (West Germany) (Steiner, 1980).

The information coming from Belgium indicates that at least some persons are aware of the problem area. It is reported that in the upper secondary level girls choose less ambitious mathematics courses than boys. In interviews, members of the inspectorate and constructors of curriculum globally explain the course-taking behavior of the girls as a result of their sex-role perceptions. It is hoped that the Second International Mathematics Study will bring along further insight.

From the Netherlands one item is reported that might lead to change in the near future. In 1981 there was a discussion, organized by a group of female mathematics teachers, concerned with mathematics and gender. There were two starting points:

a) In a final examination of interest, the percentage of boys who chose mathematics as subject of examination was much higher than that of girls.

b) The proportion of female mathematics teachers is only 9 percent. It came out of the discussion that investigations analyzing the background are earnestly requested.

At this point I want to stress that the non-existence of relevant empirical studies does not necessarily mean that there is no interest in the subject. The existence of empirical investigations about mathematics and gender may be influenced by the degree to which empirical research is seen as an adequate research strategy in the field of mathematical education in general. As there is no systematically gathered information about the state of empirical research concerning mathematical education in general, the importance of the argument cannot be checked for the individual countries. As an essential point, it is explicitly stated in the report about Ireland and is correct for West Germany, too.

Besides the absence of relevant researches, a further reason holds in some cases. Some persons interested in writing the report miscalculated their time, so that they could not follow the timetable. This reason holds, for example, for West Germany; that is why I will add some items concerning this country in the introduction.

Besides the reports, this survey contains international references, to enable the reader to find the original publications easily, to the end that further research is stimulated and facilitated. Obviously, there is an extreme need for this. The references given in the reports are included in this survey.

In order to get a differentiated picture of the state of research and to get reports focussing on the same items, the following outline of points that should be considered in the reports were sent to those persons interested in doing this job:

1) Please describe the general interest in the topic 'gender and mathematics' in your country. Does it play a central role in the scientific discussion and/or in discussions in magazines and newspapers? Which groups are interested in the topic (e.g., researcher of mathematical education, psychologists, women's libera-

tion movement) and what is the general background of this interest (e.g., psychologists may be interested in sex-differences, mathematics teachers in learning difficulties)?

2) Primarily we are interested in empirical researches and their results. Here are some aspects that should be considered in summarizing the types of empirical researches.

   a) Is 'sex' a variable that is only considered, in the way that, e.g., results in mathematical achievement tests are reported by sex, differences are stated and are globally explained by sex-role-perceptions or differences in (inherited) ability; or are there no sex-related differences in achievement and attitudes?

   b) Are the researches embedded in theoretical frameworks (e.g., a learning theory concerned with sex-role-learning) and which are the critical variables in the models (e.g., parents' and teachers' expectations about sex-role)? Does the theoretical framework imply that differences can be altered (e.g., if you believe that inherited factors cause the differences, you cannot alter them; if you have concrete ideas how sex-role-perceptions are learned by children and if you believe that the linkage of mathematics to sex-role-perception is essential for lesser achievement of girls in mathematics, you have the chance to alter the situation)?

   c) Did the results of the empirical researches initiate further activity (e.g., are there any programs to increase the interest and achievement in mathematics in general or in special for girls and women such as new courses, in-service projects) and have they reached their goals?

3) It may be that the topic 'mathematics and gender' is not considered in empirical researches or that outside these researches there is a discussion about this topic. What are the viewpoints under which the discussion is held and to what end (e.g., is the intention to alter curricula)?

4) It may be that there has been a development in the aspects under which the topic 'women and mathematics' is considered in your country. Please describe this development and give some ideas about the future development.

5) Please give us a list of publications that have been written in your country.

6) If the above stated aspects do not at all fit the situation in your country, please give us an idea about this special situation.

Looking through the reports at hand, it is evident that in the U.S.A. the state of research is far ahead, followed by England and Wales. There is a respectable gap between these and the other countries. Australia, Canada, Israel and New Zealand can be grouped together as countries in which some research has been carried out, although there are differences between them. In this group West Germany can also be classified. Ireland and the Dominican Republic seem to be on the brink of starting research. India holds a special position. Sundar reports that this country sees itself confronted with the problem to raise the effective literacy rate, which is less than 40% for men and less than 20% for women. Therefore, not the topic 'gender and mathematics' is of interest but 'gender and education'. Sundar focuses on the latter, and describes what has been undertaken to close the gap between the education of men and women.

The fact that 'mathematics and gender' is an important subject of scientific research in the U.S.A. was essentially initiated by the women's liberation movement. As mathematical competence was identified as a critical skill directly related to admission to many colleges and most professional occupations in both technical and non-technical fields, there was increased attention to the evaluation of achievement differences, in order to increase the educational and occupational choices of women. This motivation came together with a public demand for mathematically qualified people. The relevance of the problem area was recognized by the scientific community. The result is, as comes out of the report by Becker, that not only detailed information is available, whether achievement differences between boys and girls exist, but also there are many extensive investigations starting from different theoretical backgrounds. They focus on explaining not only achievement differences - that do not appear as often and as consistently as often thought - but also course-taking behavior and career plans. Moreover, the topic is more and more looked upon as being a special aspect of learning problems in mathematics in general. As a result, activities to increase interest and achievement in mathematics, (e.g., the so-called 'Math Clinics' (Tobias, 1977, 1978)), are not only directed to one sex but to both women and men having failure experiences in the subject matter.

In England and Wales, as in the U.S.A., groups interested in mathematics and gender include mathematics educators, psychologists, sociologists, and feminist groups. Although in England and Wales there do not exist by far as many empirical investigations concerning our subject as in the U.S.A., those that are reported by Isaacson demonstrate a complex theoretical background. In recent years, researches were mainly interested in the topic 'gender and sciences', as in this subject the learning possibilities are not the same for girls and boys. The deeper knowledge that came out of these investigations has had the effect that, first of all, the linkage between the learning of mathematics and sciences is stressed. By now there has been a rise in the number of projects considering causes of sex-related achievement differences in mathematics that are not directly related to those in sciences.

The discussion and the research activities in the U.S.A. had and have a worldwide influence. The reports about Australia, Canada, Israel and New Zealand written by Shelley, Mura, Lewy, and Wily indicate increasing attention to 'mathematics and gender' that is stimulated mostly by those people concerned with equality for women in the different countries. Statistics are available and some researches considering special aspects are at hand. Investigations starting from an elaborated theoretical background are rare. I got the impression that the state of research in Australia is similar to that in Canada and New Zealand, and it may be the most advanced of these countries. Shelley reports some investigations considering not only personality variables (like attitudes) as possible causes of achievement, but also teaching methods. Moreover, in another project, an alternative approach for teaching mathematics is evaluated.

I mentioned already that the state of research in West Germany is to a certain degree comparable to one of the just-named countries. About 1969, I started to be engaged in understanding achievement differences between boys and girls. At that time, there were only very few empirical studies carried out on this topic in West Germany. The theoretical background from which I started my research work (Schildkamp-Kündiger, 1973, 1974) is deeply influenced by the results of Fuchs (1957), Lesser et al. (1963), and French and Lesser (1964) that explain sex differences in the development of achievement striving.

The scientific results from overseas also influenced activities in West Germany. More often books written by psychologists were published, having sex-related differences for subject. Most of the books start from the viewpoint that many of these differences are caused by stereotypes (e.g., Wagner et al., 1978). In an interdisciplinary working group (Brämer, 1976), the socialization effects of learning mathematics and natural sciences were analysed. Moreover, mathematics and gender was discussed in connection with affective learning goals that go together with the learning of mathematics (e.g., Schmidt, 1976).

Parallel to this development, empirical methods as a possibility of evaluating questions of mathematical education were increasingly discussed and partly accepted. Some empirical studies, influenced by American research, were carried out on selected topics, e.g., sex-typing in mathematical schoolbooks (e.g., Glötzner, 1979).

From presentations of my research at conferences, I got the impression that there is some interest in the topic but that 'mathematics and gender' is surely not a central area of discussion. In the last meeting, the relative high rate of unemployed women was discussed. It is recognized that only very few women hold leading positions in industry and at the university and, moreover, that they mostly work in areas typically classified as female. As a result, girls should be encouraged to strive for occupations that at the moment are a domain of men. Maybe this discussion will lead to an increasing interest in the research area 'gender and mathematics' in the future.

In the Dominican Republic and Ireland very little information dealing with our topic is available. Luna and Gonzales report that in the Dominican Republic nearly all data come from pilot studies carried out in connection with the Second IEA International Mathematics Study. In these studies it was tested whether the instruments developed by the International Mathematics Committee to measure achievement in different mathematical areas are appropriate for students in this country. By nature the results are mainly descriptive and preliminary. Until now no hypothesis that leads to an explanation of achievement differences that seem to be in the favour of male students has been tested. It is hoped that some results will be available by an investigation planned in the near future.

The report from Ireland, written by McGuiness and Oldham, demonstrates increasing interest in the subject area. To an essential part, the motivation grows out of an increasing demand for mathematically qualified people and the growth of the women's movement. The situation in Ireland has to be seen with the background that it is only ten years ago that the last official constraints and concessions on women's participation in mathematics courses were removed. The authors analyze the historical background for this and give a hopeful picture for the future. The gathering of information about girls' participation and performance in mathematics courses has started. As the statistical approach is more and more accepted as an adequate research strategy, the time seems to be ripe for investigations that look at the reasons.

Summarizing the information received, I must conclude that in most countries 'mathematics and gender' is not a central subject of empirical research. Nevertheless, there are some hopeful indications that once interest arises, the importance is recognized and leads to research. In many cases, the relevance of the subject matter is not primarily seen by those persons engaged in mathematical education but by those striving for equal opportunities for women.

There are great differences between the countries in the extent to which sex-related achievement differences occur; if they occur, they often are in favour of men; but within a country they are not consistently found at different school levels. As a single example, I want to point out that, in England and Wales at the age of 11, the achievement of girls is higher than that of boys and the passing mark to get a place at a grammar school is higher for girls.

Already in the first International Study of Mathematical Achievement great variability of achievement differences was found (Husén, 1967; Keeves, 1973). Concerning the extent to which the achievement of boys exceeds that of girls, Keeves (1973) summarizes:

> The range of differences across countries is too great for a simple explanation to be advanced as to why such sex differences should have been observed. Furthermore, no combination of factors, operating together, comes readily to mind. Nevertheless, it is clear from this evidence that girls tend to be less well prepared to enter occupations and careers that require a prior knowledge of mathematics and science. To this extent inequalities between males and females are built into educational systems. (p. 57).

Looking at the reports and the references, I found that different research strategies are used to come to a better understanding of sex-related achievement differences. Roughly three characteristic approaches can be identified:

a) Achievement differences are explained by sex role perceptions.

b) Achievement differences are explained by differences in personality traits.

c) Achievement differences are the results of a differentiated interaction process of environment and personality variables between which cognitions bridge the gap.

These approaches will be briefly described so that their possibilities and limitations become evident. Since most of the empirical studies are carried out in the U.S.A., I mostly refer to results from this country.

a) <u>Sex role perceptions</u>

In many countries, mathematics is widely looked upon as being a male domain, and thus engagement in mathematics becomes part of the male sex role. To explain the learning of the sex role, all general psychological theories explaining change of performance can be considered: psycho-analytic theories based on Freud; stimulus response-theories, social learning, and modeling; cognitive learning theories. These approaches not only give models of how sex roles are learned, but they also try to explain what has happened when not-sex-appropriate behavior appears.

In speaking of sex role, one might forget that sex role is <u>not</u> a set of well-defined habits that govern the behavior of an individual and the behavior expectations of others, but that sex role is a concept, the perceptions of which differ not only between persons but also within a person depending on situations and personal development. Misconcepts may cause the concept 'the sex role' to be used quickly as a global explanation for sex-related differences without trying to get a deeper understanding (e.g., girls are not interested in mathematics because mathematics belongs to the male area).

The reports in this survey indicate that there is great empirical evidence supporting the hypothesis that, if mathematics is accepted by a woman to be a male domain, then this explains, at least to a great extent, her inferior achievement, course-taking behavior, and career plans.

When a child perceives a school subject as appropriate for his or her own sex, this influences most the achievement in this subject, more than liking the subject or even whether the child is male or female (Dwyer, 1974). Obviously, it is of great relevance what is looked upon as "sex-role adequate behavior" in our context, especially sex-role adequate achievement behavior.

To what degree a girl has adopted the concept that mathematics is a male domain significantly depends on the sex-role conceptions of her environment. Casserly (1975a) and Fox (1977) extensively report studies that demonstrate the influence of parents, peers, and teachers. In this context also the researches on sex-typing in mathematical school books have to be seen.

Sex-role perceptions differ not only from country to country and between individuals, but there is an individual development over time. By entering new situations, people develop variations of their sex roles as they grow older. If a woman enters an area looked upon as a male domain, she may redefine her activity as suitable for the female role (Stockard and Johnson, 1980).

The question occurs as to whether mathematics has always been looked upon as being related to the male domain. Perl (1979) tries to get an answer for this question by analysing the "Ladies' Diary", one of the first popular magazines that appeared in England from 1704 to 1841. She concludes that in the late 17th and early 18th century, women were not considered less capable of learning mathematics than men. In the 18th throughout the 19th centuries the attitudes towards women changed; they were looked upon as weaker, and less capable of engaging in intellectual areas like mathematics. Perl sees the stereotype of mathematics as a male domain as an effect of changing social roles in the 18th century, accompanied by a growth of mathematical knowledge that necessarily presupposes intensive training.

Coming back to the present, Fox (1977) suggests that the sex-typing of mathematics is not as prevalent as it once was.

b) Personality traits

The explanation of behavior by personality traits has a long tradition in empirical research. In our context I only mention two aspects: intelligence and attitudes. It is a common concept that ability on the one side and attitudes and interests on the other side explain together a great deal of a student's achievement.

Starting from factorial models of intelligence, it seems reasonable to try to find intelligence factors relevant for mathematics, and after that to look and see if differences in achievement can be explained by differences in these factors (e.g., Aiken, 1971; Treumann, 1974). Problems arise as there obviously do not exist two or three well-defined factors related to achievement in mathematics.

Sex-related differences appear relatively consistent in spatial visualization and verbal ability, the former in favor of men and the latter in favor of women. Becker reports findings from the U.S.A. which do not support the idea that sex-related achievement differences can be explained by differences in spatial visualization.

There is one further reason why 'spatial visualization' stands at the centre of some discussions. Some researchers believe in the X-linked hypotheses of the inheritance of spatial visualization. As Sherman (1977) has pointed out, only weak empirical support can be found for this. I hope that the unfruitful quarrel about how far inheritance and environment are determinants of intelligence will not start again, taking spatial visualization, for example, to explain differences in sex-related mathematical achievement.

The first IEA-study gives a good survey about the relation between attitudes and achievement (Husén, 1967; Keeves, 1973). In most countries and age levels, boys show a greater interest in mathematics than girls (Keeves, 1973, p. 59). Moreover, an analysis of variance shows that there is a significant effect between countries and between sexes and a significant interaction for the lower secondary school populations and for the mathematics specialists (Husén, 1967, Vol. II, p. 245).

The idea that ability and attitudes together explain a great deal of student achievement does not, in this generality, resist empirical check (Suydam, 1975). Besides a better definition of which attitudes are considered (e.g., liking mathematics, believing it is important), a more elaborated theoretical framework is needed linking attitudes and achievement.

It comes out of the reports that perceived usefulness of mathematics and the self-esteem of one's mathematical ability are aspects that may help to understand differences in achievement and in course-taking behavior. This becomes understandable in a broader theoretical context, in the center of which is a cognitive view of the achievement motive. Only if an area is achievement-relevant for an individual will he or she make efforts to reach an achievement goal. Achievement striving is embedded in overarching projects such as the desired profession. Special sex-role perceptions can cause a girl to perceive mathematics as a non-achievement-relevant area.

c) Differentiated interaction processes

The more information available about the occurrence of sex-related achievement differences, the more grows the demand for models that give explanations coming out of broader theoretical backgrounds. This demand can be recognized not only in our context, but in education in general (Travers, 1969). I believe that many empirical results become clearer when the learning of mathematics and its sex-typing is related to a cognitive view of the achievement motive. I am going to describe this conception, in the course of which I only give a selected number of references that demonstrate its consistency with empirical results.

During mathematics lessons, pupils have to solve tasks (achievement situation) that, especially in mathematics, are looked upon as intellectual problems. The relevance which intellectual achievement is given brings about the situation where failure may burden the individual pupil with not having reached the standard of performance the school and the society has set. A young girl sees herself confronted on the one side with the intellectual achievement norms of the school, on the other side with sex-role perceptions that may be in contrast to the school norms. Heilbrun (1963) verified that some female students already perceived the general intellectual demands of a college as being incompatible with their female sex role. As a consequence of the sextyping of mathematics, mathematically gifted girls may fear negative consequences for their relationships with boys when accelerating their progress in mathematics (Casserly, 1975; Fox, 1976; Fennema and Sherman, 1977).

Stein and Bailey (1973) discuss studies concerned with the achievement motive of women. As for the effects of sex role on female achievement striving, there is empirical evidence that attainment value for a given area of achievement is a good predictor of both female efforts and performance. Schildkamp-Kündiger (1974) found that girls having lower achievement in mathematics than would be predicted on the basis of their intelligence (underachievers) see intellectual achievement as appropriate for men only; whereas female mathematical overachievers believe intellectual achievement to be suitable for women, too. The persistence a student develops to master learning difficulties on the one hand depends on his or her experience with the efficiency of the efforts and on the other hand on the relevance the subject matter has for the student (Raynor, 1974).

This becomes obvious - as already mentioned - by the importance that the variable 'perceived usefulness of mathematics' has for achievement and course-taking. The conflicts caused by sex-role perceptions that may arise for a young woman in developing career interests in general and especially in mathematics and scientific fields are discussed by Fox (1977).

If a student has not reached the antecedent achievement goals, this has two different impacts for the learning processes to come:

Firstly, a more subject-matter directed one: the student's deficiency lessens his or her chance of reaching the following goal because of the fragmentary antecedent knowledge. Accumulating deficiency will appear, the more the subject matter is hierarchical in nature and is taught in this way.

Secondly, a more motivational directed one that can be described when cognitive achievement motivation models (Heckhausen, 1974; Gorlitz a.o. 1978) are adopted to school situations (Fuchs, 1975; Kornadt, 1975). It is assumed that during the years at school a student has developed a subject-matter related achievement motive associated with a self-concept of his/her abilities and causal attributions of success and failure (e.g., good luck, efforts, ability, easiness of the task).

Failure can lead to different reactions; it is possible that the student makes more efforts to compensate for the deficiency and, if these efforts lead to success, the learning potential for the next learning steps is strengthened and the achievement motivation, too; if the efforts fail and if this occurs over and over again, a failure cycle is settled (Shapiro, 1962). The negative motivational development and the lack of knowledge relevant for the next learning step are affecting each other. In analogy to this failure cycle, a success cycle can be developed. The developmental process leads to certain types of students (Schildkamp-Kündiger, 1982); the extremes may be characterized as:

<u>the achievement motivated student</u>: good knowledge; positive <u>self-esteem of his or her mathematical abilities</u>; success will be attributed to his or her own ability and efforts, failure due not to lack of ability but to internal or external variable causes, e.g., lack of efforts or bad luck; and

<u>the fear-to-fail student</u>: poor knowledge; negative self-esteem of <u>his or her mathematical abilities</u>; success in mathematical tasks is not attributed to ability but primarily to external reasons such as good luck and easiness of the task, failure to lack of ability.

Sex differences in self-confidence in mathematics are found, as already mentioned, in quite a few of the studies noted in the reports. There is some evidence that women, having a more traditional sex-role perception in intellectual achievement situations, show an attribution pattern and have a self-esteem of their ability similar to the fear-to-fail student (Stein and Bailey, 1973; Deaux, 1976).

The development of a student's self-concept of his or her mathematical abilities and his or her causal attributions is a process which is remarkably influenced by the teacher, seen as a "significant other." By direct or indirect causal attribution of the achievement results of a student, the teacher delivers information to the student about the achievement standards the student can or should reach, and by this influences the self-concept and attribution of the student. For example, if a student has success in solving a problem and the teacher reacts: "It's very nice that you gave us the right solution, you worked well at home, but the question was not so very difficult", this may mean that the teacher thinks that the student is not very able (the teacher praised the student for solving an easy task) and that the student could only give the right solution because he or she made great efforts. It can easily be assumed that a girl will make no special efforts to solve a mathematical problem when the teacher gives her the information that she is not expected to be successful because of lack of ability or because mathematics is not appropriate for her.

There are quite a few empirical studies showing that the teacher-student interaction is different for boys and girls (e.g., Brophy and Good, 1970; Sikes, 1972). For mathematics classes, the study of Becker (1979) demonstrates the way in which the different teachers' expectations based on sex for student performance and behavior are transformed into a sex-based interaction pattern.

In relating the area 'mathematics and gender' to the development of achievement striving, the topic is related to learning difficulties in mathematics in general. In this context the theoretical background just briefly described has to be enlarged by a further aspect that is the teaching method. The complexity of this aspect becomes obvious in Travers et al. (1977). It comes out of the reports that only very little information is available relating pupils' motivational and cognitive presuppositions to teaching strategies, so that at the moment no theoretical model can be proposed. Research that leads to an explanation about the mutual dependence of teaching strategies and pupils' development of the denotative and connotative meaning of mathematical concepts is badly needed. It seems reasonable to assume that these meanings of mathematics may or may not be in contrast to the personal value-system held by a pupil and by this essentially influence the learning process.

It can be stated that in the near future there will be progress in our knowledge about the relations between teaching strategies, motivational variables, and learning outcomes, and to what degree these relations help to understand sex-related achievement differences. These variables are considered in the Second International Mathematics Study.

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II. National Reports

Gender and Mathematics in Australia

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Introduction

This report concerning gender and mathematics in Australia must be seen only as an interim report and in no way a comprehensive one. There are two main reasons for this. Firstly, there has been an upsurge of interest in the subject in recent years and many individual projects are being conducted in several states and territories of Australia, while at the same time there has been no systematic collection of the available information. Secondly, in the time available to me it has been impossible to make more than a beginning in attempting to obtain the information that is available, and much of the information needed to make an adequate report is not available.

While there has been limited interest in the subject of girls/women and mathematics for nearly a decade in Australia among classroom teachers and some mathematics educators, the tremendous rise in interest has gained impetus from the concern of women, largely outside the area of mathematics, and, more particularly, from the continued publication of the figures of unemployed persons in this country. The latter has had a very significant impact upon the subject of girls/women and mathematics when it has been evident that unemployment among young females is the highest of any section of the unemployed.

In February 1979, 23.5 percent of females in the age-group 15-19 were unemployed, compared with 18.7 percent of males.[1] Between August 1970 and August 1979, the number of teenage males holding full-time jobs fell by 8,200 and the number of teenage females holding full-time jobs declined by 71,000. This is a 26 percent decline for females and a 3 percent decline for males.[2]

As reasons have been sought for the greater number of young females unemployed as compared with young males, it has been evident that the sex-segmented labour market, with its assumptions about men's work and women's work, has had a large effect. This in turn has affected, and been affected by, the limited choice of subjects which girls have tended to study at the secondary level, and, in particular, their opting out of the study of mathematics.

In this way entry to a large number of career possibilities has been prevented, and the narrow field where women have traditionally worked has been perpetuated. Another factor which has caused concern is that these limited areas of female employment are threatened by technological changes. The recent Report of the Committee of Inquiry into Technological Change in Australia (The Myers Report, AGPS, Canberra, 1980, vol. 1, 5.121) stated bluntly that "women are disadvantaged by their education as well as by their jobs at risk."

Another difficulty that is faced in making any real assessment of the situation in relation to girls/women and the study of mathematics is the inadequate collection of data in the several states and territories; moreover, there is no standardisation of procedures which would facilitate comparisons across States, when and where information is available. Consequently moves have been made to impress the importance of such data collection upon the appropriate authorities. However, there is some doubt whether, in the present financial climate, funds will be allocated to implement such recommendations.

Among researchers in education and mathematical education and some psychologists there has been an increased interest in the subject, with a corresponding rise in the number of research projects. Some of these have deliberately set out to study sex differences; others have 'stumbled upon' differences in the course of a study.

Many of the writers of papers for conferences rely heavily upon overseas findings, either in their survey of the literature or to highlight the situation as they see it. Whether or not such overseas studies are applicable in the Australian context is only recently being attended, with an increasing number of studies being conducted to attempt to replicate those overseas findings. However, by far the majority of papers presently available attempt to draw together the several findings of work done particularly in the U.S. and the U.K., and seek to make known to Australians that there is an issue here which needs attention.

Sociological Studies

In November 1975, a Study Group of the Schools Commission published its report entitled "Girls, School and Society." This report has had a considerable influence on future enquiries and, indeed, has set a standard by which movements towards the achievement of equal opportunity in our schools and in society can be measured.

In the Foreword to "Girls, School and Society" it is written: "Equality of opportunity cannot be achieved where the forces acting on all girls, irrespective of social class or ability, cause them to have lower self esteem and less self confidence than boys, and where those forces go unquestioned and unchallenged." Later, it says: "This Report .... focus(es) attention on analysis of practice and on changes in schools designed to redress any sex bias in them which limits the horizons and reduces the self esteem of girls."

Perhaps the main impact of this report, for our purposes here, is that it prepared a stage for sociological research in the whole field of girls/women and consequently for research into the factors which affect girls/women in their study of mathematics. Indeed, the report draws attention to the neglect of sex differences in research saying: "Sex has in the past been consistently overlooked and underestimated as a major independent variable by Australian researchers and scholars, especially in education but also in psychology and the other social sciences" (p. 148). The report went on to recommend "that, in establishing a base for future data collection, all information about students and teachers be collected by sex" (p. 149).

By far the largest amount of work, therefore, is of a sociological nature, with the collection of data upon the following elements:

1. Mathematical Performance: Keeves (Australian Council for Educational Research, 1973) found that the general pattern of his results was one of superior performance by male students in both mathematics and science. In all comparisons made between the scores of boys and those of girls, the boys performed better. He found that the sex differences in achievement are in general greater at the pre-university level than they are at an age level where attendance at school is compulsory.

Alongside this, one must note that across-sex differences are greater than between-sex differences. "Girls, School and Society" concluded: "In capacities and personality traits the differences within each sex are much greater than those between sexes" (p. 155). Bradley (1980) has said: "None of the slight differences between the sexes which have been reported can explain why so many girls in South Australia drop Mathematics when that option is open to them."

2. Retention rates: A comparison of the retention rates of girls and boys at school in the years 10, 11, 12 of schooling in every state and each of the territories for the year 1978 indicate a higher percentage of girls compared with boys remaining at school in all cases except year 10 in the Northern Territory (Widdup, 1980).

In Victoria, Higher School Certificate statistics indicate that more girls than boys in 1977 were successful in their HSC and in meeting university requirements. While 67 percent of boys who attempted HSC were eligible to enter universities, the figure for girls was 71.4 percent.[3]

3. Subject Choices: There has been a consistent trend throughout Australia for girls in secondary schools to drift away from mathematics and science by Year 12. This is shown in Tasmania (Widdup, 1972); New South Wales, Queensland, and Victoria ("Girls, School and Society," Appendix A); South Australia (Delin and Sanders, 1976). It was observed in the A.C.T. (Richards, 1979), and White observed the trend in Victoria for the period 1956-1972 (White, 1973), (Widdup, 1980).

In concert with these statistics are the figures for four states and one Territory for 1977 which indicate that for boys the percentage of enrollments in mathematics for HSC greatly exceeded that for girls, except in N.S.W. where 52 percent of enrollments were girls.[4]

Another feature is that where different levels of mathematics are offered, girls tend to take the lower levels.

It should be noted that in 1977 in Victoria, where figures are available, 39.8 percent of enrollments in Mathematics in the HSC were for girls; 70.0 percent of those girls obtained a pass or better. For the boys, 77.3 percent of those enrolled obtained a pass or better.

4. Sexism in Texts: The prevalence of sexist language in textbooks and sex bias in activities of males and females has been recorded. For

PARTICIPATION IN MATHEMATICS BY SEX BY LEVEL OF DIFFICULTY

Year 12		M	F	% M	% F
Mathematics -	4 Unit	440	99	81.6	18.4
	3 Unit	2504	1673	59.9	40.1
	2 Unit	4762	5535	46.2	53.8
	2 Unit A	2278	3502	39.4	60.6

New South Wales - 1979

	M	F	% M	% F
Applied Mathematics	2819	1032	73.2	26.8
General Mathematics	3345	3082	52	48
General Maths (Computing Option)	210	96	69	31
Pure Mathematics	2948	1257	70	30

Victoria - 1977

	M	F	% M	% F
Mathematics 1	1543	609	72	28
Mathematics 2	1540	605	72	28
Mathematics 1S	1325	1328	49.9	50.1

South Australia - 1978

	M	F	% M	% F
Mathematics 1	32	7	82.1	17.9
Mathematics 2	32	7	82.1	17.9
Mathematics 1S	23	25	47.9	52.1

Northern Territory - 1978

example; in a study of 12 texts in common use in Queensland, of specific reference to males and females, 78 percent were to males; of illustrations, 72 percent depicted males; of occupations mentioned, the ratio was approximately 11:1 in favour of male occupations; of activities engaged in, the ratio was approximately 3:1 in favour of males.[5]

In a similar study of texts used in Victoria, the Victorian Committee on Equal Opportunity in Schools (1977) examined five mathematics texts. Their figures show that girls appear less than once in five mentions or illustrations in the textbooks analysed. Furthermore, most examples show men acting: saleswomen never appear, nor do women fill in cheques or bank forms. All wage-earners are men and counting is done by men only. It is stated that "more importantly perhaps 'a mathematician' in the abstract is always male." This latter statement was true for all the textbook series examined in this report.

5. Sex Distribution of Teachers: The sex distribution of teachers in several subjects, including mathematics, was collected for some states and territories for a Discussion Paper prepared by the Women's Advisers in State and Commonwealth Education Systems for a Conference of Directors-General in June 1980. This paper indicated that in 1979, in the A.C.T. 41.4 percent of mathematics teachers were female; in N.S.W., 37.1 percent; and in Tasmania, 29.7 percent. The figures for the other states were not available. The Discussion Paper comments that although "the relationship between teachers as sex-role models and the interests, achievement and vocational aspirations of girls and boys has not been adequately researched ... It could be hypothesized... that lack of female teachers in certain subjects could identify those subjects as 'masculine' and the opposite identification may occur in subjects where male teachers are absent or in a minority. In Mathematics, for example, this may have the effect of promoting the image of women as incapable of grasping mathematical concepts, or the message that there is little relevance in the subject for a women's future employment."

Explanations for Differences

As well as this collection of data there have been some studies which have looked at particular aspects of the differences and attempted partial explanation.

Leder (1974, 1976) "examined the effect on students' performance of the contextual setting of mathematics problems."

Leder also looked at attitudes of students and found fear of success (FS) and learned helplessness. Her experimental evidence (1979, 1980a) indicated the following:

(1) Girls are more likely than boys to attribute sex differences in participation in careers in mathematics and science to external factors that are potentially modifiable rather than to innate factors.

(2) Girls, on average, had higher FS than boys.

(3) For both boys and girls, those considering taking less traditional courses tended to have higher FS than those taking traditionally sex appropriate courses.

(4) For both boys and girls, FS tended to be more characteristic of high performing than of low performing students.

(5) For girls, but not for boys, FS tended to be more characteristic of students with high educational and vocational intentions.

(6) Girls who elected to continue with intensive mathematics courses tended to be relatively low in FS.

(7) Evidence with respect to the relation between FS and mathematics performance has been contradictory. The fact that girls with high FS were more likely to opt out of intensive mathematics courses may be a confounding factor.[6]

In a study done in Canberra, Keeves (1972) reported that "attitudes of girls towards mathematics were related to the level of the mother's occupation before marriage."[7] In the same study he found that: (1) for boys, but not for girls, liking mathematics was related to prior achievement in mathematics; and (2) for girls, achievement in sixth grade was negatively related to motivation scores at high school, but for boys a stronger positive relationship was found.

Evans (1968), in the Queensland study, suggests that the superiority of girls in mechanical arithmetic "possibly reflects a more conforming attitude on the part of the girls to the school requirements that children become automatic in their response to number combinations. This same conforming attitude may well prove a hindrance to the girls in problem solving tasks." In Queensland emphasis on automatic responses in number combinations may be greater than elsewhere (Drinkwater, 1970).

Keeves (1973) reports a correlation between achievement and interest in learning mathematics that begins to develop in early secondary school.

Another aspect which has received some attention has been that of perceived usefulness. Gee (1973) says "that boys disliked and avoided humanities because they could not relate them to life: girls disliked mathematics for those same reasons." Humphreys (1968) observes that "boys tended to choose subjects for future career requisites, girls were more influenced by school organization or by interest in and liking of a subject."

While acknowledging that, "home and community environment and peer group pressures have a greater effect than school factors on differential mathematics performance by males and females", Widdup (1980) goes on to say that "schools do nevertheless have some effect." He isolates a number of elements of the school which produces that effect. These are: (1) vocational guidance, (2) unbiased curricula, (3) supportive environment, (4) supportive networks, (5) a changed view of the use of mathematics, and (6) a change to the methods of teaching mathematics.

Cass (1973) states that biological theories of intellectual performance, while they may provide an account for between-sex differences, fail to account for within-sex differences. As Bradley, writing in 1980, concludes: "It is clear that:

a. There is conflicting evidence about sex differences in mathematical ability.

b. A slight difference between the sexes in spatial ability becomes evident at about the onset of puberty.

c. From about the onset of puberty it seems likely that girls as a group perform better at mathematical computation and boys as a group perform better at mathematical reasoning.

d. None of the slight differences between the sexes which have been reported can explain why so many girls in South Australia drop mathematics when that option is open to them."

As Widdup (1980) reports: "Perhaps the most convincing evidence against biologically produced sex differences, in ability and in favour of socially produced differences, is found in the results of a study of 79% of full-time year 12 students in Victorian secondary schools in 1973 by Mackay et al. (1976). In these results sex-differences are further broken down by socioeconomic level,... and whereas boys do have higher spatial ability, highest are the middle socio-economic girls. In contrast to this, among the boys the highest ability group is the high socio-economic level group, although even they are below the middle socio-economic level girls in measured spatial ability."

Methods of Learning

One further series of studies of particular value has been those carried out by Lee Owens and Jennifer Barnes of the University of Sydney, with published results in 1980 and 1981. As a result of the Co-operative, Competitive and Individualized Learning in Education Project (CCILE) begun in 1977, they have developed a Learning Preference Scale for Students (LPSS), for Teachers (LPST), and for Parents (LPSP).

Beginning with the modest aim of investigating the attitudes of students towards different modes of learning that have an effect on achievement, they soon realized that student preferences form only a portion of the information necessary to understand the dynamics of classroom learning. Since then they have successfully developed the three scales and recommend them particularly for the use of curriculum planners and educational researchers.

As a result of this work, one of the authors writes "we have found ("stumbled on to" is more apt) another piece of the puzzle about the disinterest shown by girls to the study of mathematics at senior secondary level."

First it was established (Owens and Straton, 1980) that mean cooperative preference scores on the LPSS were higher in all secondary years than both competitive and individualized learning preference scores.

In their 1981 study, "the first major conclusion which can be stated with certainty is that senior high school students express a much greater preference both for more co-operative and for more competitive social contact during learning than first-year high school students. English generally is seen as providing more opportunity for co-operative interaction than Mathematics, though girls prefer competing in English more than boys do, whereas boys prefer competing in Mathematics more than girls do.".

There is evidence to indicate that differing content in school subjects is seen apparently in terms of freedom and restraint - English apparently frees co-operatively inclined students to learn through relationships and personal development, while mathematics does not.

In a paper presented by Lee Owens in November 1981 to the Annual Conference of the Australian Association for Research in Education, the following comments are made about teachers: "At both primary and secondary levels, male teachers express a stronger preference for competitive learning than females do. This pattern for male and female teachers duplicates the results obtained from a large sample of school students, with males at each year level expressing more competitive preference than females, and females expressing more co-operative preference than males."

"The data reported in this paper, in conjunction with those in two previous ones (Owens and Straton, 1980; Owens and Barnes, 1981), give a foundation for the following informed speculation. Girls are socialized during their early development generally in the direction of nurturant behaviour towards others, with emphasis on co-operative relationships and mutual assistance.... Boys are socialized towards adventurous striving, both on their own and in competitive contact with others....The co-operative and competitive learning patterns are being established, however, by the English and history teachers, the majority of whom are female, and by the mathematics and science teachers, the majority of whom are male (Women's Advisers, 1980). These patterns reinforce the basic dispositions of the learners. The time comes to choose courses for further study in the senior years, and girls, disinclined to favour competitiveness in learning, and faced with male teachers and subject matter that seems oriented to competitiveness, opt out and transfer their enthusiasm to other subjects."

This work links well with Shelley's "An Exploration of How Different Teaching Methods Affect the way in which Students Come to Acquire Mathematical Concepts" (unpublished M.Ed thesis, 1977), who worked with groups of students who had a previous history of failure in mathematics.

The theoretical basis of this exploration dealt with the development of a schema in which the relationship between teacher, content of mathematics, and learner were seen to be linked to the view of mathematics which was held. That view, Shelley argues, "affects the teaching approach which is adopted and has implications for curriculum as well as for learning and particular perceptions of failure." The schema indicated "different cultural/social/'philosophical' positions from which several views of Mathematics have arisen and the accompanying views of man."

Shelley then develops an alternative approach to the teaching of mathematics, working with three main groups ('drop-outs' from the normal school system, women, and Aborigines) and developing a co-operative, small-group method of teaching/learning. This approach "requires the affirmation of the humanness of the learner through the valuing of his/her experience, involves the members of a group - together with the 'teacher' - in participating in a process of constant transformation, as reality, relationships and knowledge alter and develop."

Since then, Shelley has continued her work both with Aborigines and with women and is collecting material of a case study nature to be published at a later date.

Public Conferences

There have been two major conferences held in Australia in the last two years concerned specifically with girls and mathematics. The first, in May 1980 in South Australia, under the title of "Improving Mathematics for Girls," drew speakers from across the country and produced a comprehensive report which has supported action taken, particularly in South Australia.

The second conference, "Expanding the Options - Girls, Mathematics and Employment", was held in Sydney in August 1981 and was organized under the direction of the Minister for Education in New South Wales. Here, too, a range of speakers, this time of international repute, presented challenging papers.

Conferences of this type are valuable in bringing to the notice of decision makers in education as well as to classroom teachers and teacher educators, the disadvantage which girls face in the study of mathematics, as well as their attempts to obtain employment without having reached a reasonable level in that study.

The Immediate Future

In South Australia action has been taken to increase the number of girls taking mathematics, and hence broadening their options. "The methodology used in South Australia has been to

1. encourage people to implement change at many different levels - state, regional, school, class and individual students.

2. provide as many support resources as possible.

3. enlist departmental support for initiatives at any level.

4. liaison and continual interaction with subject Principal Education Officers and Advisory Staff.

5. Organising and funding of conferences for students, parents, teachers, counselors, etc.." (Symons, 1981)

MERGA, the Mathematics Educational Research Group of Australasia, has a sub-group specifically interested in Women and Mathematics. The report of this group's meeting at a recent conference of MERGA notes that the following areas were identified as important: replication of overseas research; identifying factors which cause girls to drop out of mathematics courses; monitoring of intervention programmes; investigation of differences in cognitive styles and development of appropriate teaching strategies; use of available databanks of mathematical performance; investigation of mathematics prerequisites; monitoring of subject choices; and investigation of the need for bridging courses. There will be a further meeting of MERGA in January 1981 at which this group will meet.

In January 1981 the first National Conference of IOWME (International Organization of Women and Mathematics Education) will be held. This conference will explore two different strands in relation to the subject "Women and Mathematics." The first will be concerned with equal participation in the mathematics that is presently taught, created, and researched. The second strand will seek to explore the implications of there being not only one mode of mathematical thinking and ask the questions: Could it be that there is a mathematics more continuous with women's experience than that mathematics created by men? What effects would this have (1) for the learning of mathematics? (in particular, for women's learning?) (2) for mathematics itself? (3) for the type of mathematics which would be researched? (4) for the uses to which mathematics would be put in our society?

Conclusion

The subject of women/girls and mathematics is one which is receiving more attention in Australia in recent times. The main thrust has come not from those involved in mathematics education, but from those women and some men concerned with equality for women in our society. Some mathematics educators have responded to this and the subject is now receiving attention in research and among some teachers.

There is still much to be done, not least to make a much wider group of mathematics teachers aware that the subject is worthy of their attention.

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Gender and Mathematics in Canada

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1. Introduction

Mathematics is one of the many occupations in Canadian society in which one sex is engaged in a much larger proportion than the other one. According to Statistics Canada (23),* in the year 1978-79 only 4.2% of the full-time university teachers in mathematics and physical sciences were women. (Of course, university teaching itself is a predominantly male activity, with a total of 14.8% of women, for the same year. This should be compared with the female proportion of the full-time labour force which was 39%.) At the time of writing, there still exist in the country mathematics departments with no women among their regular faculty members.

It is only recently that this kind of sexual division of labour has begun to be questioned. Many Canadians still do not see any cause for concern, as long as there are no formal legal barriers preventing people from entering a trade or a profession on the basis of their sex. Others do feel that there is cause for concern and would like to see the same percentage of women present in all sectors of the labour market; however, they do not think that mathematics should be selected out of the many other instances of sexual imbalance in our society, and would rather attack the global social problem. These two positions account for the relatively small number of Canadian works dealing specifically with gender and mathematics.

The present report is based mainly on the information gathered by contacting the Ministries of Education of each of our ten provinces, the members of the Canadian Mathematics Education Study Group, the members of the Canadian Mathematics Education Study Group, the members of the Canadian Mathematical Society present at the 1981 summer meeting of the society, the Canadian members of the Association for Women in Mathematics, the Canadian members of the Special Interest Group for Research in Mathematics Education of the American Educational Research Association, the Ontario Institute for Studies in Education, provincial associations of mathematics teachers and some national organizations such as the Science Council of Canada, the Canadian Education Association, the Canadian Teachers' Federation, and the Council of Ministers of Education. In several cases the respondents suggested further contacts which were then followed up.

Admittedly, my first contacts were restricted to people in the areas of mathematics and education, whereas the topic of gender and mathematics could be of interest to people in a variety of other fields, such as sociology, biology, psychology, women's studies, history, etc. Time prevented a more thorough search in these other domains; however, it can be hoped that any major work dealing specifically with gender and mathematics would have come to the attention of some members of the mathematics education community.

*Numbers in parentheses refer to items in the list of references.

I wish to thank all the people who directly or indirectly contributed the information and the material on which this report is based. In particular I wish to express my gratitude to Claude Gaulin and Shirley McNicol for their concrete help and moral support during all the stages of this work.

2. Women and Mathematics at the University Level

Statistics about women in mathematics in the universities are readily available from Statistics Canada (23) and (24). It is to be noted, however, that mathematics is often treated as forming one category together with physical sciences.

In 1979-80 the percentages of women among those earning a bachelor's degree, a master degree, or a doctorate in mathematics and physical sciences were respectively 28%, 19%, and 10%. Thus, the percentage of women decreases as the level of study increases. Moreover, the percentage of women enrolling in graduate studies is consistently smaller than the percentage of women earning a bachelor's degree the previous year. In other words, the fact that a certain percentage of the students earning a bachelor's degree are female does in no way guarantee that the same percentage of women will be found among those earning a doctorate a few years later.

As already mentioned, in 1978-79 women constituted only 4.2% of full-time university teachers in mathematics and physical sciences, and even there their proportion decreases as one moves from assistant professor to associate professor to full professor. Furthermore, within each rank the women's median salary was lower than the men's (23).

A brilliant analysis of the status of women students and teachers in Canadian universities is presented by Jill McCalla Vickers and June Adam in their book But Can You Type? (11). Many of the obstacles to women's participation in higher education that they examine are common to all fields of study: institutional factors (e.g., inadequate facilities and rigidity of programs), economic factors (e.g, lower-paying summer and part-time employment for female students), psychological factors (e.g., sexism and stereotypes), difficulties related to part-time and continuing education, etc. Some, however, touch more specifically on mathematics. Here is what they write:

> Almost from the cradle on, Canadian girls are presented with images of occupations appropriate for them. These images rarely lead girls to even contemplate careers in traditionally male fields. And because few girls contemplate careers in fields traditionally closed to women, they tend not to qualify themselves appropriately for entrance to programs leading to such careers. For many, the discovery of alternatives to the traditonal female careers comes too late because they are unprepared, most often in the physical sciences and mathematics. (p. 134)

Thus, although the problem manifests itself more severely at the university level and is compounded by some aspects of the universities' structures and attitudes, its origins have to be looked for at previous educational levels as well as outside the educational system.

Three more publications on the subject should be mentioned: two recent reports on the status of women at two universities in Quebec (3) and (6), and an article on female scientists by Isabelle Lasvergnas-Gremy (10). At the time of writing, Isabelle Lasvergnas-Gremy and Jacques Dofny are completing an historical study of women in science (including mathematics) in Quebec in the years 1960-75 (28).

3. Women and Mathematics at the Elementary and Secondary School Levels

National statistics about girls' enrollment and achievement in school mathematics courses are not readily available. This is due to the diversity of the educational systems and of the statistics kept by the Ministries of Education in the various provinces. National statistics about female mathematics teachers are not available in published form. However, the data banks of Statistics Canada and of the Quebec francophone teachers' union indicate that the percentage of women among those who teach mathematics and science in secondary schools varies between 13% and 35% in nine out of ten provinces.

Enrollment

In the British Columbia provincial assessment of 1977, it was reported that:

> Only forty-two percent of the Mathematics 12 students were female, while sixty-four percent of those whose last mathematics course was Mathematics 10 were female. In other words, a disproportionate number of female students have decided not to study any mathematics in secondary school beyond the last course required, Mathematics 10. (17, p. 20)

No explanation of the phenomenon is offered; however, this finding prompted the authors of the report to formulate the following recommendations:

> Recommendation 5-1: The Ministry of Education should institute a program of research designed to ascertain why such a high proportion of female students do not continue to study mathematics beyond the last compulsory course.
>
> Recommendation 5-2: On the basis of the evidence obtained as a result of the implementation of Recommendation 5-1, the Ministry of Education, in cooperation with local school districts and teachers' groups, should institute professional development programs to sensitize teachers and counsellors to this tendency and with ways of dealing with it. (18, p. 121)

In Ontario, Marlies Sudermann carried out research on sex differences in high school course choice and achievement for the Ottawa Board of Education. Concerning mathematics enrollment, she found that:

- a much smaller proportion of girls than of boys was taking Enriched or Advanced phase mathematics by Grade 12. (35% vs 67%)

- a far higher percentage of girls drop mathematics altogether by Grade 12 (26% of girls vs 4% of boys). (25, p. 23)

This situation is attributed to sex role stereotyping; the factors leading to it are described as being complex and including home and peer influences, the media, and the school system.

Joan Pinner Scott reports some further statistics in a paper presented at the Science Council of Canada's workshop on "The Science Education of Women in Canada," (22) and (31):

- In Ontario, in 1979 only 39% of the Grade 13 mathematics students were girls;

- in New Brunswick, while girls predominated in the higher level mathematics courses at Grades 10 and 11, there were more boys than girls in both higher and lower level mathematics at Grade 12;

- In Newfoundland, a higher proportion of girls than boys took the demanding course (algebra) at the Grade 11 level.

In Quebec, Lesley Lee, a speaker at the 1981 Mathbec Conference, looked at female and male enrollment in the different programs offered at the junior college level (29). She rated the programs according to the number of mathematics courses that they require and found that 38.7% of the women and 10% of the men were enrolled in programs not requiring any mathematics courses. The situation was reversed for programs requiring four or more mathematics courses: 10.5% of the women and 32% of the men were enrolled in such programs.

Achievement and attitudes

Differences in school mathematics achievement have been found favouring sometimes girls and sometimes boys.

In the 1977 British Columbia mathematics assessment already mentioned (17), students were tested in grades 4, 8, and 12 in three domains: computation and knowledge, comprehension, applications.

> Female students outperformed males on most of the computation objectives on all three tests, while males outperformed females on all of the problem-solving objectives. Most such differences, whether in favour of males or females, were small. (17, p. 3)

In Alberta, a study of sex differences in mathematics learning was done by Daiyo Sawada, Alton Olson, and Solberg Sigurdson (20) in conjunction with the 1978 provincial mathematics assessment. Students were tested in grades 3, 6, 9, and 12 at three cognitive levels (knowledge, comprehension, application) and five areas of mathematical content (number, algebra, geometry, measurement, statistics). Significant differences in favour of males were found at each grade level, increasing with each grade level as well as with the cognitive level. Discussion of the results is brief; however, the differential performance is attributed to socio-educational-cultural variables. At the time of writing, Daiyo Sawada (30) is completing a study aimed at assessing the effect of four background variables in accounting for the previous results. The four variables are: mathematics courses studied, perceived usefulness of mathematics, attitude towards mathematics, and degree of use of hand-held calculators.

Another study was carried out in Alberta by Garnet Millar, Sharon Cote, and Glenna Moorey (14) on a much smaller sample (one school only), but spanning five consecutive years, from 1972 to 1976. The subjects were 422 grade 8 pupils and the measure of achievement was the end-of-year mathematics score. A statistically significant difference was found in favour of girls. Here is what the authors write in trying to explain their results:

> Staffed mostly by women, emphasizing verbal behaviors and rewarding passive compliance, schools are seen as better suited to "feminine" skills and temperament. ... Teacher expectation or attitude may also account for the girls performing academically better than the boys. Teachers (mostly female) may expect more from female students, hence their better performance. ... Perhaps, our elementary and middle schools are female oriented and consequently are suited to the interest and enhancement of feminine activities. ... Academic excellence may be a secondary objective for grade eight boys in the school setting. (p. 18)

Joan Pinner Scott, in the paper already quoted (22), reports that:

> ... more girls earn higher marks than boys in Newfoundland (Grade 11), girls have a higher pass rate in Ontario (Grade 13) and enrollment data shows more girls in more challenging courses at Grades 10 and 11 in New Brunswick.

She concludes:

> Good pass rates combined with low enrollment in some places suggests that girls in those places have either a quite incorrect estimate of their mathematical abilities and/or no appreciation of the value of mathematics to their future careers or no expectation of having a career.

The issue of girls' incorrect estimate of their mathematical abilities has been addressed also by David Robitaille (16). In this study, boys' and girls' degree of self-confidence in their methods of performing the four basic operations with whole numbers are compared with their actual performance. The subjects were 5,440 British Columbia students from grades 5, 6, 7, and 8.

> Despite the fact that the girls consistently outperform the boys as regards achievement, in only 3 out of 20 cases is the girls' mean self-confidence score greater than that of the boys. (p. 20)

In Quebec, Richard Pallascio investigated attitudes towards mathematics among students who had just started attending junior college (15). The instrument used was a slightly modified version of a 67-item questionnaire developed in France by Jacques Nimier. The results were reported by sex as well as by program. Statistically significant differences between the women's and the men's answers were found on 7 of the 67 items. Women agreed more strongly than men with the statements: "When solving a problem, I panic fairly often" and "The difficulties I encounter when solving a problem are like a barrier that I must break down in order to make progress." Men more than women perceived mathematics as being "a subject where you cannot fake it: either you know it or you don't." Men also agreed more strongly than women with the statements: "Doing mathematics is doing something fundamental, which is basic to everything else," "In mathematics there is no room for personality, all that one does has been done before by someone else, all has been thought out before" and "Those who spend too much time doing mathematics run the risk of losing touch with reality." The last two results seem to surprise the author. Further differences were found when restricting the analysis to students in vocational programs and to students in academic programs. No interpretation is offered of the results observed.

Further relevant literature

The studies quoted so far include all of the empirical research on sex differences related to mathematics that I have found. "Sex" is rarely used as a critical variable in Canadian mathematics education research. I have come across two articles, (8) and (9), in which some sex differences are mentioned in passing. In neither article was observing sex differences an objective of the study. In the first one, the author describes how familiarity (or lack of it) with a particular problem situation (racing cars) influences boys' and girls' performances. Familiarity seemed to help the boys at one stage and to hinder them later on. In the second article, children were observed while performing rational number tasks using two different representations: a "real problem packing machine" or a number pattern setting. Boys had more success using the machine representation while girls had more success with the pattern representation.

Two researchers told me that they feel reluctant about publishing their results by sex or publicizing any sex differences that they may notice in the course of their studies because they do not see any positive use for this kind of information.

Among non-empirical research should be noted the 1980 report on Gender and Mathematics/Science Education in Elementary and Secondary Schools prepared by Gaalen Erickson, Lynda Erickson, and Sharon Haggerty (5). This report was commissioned by the Ministry of Education of British Columbia as a result of the recommendations, already quoted, presented in the 1977 mathematics assessment (18) and in a similar science assessment. The report is divided into four parts. The first two parts consist of an extensive review of the literature on the subject of sex-related differences in science and mathematics achievment and enrollment as well as on the question of the origins of these differences. Some attention is given to the literature on sex-related differences in cognitive abilities, but most of the space is devoted to affective and motivational factors (stereotype of science as a male domain, girls' career interests, attitudes to science, fear of success in a male domain, math anxiety), to educational variables (teachers, counsellors, course materials and textbooks, coeducational education) and to other socio-cultural factors such as parents and peers. The third part describes programs and projects undertaken in the United States to increase girls' interest and achievement in mathematics and science. The final part of the report consists of appropriate recommendations to several educational constituencies in British Columbia.

An early and interesting article on the subject was published in 1974 by Jean Hewitt under the title Why Doesn't Jane Count? (7). The author examines "four stumbling blocks in the path of potential female mathematicians": sexual stereotyping, anxiety and the narrow coding caused by it (coding refers here to the way in which individuals simplify, organize and internalize information), imagination, and possible inherent differences in abilities between boys and girls. The article ends with some suggestions about teaching approaches.

4. Overview

Three general features of Canadian work on gender and mathematics seem to emerge from a survey of the relevant literature.

A. Sex differences in inherited abilities related to mathematics have not been assigned a central role so far.

An exception to this were a few articles appearing in Canadian newspapers and magazines in December 1980 and early in 1981 carrying titles such as "Study suggests boys are born superior in math" (Montreal Gazette, December 6, 1980). The study referred to is research done by Camilla Benbow and Julian Stanley at Johns Hopkins University in the United States and publicized in the magazine Science (December 12, 1980). Karen Al-Aidroos and Lesley Lee, a geneticist and a mathematician, wrote a response to these articles (26) and sent it to the Montreal Gazette, but the newspaper has not acknowledged it.

B. Much Canadian research seems to be motivated by a desire to contribute to changing the present situation.

Sex differences in enrollment and achievement in mathematics courses, and their origins, are studied in terms of finding ways to correct them. Many publications end with suggestions or recommendations directed to people in the various sectors of the educational system. However, to my knowledge, no systematic programs have been developed specifically to overcome the disadvantages girls face in learning mathematics in school. One such program may emerge from a project currently under way at the Board of Education for the City of Toronto (27).

C. There is a tendency to consider the issue of women and mathematics as one aspect of some larger issue; e.g., women and science or sexism in the schools.

In February 1981 the Science Council of Canada held a one-day workshop on "The Science Education of Women in Canada." The proceedings will be published within the year and will contain a chapter on mathematics (31).

In several provinces there has been a movement to confront sexism in the schools. Official bodies have produced detailed analyses of stereotypes present in school textbooks and guidelines for screening out sex-biased educational material (1, 4, 12, 13, and 19).

These publications touch on mathematics in two ways. First, the mathematics texts have turned out to contain as much sex bias as any other texts. Verbal problems, especially but not exclusively in older texts, provide striking examples of sexual stereotyping. Secondly, an analysis of the characters portrayed in texts of any subject reveals that male characters outnumber female characters two to one in elementary school texts and three to one in secondary school texts (4, p. 10 and 19, p. 8) and up to five to one if one considers major characters only (13, p. 14 and 19, p. 8). Moreover, the list of different occupations in which these characters are represented is at least five times as long for males as for females. Male occupations include mathematician, engineer, scientist, and other professions requiring mathematics in their training. No female characters are portrayed in such professions (4, p. 111 and 13, p. 142).

The conclusion is that school texts portray a society even more heavily stereotyped than the real one. These findings confirm in a dramatic way that there are indeed powerful socio-cultural factors working against girls preparing to enter mathemtaics-related professions. It is to be hoped that these shocking reports and the guidelines accompanying them will produce some quick changes.

In Quebec, the francophone teachers' union published a collection of activities that teachers of all subjects and levels, from kindergarten to college, may use with their classes (2). The aim is to help students observe and try to modify sexist attitudes and behaviours within themselves, the family, the school and society in general. Over half the activities deal with career related issues and some necessarily touch on mathematics (the rest deal with language, media, sports, family, violence against women, history and politics). Several activities call for surveys to be conducted by the students in their schools. Here are some examples: an inquiry into students' perception of the various trades and professions as being more appropriate for one sex or the other and a discussion of the findings; a study of girls' and boys' participation in the various courses or programs offered in their school or college; an inquiry into girls' and boys' perceptions of their own scientific aptitudes, their attitudes towards science and their actual achievements in science courses; etc.

5. Concluding Remarks

In an effort to assess general interest in the topic "gender and mathematics" in Canada, I asked all participants at the 1981 meeting of the Canadian Mathematics Education Study Group to complete a four-item questionnaire on the subject. Of the 55 participants, only 27 turned in their answers. Of these respondents, 14 feel that there is a need for research on gender and mathematics in Canada, and 12 consider the lower participation of women in mathematics as a problem for Canadian society. Among the 23 who teach some mathematics education or mathematics courses for teachers, 7 said that they spend a little time on the topic "gender and mathematics" in their courses.

I would summarize this by saying that while there does exist some interest in gender and mathematics in Canada, at present this topic is not on the priority list of mathematics educators. On the other hand, I have noticed a fairly new and growing concern about sexism in the schools. This seems to be manifested more strongly by governments and other official bodies than by the university community.

Those of us who think that a good mathematics education is important for everybody and that women should have an equal chance of participating in mathematics carry the responsibility to see that mathematics is kept within the focus of the movement to confront sexism in the schools. I think and hope that in the near future more activities will be undertaken both to develop a better understanding of the phenomenon of mathematics avoidance by girls, and to sensitize students, teachers, and the public in general to this issue.

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Gender and Mathematics in the Dominican Republic

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1. Introduction

Until now, interest in the Dominican Republic in the topic of women and mathematics has been very low. Actually, there are very few studies dealing with this topic and our information sources were limited to: (1) the Dominican studies section of the Universidad Católica Madre y Maestra's (UCMM) library, where we found data on this topic in the form of the B. S. thesis papers of students of the UCMM's Department of Education, and (2) data in the form of final mathematics examination grades obtained from the Department of Mathematics at UCMM.

In the following we will refer to the studies dealing with the topic which we found in the above sources. We would like to point out that the studies presented in this paper are exclusively descriptive, and do not deal with the different variables that influence or motivate the end results. Nevertheless, these studies may be used as indicators of a behavior that should be analyzed and investigated more deeply in the Dominican Republic. It is the authors' hope that this paper will serve as the departure point for a series of studies on a topic of such relevance and social implications.

2. Description of Study

Relation between the Results of Raven's Test of Progressive Matrices and the Students' Grades in Mathematics in the First Semester of the Freshman year of the UCMM from 1966 to 1970 (Sagredo, 1973).

One of the hypotheses of this study establishes that "the correlation between the results of Raven's Test of Progressive Matrices and the mathematical grades of male students is higher than the correlation between the grades of said test and the mathematical grades of female students" (p. 5). The controlled variables in this study were: intellectual capacity; grades corresponding to Math-101, Math-103, and Math-104 (basic mathematics courses, corresponding to Freshman year); and the gender of the individuals studied. Some uncontrolled variables were: age, social class, motivation, and physical and psychological conditions at the time of test administration. The population studied and its temporal outreach are the limitations of the investigation since it was performed solely in the UCMM and it only refers to the data of 1966 through 1970. The sample consists of UCMM students who were in the mathematics courses during the first semester of the freshman year between 1966 and 1970 and in whose admission records Raven's test results are reported. An analysis of the data of this study indicates that "the correlation between Raven's test results and the grades of Math-101 among male students is 0.2033, while for female students it is 0.3280" (p. 17). Thus, the above-mentioned hypothesis, which relates the achievement measured by the Raven and gender, must be rejected since the correlation coefficient is greater for female students than for male students.

Garret's criteria were used for the interpretation of the correlation coefficients.

3. Description of Study B

Problems of the Teaching of Mathematics at the UCMM in the Academic Year 1970 - 1971 Due to the Changes Introduced in the Programs (Morel et al., 1972).

This investigation consists of three sections. The last section relates gender with mathematics. It studies the opinions of 239 second-semester students of the academic year 1971 - 1972 on the program of the Math-101 which they had studied during their first semester that same year. The sample represented 82% of the total population. The instrument used for obtaining data in this investigation was a questionnaire of closed questions; the statistical treatment was limited to the calculation of the absolute frequencies and percentages of the alternative responses. The controlled variables were: faculty, sex, time, difficulty, usefulness, instructor, and orientation. In the analysis of the opinions by gender on the mathematics program, it was established that out of 197 students surveyed, 116 were males (59% of the sample) and 81 were females (41% of the sample). Math-101 seemed of an average difficulty with a tendency to being easy for male students, while female students found the program to be of average difficulty with a tendency to being difficult. Thus, the percentages of difficulty were higher among female students and the percentages of ease were higher among male students (see Table 1).

TABLE 1

DEGREE OF DIFFICULTY OF MATH-101 BY GENDER

	Males (N=116)	Females (N=81)
Very difficult	8%	16%
Difficult	18	24
Average	44	35
Easy	23	21
Very easy	7	4

In regard to the degree of difficulty of topics in the course, female students found Logic the most difficult, followed by Functions; male students found Functions the most difficult. Table 2 presents the listing of difficult topics by gender.

In the questionnaire, students were asked which mental operations were encouraged in the Math-101 program (see Table 3). Thirty-six percent of the male students thought the program encouraged reasoning as much as memory; 40% of the female students thought it encouraged reasoning more than memory. Eleven percent of all students thought that the program did not encourage either mental operation.

TABLE 2

REPRESENTATION OF THE TOPICS OF MATH-101
ACCORDING TO THE DEGREE OF DIFFICULTY BY GENDER

	Males	Females
Logic	23%	41%
Sets	13	10
Relations	16	17
Functions	41	26
No answer	7	6

TABLE 3

MENTAL OPERATIONS ENCOURAGED BY MATH-101, BY GENDER

Mental Operation	Males	Females
Memory only	2%	4%
Reasoning only	18	16
Memory and reasoning equally	36	34
Memory more than reasoning	9	-
Reasoning more than memory	29	40
None of them	5	6
No answer	1	-

When asked about the amount of time required for the completion of the Math-101 program, 9% of the students (18 students) thought the time "too much" (p. 43). Of the 18 students only 4 were female (see Table 4).

During the academic year 1970-1971 fundamental changes were made in the teaching of mathematics in the UCMM, changes which motivated this study. The factors included: the introduction of a new program of Math-101 for freshman students; a new outlook of mathematics; the concepts of sets and relations appear as reinterpreters of mathematical reality; and the appearance of new subjects in the college (universit) mathematical milieu. It was observed that during that year grades in Math-101 were low and a great number of students dropped out of the course; teachers' didactics were criticized; and the students' opinions on the program of Math-101 were, in general, less than favorable. This investigation analyzed possible explanations of the problem.

TABLE 4

DISTRIBUTION OF STUDENTS TO WHOM THE AMOUNT OF TIME SEEMED TOO MUCH FOR THE CONTENT, BY FACULTY AND GENDER

Faculty	Males	Females
Administration and Economy	1	1
Engineering	7	0
Education	1	2
Social Work	1	0
Law	2	1
Agronomy	2	0

4. Description of Study C

The Teaching and Learning of Mathematics in the Dominican Republic (Luna, 1980).

In the Dominican Republic, work is being done on the project of Education of the Learning and Teaching of Mathematics conducted by the Second International Mathematics Study. In the pilot tests administered to eighth-grade students or sophomores within the Reform Program of the Dominican Educational System (students of an average 13 years of age), data on achievement by gender and by different types of school were obtained. It is important to point out that in each type of school some of the classrooms visited were coeducational (that is, with both female and male students), while other classrooms lacked that characteristic.

We consider it convenient to describe some generalities of the Dominican educational system that may result in a better understanding of the characteristics of the students who participated in this pilot study. The National Council of Education and the Secretary of Education are in charge of directing the Educational Program by disposal of the Organic Law of Education of 1951. The Department of Education, Fine Arts and Culture supervises and evaluates all schools and finances a great many of them. There are different types of schools in the Dominican Republic: public schools, totally financed by the State; and private schools, which receive no financial aid from the State. Schools are also classified as <u>urban</u> or rural. Nevertheless, the study programs are common for the whole country and established by the National Council of Education, which also approves the texts used for teaching. The academic structure of the educational system is organized as represented in Figure 1. Note the co-existence of two parallel programs: the "Traditional Program" and the "Reform Program."

We would like to emphasize that samples for the pilot tests were taken from the two main urban centers of the Dominican Republic: Santiago and Santo Domingo. The schools were chosen as representative, through the years, of the three types of schools of which the Dominican Educational system is made up of: public, semi-official, and private. The pilot tests were administered in May 1979, November 1979, and May 1980. The goal of these tests was to determine if the international cognitive instruments were appropriate for students belonging to population A in Dominican Republic, that is, students whose ages halfway through the school year were between 13 years, 0 months and 13 years, 11 months. When these tests were administered, behavior by gender was also observed.

4.1 Pilot Tests - May 1979

In May 1979, three tests of 40 questions each were administered, identified as Form 1, Form 2, and Form 3. The three forms were administered in 16 schools of Santiago and Santo Domingo to some 1,500 students who had completed eighth grade (junior high) or the second year (sophomore) of the Reform Program.

Some of the resulting statistics related to achievement by gender are presented in Tables 5 and 6.

TABLE 5

ACHIEVEMENT BY FORM

	Form 1	Form 2	Form 3
Females	26.02%	30.32%	24.09%
Males	30.32	34.73	31.22

When hypotheses were tested statistically to ascertain whether the achievement differences were significant, it was found that males had better achievement ($p < .001$) than females on each of the three test forms. Nevertheless, the resultant data must be considered simply as indicators of a tendency but not conclusive, due to the character of the sample chosen and the fact that this research was merely a pilot study.

4.2 Pilot Tests - Academic Year 1979-1980

A total of 1798 students from 49 different classrooms in 23 schools in Santiago and Santo Domingo participated in these pilot tests. The schools

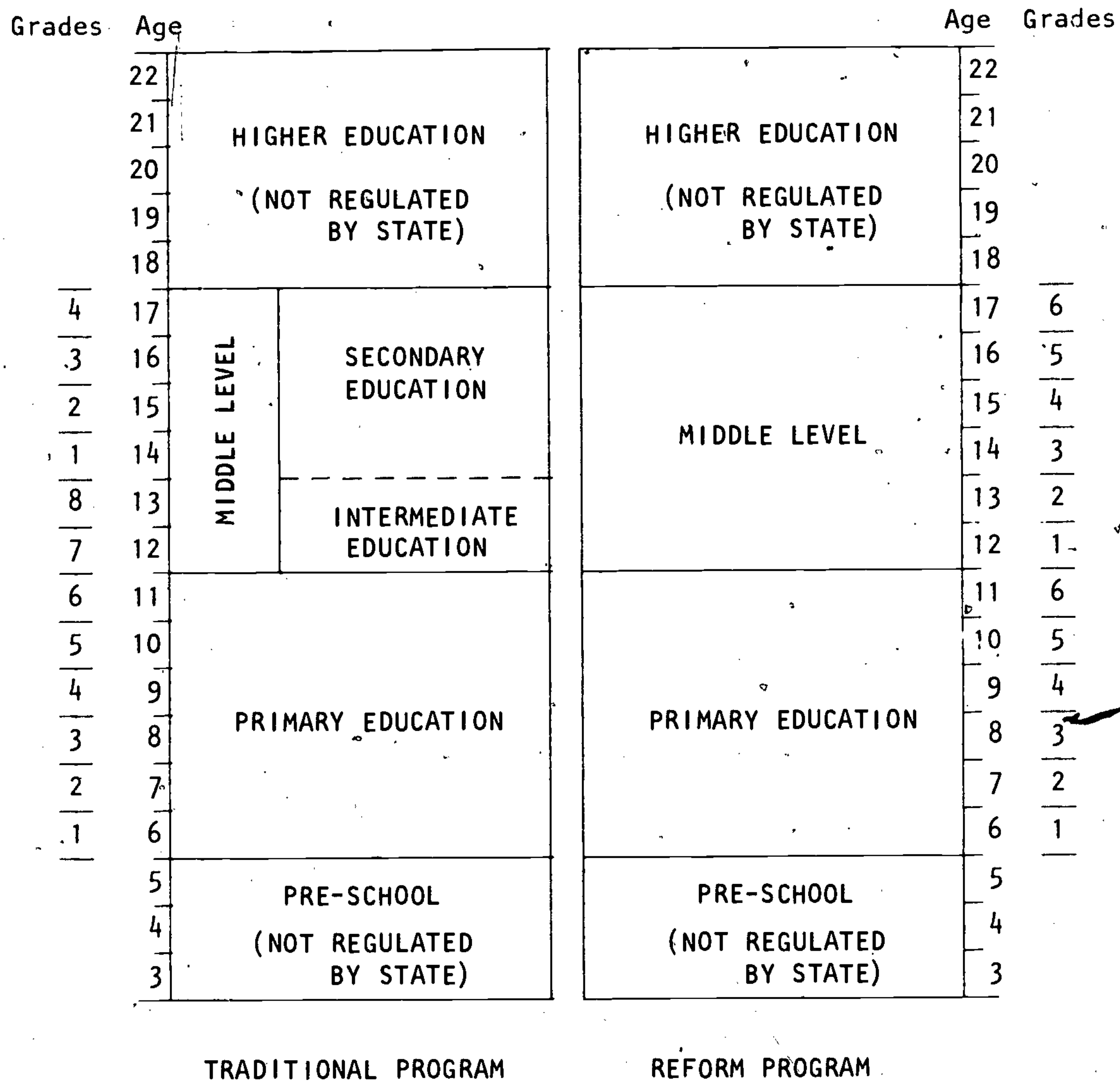

Figure 1. Structure of Education in the Dominican Republic

TABLE 6

ACHIEVEMENT BY AREA

	Males	Females
Natural Numbers	46%	42%
Common Fractions	31	25
Decimal Fractions	44	35
Reasons, Proportions and Percentages	45	18
Theory of Numbers	28	24
Powers and Exponents	44	42
Square Roots	62	50
Dimensional Analysis	14	9
Rational Numbers and Integers	33	30
Geometry	28	22
Probability and Statistics	38	29
Measurement	27	23

were of the public, semi-official, and private types. A pretest was administered before the first six weeks of the school year were over, and a posttest was administered at the end of the school year.

Some statistics by gender in both the pretest and the posttest are presented in Tables 7 and 8.

Again, statistical tests were conducted to determine whether the differences in achievement were significant. On both pretest and posttest, males achieved better than females in all types of schools ($p < .001$).

General Conclusion for Study C: The statistics gathered by the pilot tests given in the Dominican Republic as part of the Second International Mathematics Study suggest that there is a significant difference in academic achievement in mathematics between the male and female groups of eighth grade or Reform sophomore level in Dominican Republic. Due to the nature of the sample chosen, this empirical result cannot be taken as conclusive, but rather as an interesting phenomenon that should be investigated in its total extension at a national level.

5. Description of Study D

Analysis of the Relation of Final Grades of First Semester Students of the Academic Years 75-80 who took Math-101 and the Gender of the Same.

The population of this study was made up of students of Math-101 in the first semesters of the 1975-1980 academic years who obtained grades of

TABLE 7

PERCENTAGES OF STUDENTS BY INTERVALS OF ACHIEVEMENT BY GENDER IN THE PRETEST

	Intervals			
National Level	0-25%	26-50%	51-75%	76-100%
Males	67.4%	30.9%	1.6%	0.1%
Females	75.3	23.9	0.8	0
Public Schools				
Males	82.7	17.3	0	0
Females	90.4	9.6	0	0
Semi-Official Schools				
Males	80.0	20.0	0	0
Females	88.1	11.9	0	0
Private Schools				
Males	57.1	39.9	2.8	0.2
Females	61.0	37.4	1.6	0

TABLE 8

PERCENTAGES OF STUDENTS BY INTERVALS OF ACHIEVEMENT BY GENDER IN THE POSTTEST

	Intervals			
National Level	0-25%	26-50%	51-75%	76-100%
Males	47.4%	43.8%	8.02%	0.8%
Females	61.1	33.4	5.3	0.2
Public Schools				
Males	66.4	32.8	0.7	0
Females	84.0	15.3	0.7	0
Semi-Official Schools				
Males	64.2	34.1	1.7	0
Females	75.1	24.6	0.3	0
Private Schools				
Males	34.3	51.3	13.0	1.4
Females	43.6	45.5	10.4	0.4

A, B, C, D, or F, excluding students who obtained failing grades due to poor attendance, those whose work was incomplete, and those who had to take special exams. The reasons for limiting this study to the first semesters are: a) the majority of the students registered in the first semester are exposed for the first time to Math-101, that is, the number of students repeating Introductory Mathematics is low; b) there is a greater coordination in the work done by all the instructors teaching this subject in terms of the focus of topics, quality and quantity of exercises assigned to the students, elaboration of tests, and the amount of time dedicated to each topic.

It is necessary to point out some limitations of this study. While it is certain that there is intensive coordinated work that produces departmental exams (partials and finals), it is also true that in these exams (essay-type) questions are included in which the subjectivity of the teacher influences evaluation. On the other hand, in our culture, career election is very often determined by the simple fact of belonging to a determined gender. To back this statement, it seems sufficient to observe (see Table 9) data on students registered in some programs at the UCMM, as gathered by the Planning Office.

Thus, there are careers which are mainly made up of males while others are mainly made up of females. An interesting item is that in the latter only basic mathematics is required. Consequently, a characteristic of the educational system, and not precisely gender, explains why in these careers there is little motivation for studying Math-101. It simply will have no future use. On this aspect, we would like to refer to another section of Study B. This section deals with the problem of teaching mathematics in the UCMM resulting from the changes introduced in the 1970-1971 academic year and states: a) 56, 45, and 45 percent of the students of the sample of this study which belong, respectively, to the faculties of agronomy, engineering, and business administration and economy regarded the Math-101 program as useful for their careers; b) 81, 75, 54, and 54 percent of the students of the sample of this study which belong respectively to the faculties of law, nursing, education, and social work considered the Math-101 program of little use in their careers (p. 52). It seems convenient to point out that the Math-101 program we have referred to is the same one in actual use at the time of this study.

Returning to Study D, we will now consider some of the data on percentages of students attaining each grade during the seven-year period (see Table 10).

The difference in average index by gender observed in Introductory Mathematics in Freshman year at the UCMM is small. We would, nevertheless, like to emphasize that the data presented on registered students clearly signal that lack of motivation, and not gender, would be the explanation to the difference observed in achievement.

A striking fact is the low achievement registered by both genders in Introductory Mathematics. Also, in Table 10 we can clearly see that the female gender predominates in the lower extreme F while the male gender predominates in the higher extreme A.

TABLE 9

DISTRIBUTION BY GENDER OF STUDENTS
ENROLLED AT THE UCMM: 1976 - 1981

	Year	1st. Semester % Male	1st. Semester % Female	2nd. Semester % Male	2nd. Semester % Female
Agronomy	1976-1977	97.9	2.1	97.9	2.1
	1977-1978	98.7	1.3	98.5	1.5
	*1978-1979	98.0	2.0	98.7	1.3
	1980-1981	92.4	7.6	90.6	9.4
Engineering	1976-1977	89.8	10.2	89.9	10.1
	1977-1978	91.3	9.7	91.1	8.9
	1978-1979	89.6	10.4	91.2	8.8
	1980-1981	85.9	14.1	85.8	14.2
Business Administration and Economy	1976-1977	44.0	56.0	43.5	56.5
	1977-1978	38.0	62.0	46.6	53.5
	1978-1979	43.9	56.1	49.6	50.4
	1980-1981	49.1	50.9	48.7	51.3
Law	1976-1977	50.7	49.3	48.1	51.9
	1977-1978	57.2	42.8	49.0	51.0
	1978-1979	48.4	51.6	44.5	55.5
	1980-1981	46.1	53.9	55.5	44.5
Nursing	1976-1977	3.3	96.7	3.4	96.6
	1977-1978	5.5	94.5	8.6	91.4
	1978-1979	10.2	89.8	9.4	90.6
	1980-1981	14.9	85.1	14.6	85.4
Education	1976-1977	39.9	60.1	32.1	67.9
	1977-1978	30.5	69.5	30.6	69.4
	1978-1979	26.7	73.3	27.4	72.6
	1980-1981	32.4	67.6	32.3	67.7
Social Work	1976-1977	29.4	70.6	29.0	71.0
	1977-1978	26.8	73.2	28.9	71.1
	1978-1979	24.0	76.0	16.3	83.7
	1980-1981	16.3	83.7	16.4	83.6

*Note: At the time of writing this research paper we had not been able to obtain data on the 1979-1980 academic year.

TABLE 10

PERCENTAGES OF STUDENTS BY GENDER WHO OBTAINED GRADES A, B, C, D, F, IN INTRODUCTORY MATHEMATICS DURING THE FIRST SEMESTER OF THE 1975-1981 ACADEMIC YEARS

Academic Year	% Male					% Female				
	A	B	C	D	F	A	B	C	D	F
1975-1976	9.8	15.2	23.6	21.6	29.9	13.2	15.4	20.5	20.5	30.5
1976-1977	21.0	14.1	16.0	16.8	32.0	13.0	11.4	12.1	16.3	47.3
1977-1978	17.3	19.6	17.9	16.2	29.0	10.4	12.3	20.6	17.3	39.5
1978-1979	13.3	11.6	13.4	19.0	42.6	10.2	11.6	14.6	19.9	43.7
1979-1980	21.2	17.3	23.4	16.4	21.8	17.3	23.1	22.0	18.3	19.4
1980-1981	12.5	14.4	15.9	23.6	33.5	11.5	12.3	20.6	18.0	37.6
1975-1981	16.6	15.5	18.1	18.8	31.0	12.7	14.5	18.8	18.4	35.6

6. Conclusions and Recommendations

a) In the Dominican Republic, few studies have been conducted in the area of "Women and Mathematics."

b) The data signal a statistically significant difference in academic achievement by gender in mathematics. Male achievement in mathematics is better than female achievement in the populations studied.

c) There have been no studies found which regard the variables that influence the difference in achievement observed.

d) An important factor is the socio-cultural influence that predisposes and determines the type of professional activity corresponding to each gender:

> ". . .It seems clear that the development of formal structures in adolescence is linked to maturation of cerebral structures. However, the exact form of linkage is far from simple, since the organization of formal structures must depend on the social milieu as well." (Piaget and Inhelder, 1958)

e) The different research studies that appear in this study have not been conducted within the theoretical framework established by theories of learning related to gender. Up to this moment, there have been no resulting activities, as a consequence of these investigations, promoting the development of interests, aptitudes, and attitudes favorable towards mathematics.

f) We recommend that local researchers become interested in finding the underlying causes of the differences observed by gender in the learning of mathematics, especially if new research based on data at a national level should confirm the empirical data of the studies presented in this report.

g) Research in this area is extremely important because of the need to apply to the educational system the required correctives that would allow the amending, or at least the lessening, of the socio-cultural and other possible negative factors which impede the learning of mathematics by the Dominican woman. It is important to include female talent in the scientific and technical areas that our society has traditionally reserved for males.

h) When we consider the Dominican woman's mass participation as teachers, especially at the primary level, the utmost importance of her mathematical education becomes clear. Primary teachers in our country have no specialized academic preparation by subject area.

i) We hope that in the research on "The Teaching and Learning of Mathematics in Dominican Republic" (which will be conducted shortly), a model explaining how the gender variable must be studied in an urban and rural setting and in each type of school will be presented. In this way, the difference in achievement stated in this report may be fully supported or rejected.

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Gender and Mathematics in England and Wales

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Central to the issue under discussion is the fact that, although the curriculum in this country has been and still is differentiated by both gender and class, especially in the sciences and in practical and technical subjects, mathematics has been considered a core subject, and has been studied, in one form or another, by almost all children up to the end of compulsory schooling. Gender differences in mathematics achievement have, as a result, gone largely unnoticed, whilst much attention has been paid to such differences in science. As long ago as 1918, the Thomson Committee was reporting on the general inferiority of laboratory accommodation and equipment in girls' schools, and the "lack of systematic teaching of physics to girls" (Jenkins, 1979, p. 178). In recent years many researchers have contributed to our knowledge in this field (e.g., Dale, 1974; Ormerod, 1975; Kelly, 1979; Harding, 1981), and the publication this year of The Missing Half: Girls and Science Education, edited by Alison Kelly (1981), has brought together much of this research in a comprehensive and enlightening survey. Much of this work is, in fact, of relevance to mathematics educators. For example, mathematics is one of the sciences studied by Weinreich-Haste (1981) in her work on the male image of science and by Harding (1981) in her work on sex differences in public examinations.

The realisation is now growing, however, that the problem of girls' underachievement in mathematics is separate from, although clearly in many respects related to, that of science. There has been a rise in the number of research projects being undertaken in this specific area, and a national association (GAMMA - Girls and MatheMatics Association) has been formed to encourage such research and raise awareness about the problem.

The areas of interest which have been identified, so far, as being of central importance are: the actual performance of girls as compared with that of boys in national surveys and tests (e.g., the 11+[1], the APU[2]) and

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[1] In England and Wales children normally enter secondary school in the year in which their twelfth birthday falls. Until recently, the majority were channelled into two distinct types of secondary education on the basis of '11+' tests of verbal reasoning, English and arithmetic. These determined whether a child would go to a selective, grammar school or a non-selective secondary 'modern' school. Grammar schools offered their pupils a more seriously academic education and expected many of their pupils to go on to further study, usually at a university. Secondary modern schools took the '11+ failures and offered a less demanding course of study with fewer options. In addition to being selective by ability, grammar and secondary modern schools largely catered for middle and working class children, respectively, although this was not the intention of the planners of this system. In the 1960's and 1970's, much of the country was reorganised into a comprehensive system of secondary schools which take the full range of ability (excluding physically and mentally handicapped children).

[2] Assessment of Performance Unit (DES, 1980).

in public examinations (CSE, O- and A- levels); problems related to the transition from primary to secondary schooling; and some underlying variables which might throw light on these. These variables include:

(1) The organisation of schools and teaching groups, especially with respect to mixed and single-sex groupings.

(2) Curricular differences which might affect mathematics performance at the compulsory stage and choice of mathematics at a later stage.

(3) Additudinal factors, such as those to do with linking, confidence, and the perceived importance of mathematics.

(4) Sexism in mathematics texts and other classroom material.

(5) The socio-political perspective.

Interested groups include mathematics educators and those concerned with the sociology and/or psychology of education; bodies such as the Equal Opportunities Commission and the Schools Council; and feminist groups. 'Innate ability' theories do not find many supporters among these groups. The feeling, rather, is that educational, societal, and attitudinal differences are more likely to be crucial and must be investigated first. The remainder of this paper will be devoted to describing the research which has been carried out in this country.

Achievement at 11 and in Public Examinations: The Primary/Secondary Transition

When most secondary education was selective, there was a careful monitoring of the tests of verbal reasoning, English, and arithmetic which were given to children in their last year of primary school. This provides us with useful data on the relative achievement of girls and boys in mathematics at age 11. The recent upsurge of interest in gender differences in education has highlighted the fact that girls, on the whole, did better than boys in all three types of 11+ test. However, as it was considered 'unfair' to offer grammar school places to more girls than boys, the pass mark was set higher for girls than it was for boys, with all this implies in terms of future opportunities. More recently, the Assessment of Performance Unit Primary Mathematics Survey (DES, 1980) has yielded the following information:

> The data on sex differences show a slight, and generally non-significant, advantage to the boys in most sub-categories, but girls perform significantly better statistically in computation (whole numbers and decimals). (p. 72)

What is striking about this evidence is that girls have maintained their superiority in computation and that in other areas of mathematics, which were not previously investigated, no significant differences between girls' and boys' performance at age 11 have been found.

Public examinations at 16 and beyond offer the next possibility for comparison using hard data. They show that girls lose ground relative to boys after the age of 11 and that, as the level of difficulty increases, so the numbers of girls relative to boys achieving success decline (see Table 1). (It is interesting, however, that the proportion of girls achieving success at each of these levels has been steadily increasing over the years. At O-level, for example, girls have improved from obtaining 33.3% of the total number of passes in 1967 to 39.6% in 1978.)

One major piece of research for which a pilot study has already been carried out (Eynard and Walkerdine, 1981) is seeking to investigate this "discontinuity of the mathematical attainment of girls" (p. 84). Eynard and Walkerdine intend to follow a group of girls from the primary to the secondary school in order "to examine the changes which occur in the education and experiences of girls" (p. 84). They discuss with some rancour the attempts of many researchers and educationalists to "play down the early performance of girls" and attribute it to "just, simply or only something or other" (pp. 5-6) (e.g., 'only' low-level computational skill). They argue very strongly that girls' achievement at age 11 is real, and that, rather than explaining this away, we must study the processes by which this early success is transformed into a later, relative failure.

Mixed and Single Sex

The 'mixed or single-sex' variable has been studied in Stamford secondary school by its deputy headmaster (Smith, 1980). Teachers had noted the rapid decline in mathematics performance of girls in their school and therefore decided to organise some of their pupils into single sex sets. Two sets, one of girls and one mixed, were then matched for intake. Smith found that within 18 months of as near-identical educational treatment as possible, the mathematics performance of the girls in the mixed set had declined markedly, both in relation to that of the boys in their class and to that of the girls in the all-girls set. The girls in the all-girls set, however, had held their own relative to the boys in the mixed set. After the experiment had ended and they had been put into mixed sets, the girls who had been in the all-girls class for two years reported that they had preferred their all-girls class and had found it easier to study in that environment.

These findings point in the same direction as research which suggests that girls in girls' schools are more likely to choose science and mathematics (e.g., Dale, 1974; DES, 1975; Omerod, 1975). For example, the Department of Education and Science Survey, "Curricular Differences for Boys and Girls" (DES, 1975), shows that, of those fourth and fifth form girls who were offered physics as an option, 23% of those in girls' schools as compared with 15% of those in mixed schools chose physics (p. 13). At A-level, the comparative figures for girls choosing mathematics and physics are:

	Single sex	Mixed
Mathematics	19%	12%
Physics	12%	7%

TABLE 1

MATHEMATICS EXAMINATIONS 1978
ENGLAND AND WALES

		entries	graded results	percentage awarded grade 1	percentage awarded grade 5 or better
CSE	girls	207 767	181 904	12.3	87.6
	boys	202 278	180 662	15.6	89.3
girls as % of total		50.7	50.2		

		entries	passes-grades A-C	percentage pass rate
O-LEVEL	girls	126 125	66 123	52.4
	boys	165 632	100 711	60.8
girls as % of total		43.2	39.6	

		entries	passes - grades A-E	percentage pass rate
A-LEVEL	girls	17 028	11 849	69.6
	boys	58 188	39 803	68.4
girls as % of total		22.6	22.9	

Figures taken from:

Department of Education and Science (1980), Statistics of Education 1978, Volume 2, HMSO

Note: CSE (Certificate of Secondary Education) and O-level (Ordinary Level) are normally taken at age 16. O-level is a higher grade qualification than CSE.

A-level (Advanced Level) is normally taken at age 18.

Other contributing factors need to be taken into account, however, such as the ethos of the school and whether or not it has a selective intake. Thus, in their survey of secondary schools (DES, 1979), HM Inspectors comment that "the infrequent uptake of physics by girls in girls' modern schools reflected traditional attitudes to this subject in some of these schools" (p. 168) (my emphasis). This survey confirms, however, that when grammar schools alone are looked at, girls in girls' schools are more likely to study physics than girls in mixed schools. (There were too few single-sex comprehensive schools in the survey to allow valid comparisons to be made.)

Some researchers hypothesise that pupils who do not study science are disadvantaged in mathematics. (One such study will be discussed below.) If this is so, then girls in some mixed schools may be doubly disadvantaged--both directly in mathematics classes and indirectly through the effect of mixed schooling on their choice of science and hence achievement in mathematics.

Differences in the Curriculum and the Effect on Mathematics Performance

Evidence suggesting that pupils who study physics or technical subjects do better at mathematics than those who do not has been provided by Sharma and Meighan (1980). Their work also shows that whether pupils have studied these subjects is a better predictor of success in mathematics than is their sex. Sharma and Meighan looked at six categories of entrants to one particular O-level Mathematics examination--the Cambridge Local examination held in 1977. Twenty-five candidates were selected at random from each of the following categories: (1) girls who had also entered for physics O-level, (2) girls who had also entered for Technical Drawing O-level, (3) girls who had entered for neither, and (4) - (6) three boy-categories similarly defined. Analysis showed that the best candidates were those who had also studied physics, the next best were those who had also studied technical drawing, and the worst were those who had studied neither. This was true for both sexes, and there was little to choose between girls and boys in any one subject category. As far more boys than girls study these subjects, as well as craft subjects such as woodwork and metalwork, this curricular variation, it is suggested, affects not only girls' achievements in the subjects themselves but also their performance in the compulsory subject mathematics. We have no way of knowing how many girls drop down from O-level to CSE in mathematics as a result of such curricular variations.

Attitudinal factors

Attitudes toward mathematics have been studied by Preece (1978, 1979) and Sturgeon (1979). Preece tested 1250 children at the beginning and end of their second year of secondary schooling (age 12-13). She found that in the course of the year "the overall (attitude) scores for the boys increased slightly while those for the girls dropped, a swing to many more negative responses from the girls being clearly apparent" (Preece, 1979, p. 28). She comments on careers that teachers who reported "clear signs of girls moving away from preferred choices of career simply because a mathematics entry qualification was required" (p. 29), the implication being that girls' career choices are affected significantly by their attitude toward mathematics. Isaacson and Freeman (1980), however, in a response to Preece, point out that it is equally likely that "girls may well turn away from mathematics and change their career choices primarily because their careers are not very important to them" (p. 25). Further research is needed to determine the direction of causality. Sturgeon (1979) found that 50% of the boys she interviewed, but only 25% of the girls, said that math would be useful to them in work. (The children she interviewed were a sample of those, now in their third year, who had been tested by Preece the previous year). Sturgeon also found a tendency of the more-able girls to underestimate their own ability in mathematics. Further evidence of girls' poorer self-concept is provided by a small study carried out in her own school by Russell (1981). She found that when she asked fifth form girls and boys and their teachers to predict their success in the forthcoming O-level examination, more boys expected to pass than were expected to pass by their teacher, whereas fewer girls expected to pass than were expected to do so by their teachers. Although the research evidence on attitudes is scanty, it does at least point in the same direction as the grass-roots knowledge of teachers who work with girls during the secondary school years. Many teachers comment on girls' relative lack of confidence, and their unwillingness to apply themselves when the going gets tough--a reasonable response if you believe that mathematics is not very important for your future. These attitudinal factors may well account for at least some of the under-achievement of girls in acquiring higher level mathematics qualifications. As Isaacson (1980) comments, girls who are not allowed to drop out of mathematics nevertheless can and do drop down (in attainment and ultimately in level of examination taken).

Sexism in Mathematics Textbooks

Sexism in mathematics classroom materials and text-books has been little investigated in this country. Although at present we lag far behind other parts of the world in this, it is recognised as an important issue, and one in which much work is needed.

The Socio-Political Perspective

Debate in this country has been informed and enlivened by much socio-political discussion concerning gender in education, including work on classroom interactions, the construction of feminity in the classroom, and so on (e.g., Sharpe, 1976; Marks, 1976; Byrne, 1978; Wolpe, 1978; Deem, 1980; Spender and Sarah, 1981). The mathematical education of girls has, in this context, been seen as just one facet amongst many in a society where careers and jobs are still regarded as being more crucially important for boys, while girls must be educated for home-making and mothering. Additionally, even those groups in society which have long encouraged their daughters to gain an education and contribute to society have seen this contribution as being more appropriate if it was <u>not</u> in the fields of science or technology.

Summary and Concluding Remarks

At the end of primary schooling in this country, that is at the age of 11, there is little to choose between the mathematical attainment of girls and boys. By the age of 16, the end of compulsory secondary schooling, girls have fallen behind boys in their attainment, particularly in the higher grade O-level examination. This trend continues to A-level and beyond. Variables which have seemed to be of particular importance and have been studied, include:

(1) mixed and single sex groupings,

(2) curricular variables, especially in science and technical subjects

(3) attitudes to mathematics, and

(4) socio-political variables.

As well, much of the work on 'gender and science', of which there is a great deal, is relevant to those interested in 'gender and mathematics.'

Clearly, these variables are interrelated, creating a complex arena. Much work remains to be done, both in ascertaining more clearly the causes of girls' relative underachievement in the higher reaches of mathematics and in devising strategies for effective change.

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Gender and Mathematics in India

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It is difficult to talk about "gender and mathematics" in a country where the effective literacy (people who can read and write) rate for the population is 29.4% and the male and female literacy rates 39.5% and 18.7%, respectively (see Table 1). It is recognized that sex stereotyping may exist in the instructional materials used in elementary schools or more specifically within elementary school mathematics textbooks. No major study has been done to evidence the sex bias in school mathematics textbooks. This problem of identifying "gender and mathematics" is a relatively new one for the Indian Educational system.

However, interest in "gender and education" has been growing in India throughout the last decade. This in itself is very significant because of the sex-segregated character of the society, the condition of poverty, and the traditional value systems--which are different and sometimes mutually conflicting.

The education of women was sadly neglected in the past, and consequently there is a wide disparity between the general educational attainments of men and women and between girls and boys at all stages of education. Because of this, since Indian Independence in 1947, special efforts have been made to close the gap between the education of men and women in as short time as possible (see Tables 2 and 3).

In recognition of the importance of the education of girls and women in accelerating socio-economic development, the government has formulated a variety of measures from time to time in this direction. Special programs for the promotion of girls' education were initiated as early as 1957-58. The main schemes initiated were provision of attendance scholarships for girl students, appointment of school mothers, construction of quarters for women teachers, and payment of stipendsfor teacher training courses. It was observed that there had been a gradual but progressive increase in the enrollment of girls over the plan periods and that the gap in the education of boys and girls appears to have been narrowing down during the last two decades. At the end of 1977-78, 68% of girls in the age group 6-11 years are reported to have attended primary schools as against 32.4% at the end of the first plan. Bythe end of 1977-78, 71 million in the age group 6-11 years were going to schools and girls constituted 39.3% (2.8 million) of total school-going children. As for the attendance in age group 11-14, the enrollment was 18 million girls, accounting for 31.2% (6 million) of the total. At the end of 1957-58 the percentage of girls attending primary/ middle schools was 32.4%, whereas in 1977-78, it had increased to 68.2% in the 6-14 age group. Enrollment for secondary education increased from 0.17% in 1950-51 to 10.7% in 1977-78.

Indian women have made significant contributions to the cultural, educational, and political leadership of India through the ages. In fact, the University Education Commission said that there could not be "an edu-

TABLE 1

ACHIEVEMENTS IN ADULT EDUCATION IN INDIA

(millions)

Age groups	1961				1971			
	Literates		Illiterates		Literates		Illiterates	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
5-14	33.66	29.5	80.32	70.5	53.10	35.2	97.68	64.8
15-24	26.33	36.0	46.88	64.0	43.65	48.2	46.92	51.8
25-34	19.23	28.5	48.19	71.5	26.79	34.8	50.22	65.2
35+	26.27	22.3	91.77	77.7	37.84	25.2	112.29	74.8

TABLE 2

ENROLLMENT TARGETS AND ACHIEVEMENTS IN FOURTH AND SIXTH PLANS

(millions)

Age groups			1969-70	1973-74	Sixth Plan Target 1978-83[2]	1978-79
6-11 Classes I-V	Boys		34.77 (95)	39.68 (100)	50.2 (111)	43.96 (100.2)
Primary level	Girls		20.71 (50)	24.03 (65)	41.0 (96)	28.80 (67.8)
		TOTAL	55.48 (73)	63.71 (84)	91.2 (103)	72.16 (84.5)
11-14 Classes VI-VIII	Boys		9.27 (47)	10.51 (47)	18.0 (64)	12.14 (49.2)
Middle level	Girls		3.70 (20)	4.53 (21)	10.8 (44)	5.98 (26.0)
		TOTAL	12.97 (34)	15.04 (35)	28.8 (57)	18.12 (38.1)
14-17 Classes IX-XII	Boys		4.72 (27)	5.41 (28)	101 (31)	5.86 (25.6)
Secondary level	Girls		1.60 (10)	2.06 (11)	43.0 (10.4)	2.46 (11.5)
		TOTAL	6.33 (18)	7.47 (20)	144 (23)	8.32 (18.8)
17-23 University stage		TOTAL	2.23	3.1		4.21

[1]Provisional; [2]Source--Draft Sixth Plan 1978-83 (revised)

NOTE: Enrollment ratio has been worked out on the basis of old population projections; figures in parentheses indicate enrollment as percentage of the population of the relevant age-groups.

TABLE 3

ACHIEVEMENTS AND TARGETS AT DIFFERENT LEVELS OF EDUCATION

(millions)

	1950-51	1955-56	1960-61	1965-66	1978-79	Sixth Plan targets 1982-83
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Number of pupils in classes I to V	19.15	25.17	34.99	50.47	72.39	91.20
Percentage thereof to total population in age group 6-11	42.6	52.8	62.4	76.7	84.5	103.0
Number of pupils in classes VI to VIII	3.12	4.29	6.70	10.53	18.01	28.80
Percentage thereof to total population in age group 11-14	12.7	16.5	22.5	30.8	38.1	57.0
Number of pupils in classes IX to XI/XII	1.22	1.88	2.89	5.04	9.08	---
Percentage thereof to total population in age group 14-17	5.3	7.4	10.6	16.2	20.6	---
Number of pupils at the university stage arts, science and commerce	.36	.63	.89	1.49	3.03	---
Percentage thereof to total population in age group 17-23	.8	1.4	1.8	2.7	4.1	---
Percentage of students reading science at university stage	37.8	33.0	26.9	29.5	---	---

cated people without educated women . . . and that if education had to be limited to men or women, that opportunity should be given to women, for then it would most surely be passed on to the next generation." It may be pointed out that the deity of the Hindu Pantheon chosen for knowledge, the creative arts, and the intellectual life is the Goddess Sarasvati.

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Gender and Mathematics in Ireland

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Introduction

The subject of gender and mathematics is now attracting some attention in Ireland. This attention seems to be concentrated mainly on the achievements of girls in the national examinations, and particularly on the participation rate of girls in senior mathematics courses. The low participation rate is not new, but concern over it is of comparatively recent growth; investigation of the problem is still at a fairly superficial level, and no substantial empirical findings with sex as a major variable have yet been published. Thus, per force, the main concern of this paper is the changing attitude to girls' study of mathematics.

The historical facts of the situation--the salient features of the Irish education system, and the actual courses open to girls--are described in the second section. In the third section there is a discussion of factors which seem to have been of particular importance in determining the evolution of the courses. The last summarises the type of evidence that has already been collected on girls' participation and performance, and outlines possible developments in the future.

Historical Background

Ireland has a centralised curriculum and examination system, in that school syllabuses are decreed, and major national examinations are conducted, by the Government Department of Education. This centralisation, together with a tradition of offering very little choice of syllabus in the major subject areas, has produced considerable uniformity of curriculum in Irish schools; this makes it comparatively easy to identify main lines of development. In the case of mathematics courses, the developments can be traced back to the nineteenth century, when the present system began to take shape.

State intervention in Irish schooling dates from 1831. As a result of a decision made in that year, "national" schools were established; they provided basic education in various subjects, including arithmetic and, in some cases, other branches of mathematics (Atkinson, 1969, pp. 93, 99). A typical version (Twenty-second Report, 1856, p. 122 ff.) of the programme specified a common arithmetic course for the three most junior classes, but a more demanding course for boys than for girls in the remaining three classes; in particular, the boys' course included a little elementary geometry, while the girls' did not. Similar variations are found between the training programmes for male and female teachers in national schools (Sixteenth Report, 1950, p. 303).

With the growth of the distinction between first and second level education, national schools became identified with primary education, of which they are still the main providers.[1] Their tradition of differentiation in mathematics on grounds of gender lasted, in modified form, up to the end of the 1960's, when "Algebra and geometry (were) taught in some schools, but (were) not obligatory in the smaller schools or in classes taught by women" (Investment, 1965, pp. 6-7). However, a new primary curriculum, introduced in 1971, prescribes a more typically modern and integrated mathematics course, taught to, and by, both sexes.

A similar pattern of evolution can be seen at second level--again dating from the nineteenth century. The present secondary examination system has its origins in the Intermediate Education (Ireland) Act of 1978. As a consequence of this Act, a system of public examinations was instituted, and hence programmes of study were established (Atkinson, 1969, pp. 114-115); and, as in the national school programme, the regulations affecting mathematics were less stringent for girls than for boys. The nature of the concessions varied over the years: initially, they allowed girls (but not boys) to obtain a pass in mathematics by passing in arithmetic alone; later, boys had to offer a mathematical subject in the examination, whereas girls did not (Tansey, 1978, p. 219).

A further Act in 1924 recast the secondary examination system in effectively its present form. Nowadays there are two main examinations, the Intermediate Certificate (taken, typically at age 15+, at the end of the Junior cycle), and the Leaving Certificate (taken, typically at age 17+, at the end of the senior cycle). Girls' participation in the Intermediate Certificate has been the subject of various concessions, again altering somewhat over the years. One of the most notable features, for much of the time, was the provision of a special Intermediate course in "Elementary Mathematics," open only to girls; also, boys had to pass mathematics in order to obtain their Intermediate Certificate, whereas girls were not required to present the subject at all at the examination (Tansey, 1978, pp. 221-228). However, "Elementary Mathematics" was examined for the last time in 1968. In the following year, "Mathematics" was offered at two levels--"lower" and "higher"--with no distinction being made between the regulations for boys and for girls. In contrast to the situation for the Intermediate Certificate, the Leaving Certificate courses never made different provision for the sexes; so, from 1969 onwards, there has been no statutory difference in the secondary school requirements for the mathematical education of boys and girls.[2]

Altogether, therefore, it can be seen that the mathematical courses in Ireland no longer cater separately for boys and girls,[3] but that this new tradition of equality is only about ten years old. To complete the picture,

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[1] There are also a few "private" primary schools.

[2] In the interests of brevity, no reference has been made to types of second level education other than secondary; however, the major conclusions stand. (Secondary schools, which are the "grammar schools" or "gymnasia" of the system, contain the majority of second level students.)

[3] The requirements and syllabuses are given in: Rialacha agus Clár do leith Meánscoileanna (Rules and Programme for Secondary Schools) (Dublin: The Stationery Office, published annually).

it remains to point out one other important factor of the Irish education system. Compared with that in some countries, a very high percentage of students (of the order of 90%) follow examination courses, with more than 50% of the age cohort remaining in school to take the Leaving Certificate and, as the Leaving Certificate is not a specialised examination, over 90% of these take mathematics.[4] Thus, few girls drop mathematics altogether during their school career. However, most of them take only the "Ordinary" rather than the "Higher" Leaving Certificate course, and this has implications particularly for entrance to third level education. This matter is considered again in the following sections.

First, however, an attempt must be made to identify the changing attitudes to the mathematical education of women which have produced the situations described above. The attempted analysis is presented in the next section.

Factors Influencing the Provision of Mathematics Courses

In looking at the provision of mathematics courses, and at the growth and then decline in the special regulations for girls, it seems possible to identify four major contributory factors. These are:

- the specification of syllabuses in the nineteenth century;
- the influence of the Roman Catholic church;
- socio-economic developments in the last twenty years;
- the growth of the women's movement.

These will be discussed in turn.

The reasons for specifying different syllabuses for boys and girls in the nineteenth century are related to the social conditions and to the role of women at the time. An investigation of such aspects is outside the scope of this paper; it suffices to remark that they helped to establish a tradition which had a particularly widespread and lasting effect.[5] The Intermediate Board regulations, in particular, may have been a mixed blessing for women's mathematical education. The fact that girls' schools were included in the scheme at all led to favourable comment from contemporary writers; the immediate effect of the Act was to extend the range of subjects available in girls' schools (Oldham, 1897, p. 257), with female students having to show that they were "capable of grappling even with Mathematics" (Alexandria College, 1919, p. 13). Nonetheless, it might be argued that the acceptance, in principle, of reduced mathematics courses for girls, and the further institutionalisation of this principle with the introduction of the "Elementary Mathematics" course, in the long term did women's mathematical education more harm than good.

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[4]See the statistical reports issued by the Department of Education; for example, Tuarascáil Staitistiúil (Statistical Report) 1976-77 (Dublin: The Stationery Office, undated), pp. 32-54.

[5]Recall that it is only about ten years since the different syllabuses for boys and for girls were finally abolished.

However, perhaps the situation was inevitable in the context of the times. As has already been indicated, that is too large a subject to be treated generally in this paper; but one aspect does require mention: the influence of the Roman Catholic church, especially through the convent schools. For most girls, secondary education meant education in a convent school, run by an order of nuns. These schools have made--and are continuing to make--an enormous contribution to Irish education, and nowadays are quite likely to be at the forefront in encouraging girls to take scientific and technological subjects; but in the earlier part of the century, they accepted and actively promoted a "traditional" role for women; a role concerned with marriage and home-making, and in which mathematical education had little part. This can be seen from the annual reports of the Conference of Convent Secondary Schools (CCSS). A number of these reports explicitly welcome the reduced mathematics course for girls; one even indicates that the total exclusion of mathematics from the girls' curriculum had been considered (although rejected), and there are accounts of discussions on the subject with the Minister for Education of the day (Tansey, 1978, pp. 164-167). While the extent of the influence that the CCSS had on the Department is not known, its influence on the pupils in convent schools must have been considerable (Tansey, p. 167).

As indicated above, there has been a radical change in the thinking of the CCSS in recent times (Tansey, p. 168). This is an instance of a general trend: socio-economic developments in the last twenty years have produced many alterations in Irish society; and these have led, among other things, to a less restricted view of the role of mathematics for women. Once again, a detailed analysis of the situation is outside the scope of this paper; no attempt can be made to identify all the agents of change and the relationship between them. Instead, it must suffice to pick out three "milestones"--significant events occurring during the period--each of which seems to have made an important contribution to the new role for mathematics. They are:

- the publication of the influential report Investment in Education;
- the development and expansion of the Irish education system in the 1960s and early 1970s;
- the economic recession, starting in the mid-1970s.

These will be discussed in turn.

The report Investment in Education (1965), initiated by the then Minister for Education in 1962 and organised in co-operation with the OECD (p. ii) is widely regarded as having brought a new, system-oriented and statistical approach to the study of Irish education. Among the facts and figures to which it drew attention were the shortage of qualified mathematics teachers (pp. 272-274), especially women (p. 340), and to the low rate of participation by girls in what is now called the Higher Leaving Certificate mathematics course (p. 279).[6] While these facts may well have

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[6] The text refers to successful participation by girls, but takes this as an indicator of the total rate of participation.

been in accord with people's tacitly held beliefs about the situation, and thus may not have come as a surprise, yet their presentation in starkly statistical form does seem to have coincided with a recognition that the situation could be regarded as problematical.

Even before the publication of Investment in Education, changes had begun to take place in what for decades had been a very stable and static education system. The expansionist, egalitarian atmosphere of the 1960s tended to produce demands for broader curricula and easier access to different subject areas; participation in second level education grew rapidly, and the rigid separation of "academic" and "technical/practical" programmes (previously a feature of the system) was relaxed. The curriculum development movement contributed to the general reappraisal. At the beginning of the 1970s, therefore, the education system was dynamic and developing to an unprecedented extent; it was by this period that the last official constraints and concessions on women's participation in mathematics courses were removed.

Removal of restrictions, however, does not automatically produce a changed situation in the schools. Somewhat paradoxically, the world recession of the mid-1970s--which slowed down the general rate of educational development in Ireland[7]--seems to have been a positive force in encouraging girls' participation in higher mathematics courses; for these courses carry great weight in the employment market and in gaining entry to third level education. The fact that Ireland is now deeply involved in the "new technology" is adding to the demand for mathematically qualified people. It is perhaps this aspect, more than the concern of mathematicians and mathematics teachers for their own subject, that is producing the public demand for higher participation by girls.

While the growth of the women's movement cannot easily be separated from the development of other socio-economic factors over the last twenty years, it is accorded independent discussion here for two reasons. First, the women's movement has presumably been influential in changing the perceptions of women's role in Ireland--a change that is hard to quantify, but that does seem to have taken place. Secondly, it is proving to be a source of academic research.[8] This aspect is discussed further in the final section of this paper.

The State of Research: Present and Future

By now, a substantial amount of evidence on girls' participation and performance in mathematics courses has been collected; and much of it tends to indicate that both participation and performance compare unfavour-

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[7] Development can be measured in different ways, but the emphasis here is on government-financed research, and on curriculum development and innovation. Funding for such projects has been affected by the recession, and openness to change seems to have been an indirect casualty.

[8] Tansey's dissertation, cited several times already in this paper, is a notable example.

ably with boys'. For example, the number of female entrants for the Higher Course Leaving Certificate mathematics is only about a quarter of the total; and in all the national mathematics examinations, the percentage of female entrants achieving high grades tends to fall short of the percentage of male entrants doing so.[9] However, the discrepancies do not appear to be as great as they used to be (Tansey, 1978, pp. 95-106).[10]

The evidence for this comes essentially from the Government Department of Education statistics. In the past, these were not readily accessed; but Investment in Education set new standards of data collection and presentation, and the Department now publishes statistical reports on a regular basis. Moreover, the work of Tansey has brought together the relevant figures for earlier years, and has put them in--at least for the academic community--a more readily accessible form.[11] Thus, more detailed analyses of past trends can now be undertaken.

Other studies widen the frame of reference, extending it beyond the national second-level examinations. A report by the Department on primary education in mathematics shows that girls' performance was generally superior to that of boys in most of the areas tested; the findings were being analysed further.[12] Another major study of mathematical achievement examined performance at the level of transition from primary to post-primary, and reported that, at that stage, the boys were generally ahead of the girls (Kellaghan et al., 1976); but the sex-related analysis has not yet been pursued in any depth.[13] In neither study was gender the major variable (in both cases, the focus was on the achievement of specific learning objectives): publication of such studies is still awaited in Ireland.[14]

The present state of social awareness of the problem has been noted above. As was pointed out, its concern is often with "manpower" (person-

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[9]An Roinn Oideachais (Department of Education) Tuarascáil Staitistiúil (Statistical Report). (Dublin: The Stationery Office), nowadays published approximately annually. Thus, figures can readily be obtained for the years 1974/75 onwards.

[10]Valid comparisons over the years are difficult to make, both because of the altered nature and size of the entering cohort and because of the very small numbers of girls involved in the earlier years.

[11]The contribution of Tansey's work to the present paper is gratefully acknowledged.

[12]An Roinn Oideachais, an tAonad Curaclaim, Tuairisc ar Theagasc na Matamaitice sna Bunscoileanna (Dublin: July 1977), pp. 11, 13.

[13]Communication from Dr. J. Close, who is associated with the research.

[14]Some relevant work is being carried out at the Economic & Social Research Institute, Dublin, in the context of equal opportunities for women. However, the research is not specifically concentrated on mathematics.

power); for example, a recent report[15] recommends that a "programme to double the number of boys and quadruple the number of girls taking higher level mathematics" should be set up and implemented, and also considers the problem of teacher supply. But, perhaps to an even greater extent than with recent academic research, such reports do not tend to look at the problem in any depth.[16]

Thus, it seems that conditions are now appropriate for much more substantial investigations: investigations that would look more deeply at the reasons for the continuing imbalance between boys' and girls' participation and performance in mathematics--studies that would look not only at achievement statistics, but also at other variables such as the role of the teacher, the age at which attitudes to mathematics are formed, and the prevailing approach in schools for the relevant age groups. Such studies might form the basis of programmes of action in the future. At least at the time of writing, they look to be the most likely way forward in the search to improve the mathematical education of women in Ireland.

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[16] The problem of gender in mathematics is not usually the main concern of such reports.

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Gender and Mathematics in Israel

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1. Background

The topic "gender and mathematics" has not raised great public interest in Israel; nevertheless, relevant data have been available in regularly published statistical reviews and studies almost continuously since the 1950s. Information about sex differences in mathematics can be extracted from studies relating to the status of women in Israel and from statistics about school enrollment and examination records, but in most cases such information appears as a marginal aspect in studies focusing on other aspects of the society or of the school system. It should be noted, however, that the status of women in Israel has been considered as an important issue in the political arena in election campaigns, in the mass media, in public discussions, and, parallel to these, in the field of academic research. In the last decade, several research studies were published on the status of the woman in work, in the court, in the family, in various ethnic subcultures, etc. The Henrietta Szold National Institute for Research in the Behavioral Sciences publishes a quarterly titled Current Research in Behavioral Sciences, and a typical issue of this contains references to 8-10 studies dealing with sex differences in Israel.

In 1976 the Israeli Government appointed a public committee to study the Status of the Woman in Israel. The committee was chaired by a woman member of the Knesset (Parliament), and had 92 members. It was asked to prepare a report and to formulate policy recommendations. The report, published in 1978 (The Committee on the Status of the Women 1978) provided detailed information about various aspects of the status of the women in the country. One chapter of the report deals with Education and Vocational Training. But even this chapter touches upon the problem of gender and mathematics only marginally.

Occasionally small-scale studies dealing with gender and mathematics have been conducted in various Israeli universities, but they are "standalone" studies, and hitherto no systematic effort has been devoted to studying this problem in the country. One cannot identify research centers which have focused on this problem, nor are there any individual researchers in the country who are known as being associated with or devoted to research in this field.

At the general meetings of the Israel Educational Research Association (IERA), the topic of gender and mathematics has never constituted a theme for any symposium, and if lectures dealing with this topic were presented, they were included in sessions dealing with educational achievements in general.

2. Available Statistics

Higher Education

The Central Bureau of Statistics continuously provides information about the student population of universities in Israel. According to a recent publication, in the academic year 1979/80 the number of degrees in mathematics granted by all universities in the country was 453. The distribution of degrees according to sexes is presented in Table 1.

TABLE 1

ACADEMIC DEGREES IN ISRAELI UNIVERSITIES IN MATHEMATICS IN 1979/80

Degree	Male	Female	Total
Bachelor's	177	180	357
Master's	44	21	65
Doctorate	23	8	31
Total	274	209	453

(Central Bureau of Statistics, 1981[a])

It can be seen that at the bachelor's level no substantial differences appear between the number of male and female students. As one proceeds toward the higher academic degrees the discrepancy between the sexes increases. Figures are also available about the proportion of females in the total student population studying mathematics (Central Bureau of Statistics, 1981[b]). Thirty-eight percent of students studying mathematics are female. It should be noted that at the Israeli universities the majority of the students study two major subjects. Among those who study mathematics as a single subject, 40% are females, while among those who study mathematics together with physics, only 8% are females. In the group of students majoring in mathematics and science, 38% are females; in mathematics and in some disciplines of the social sciences or humanities, 56% are females; in mathematics and in statistics, 36%; and in mathematics and computer sciences, 44% are females. It should be noted that the proportion of women in the mathematics departments of Israeli universities corresponds to their proportion among secondary school mathematics teachers. Forty percent of the secondary school mathematics teachers are women, while 60% of the secondary school teachers in the humanities and social sciences are women (Shapira, 1977).

Relevant to this topic is the distribution of female and male students in non-academic tertiary education frameworks.

TABLE 2

STUDENTS IN NON-ACADEMIC TERTIARY EDUCATION (IN PERCENT)

Sex	Engineering technical	Banking, accounting	Primary school teacher training	Para-medical	Art	Total
Male	59	14	11	3	13	100
Female	5	3	63	13	16	100

Table 2 reveals striking differences between the sexes. The majority of males study engineering or related subjects, while the females tend to study in teacher-training institutes for primary schools. (Most of these teacher-training institutes do not have academic status.)

Secondary Schools

No national statistics are available about the distribution of boys and girls in mathematics studies in secondary schools. In the academic type secondary schools there is a school-leaving matriculation examination. Though mathematics is not formally a compulsory subject of the matriculation examination, only a very small group of school leavers does not take the matriculation examination in mathematics. The reason for this is that universities only rarely admit students who have not taken that examination. Nevertheless, the mathematics examinations may be based on either cumulative 3, 4, or 5-point units. (A point unit represent a course studied 3 periods per week during an academic year. Accordingly the 3 point unit represents 3 hours per week for each of three years during the grades 9-12 of the secondary school, and a 5 point unit represents 5 periods per week over three years during the four grades of the secondary school).

While national statistics are not published about the distribution of boys and girls in 3, 4, and 5 point classes, it is of interest to present here figures from an occasional report on three secondary schools in Haifa (Hadar, 1981). Of course it is not known to what extent this distribution is typical for other schools in the country. It can be seen that in all three schools more girls than boys take the less-demanding mathematics programs.

As to vocational high schools, there is continuous growth in the number of girls in the technical specialization tracks. In 1980/81 the growth was 20% in comparison to the previous year, and 50% in comparison to two years before; nevertheless, the overall percentage of girls in these tracks is only 9.1%.

Table 4 presents figures concerning the percentage of girls in various specialization tracks.

Girls tend to avoid those fields of specialization which require a relatively high level of knowledge in mathematics (Ministry of Education, Department of Technological Education, 1981).

TABLE 3

BOYS AND GIRLS IN VARIOUS MATHEMATICS PROGRAMS IN THREE SCHOOLS

School A	% boys	% girls
3 point program	49	73
4 point program	40	20
5 point program	11	7
All	100	100
School B		
3 point program	43	71
4 point program	38	16
5 point program	19	13
All	100	100
School C		
3 point program	43	69
4 point program	31	30
5 point program	26	1
All	100	100

TABLE 4

STUDENTS IN VARIOUS SPECIALIZATION TRACKS OF TECHNICAL SUBJECTS IN VOCATIONAL EDUCATION

The track	All students 1980/1	% of girls
Electronics	7236	8
Electricity	5808	5
Construction, mechanics	8956	1
Car repair, engines	6934	3
Computers	1161	26
Technical drawing	4410	30
Laboratory assistant	1002	67
All	35507	9.1

3. Achievement Differences

Information about sex differences in achievement in mathematics is av⁻ilable from general achievement surveys. The summary of the annual matriculation examinations contains relevant statistics. The last summary of the matriculation examination (for 1980/81) scores, released by the Ministry of Education and Culture, provides separate means for boys and girls. The relevant data are presented in Table 5.

TABLE 5

AVERAGE SCORES AT THE MATRICULATION/
EXAMINATION 1979/80
(PERCENTAGE)

Subject	Boys	Girls	Total
Literature	65.08	68.63	67.85
English (as a foreign language)	67.36	63.23	63.74
Mathematics	66.35	69.15	67.62
Bible	62.91	65.29	64.26

(Hadar, 1981)

Surprisingly enough, the girls' average scores is higher than that of the boys. But the summary does not contain information about the type of examinations taken by boys and girls (i.e., the proportion of 3, 4, 5 point programs), and treats together all scores obtained on a 100-point scale in mathematics, without considering the type of program. One may assume that more girls than boys took the restricted 3 point program.

Support for this assumption can be derived from a study of Lavi (1980). Lavi compared the scores of male and female applicants to the Haifa and Tel-Aviv universities on their entrance examination. She matched the male and female samples on the variables, place of birth, age, socioeconomic status and educational level of father, and found considerable sex differences (males having higher scores) on the subtests of information, mathematics, and analogy. No differences were found on the subtests of vocabulary matrices and English as a foreign language. Lavi concludes that these differences are greater than those reported in other Western societies. Reports on sex differences are contained in various achievement surveys conducted in the country. The Lewy and Chen (1976) longitudinal survey contains information about sex differences in mathematics in grades 4, 5, and 6 of the primary school. This longitudinal survey is based on a sample of 3000 learners from 70 schools constituting a representative sample of the whole student population. The sex differences between the achievements are separately calculated for students whose parents immigrated from developing countries and for those whose parents immigrated from developed (industrialized countries). Such a distinction reflects the general interest prevailing in the country concerning the relative achievement level of these two immigrant groups of the Israeli population. The results (expressed in units of standard deviation) appear in Table 6.

TABLE 6

SEX DIFFERENCES IN MATHEMATICS ACHIEVEMENT (AVERAGE OF BOYS MINUS AVERAGE OF GIRLS IN UNITS OF STANDARD DEVIATION)

	Country of origin	
Grades	developing	developed
4	.17	.11
5	.02	.04
6	.12	.10

It can be seen that in all grades boys have higher averages than girls. The study does not provide an explanation for the relatively small differences at grade 5. Examining the tests of grade 5, one may assume that the lessening of differences is an artifact of the so-called "ceiling effect" of the tests used in grade 5.

A large-scale achievement survey conducted by Minkovitz et al. (1977) provides achievement data in mathematics in grades 1, 4, and 6 of the primary school. The focus of that study was differences in achievement among children whose parents immigrated to Israel from various countries, but attention was also paid to sex differences. The within-class partial correlation between sex (male coded 1 and female coded 2) and achievements in mathematics, after controlling for classroom context variables, is: in grade one, -.06; in grade four, -.04; and in grade six, -.01; which means that practically no substantial differences were observed between the achievements of boys and girls.

An interesting study about sex differences of kibbutz children in scholastic abilities and achievements was conducted by Dar (1974). Dar found a correlation of .40 between sex and the mathematical abilities subtest of a group intelligence test and also a correlation of .40 between sex and scores of mathematics in the matriculation examination (boys scoring higher than girls). Dar explains this surprisingly high level of correlation between sex and mathematics among kibbutz children as an effect of the division of labor between men and women in the kibbutz. According to Dar, despite the egalitarian ideology of the kibbutz, most women in the kibbutz work in services, and thus girls have low motivation to study mathematics.

While most studies reporting on sex differences in achievements in mathematics do not attempt to explain the difference, Samuel (1980) focuses on identifying explanatory factors, rather than merely measuring differences. She examined the correlation between femininity and masculinity and achievement in mathematics in grades 7 and 11 for both sexes. She measured femininity and masculinity by using a modified version of the MMPI test and found that at the grade 11 level among boys masculinity had a correlation of 0.10 with mathematics and among girls of 0.29, while at the grade 7 level the correlations approached 0 for both sexes.

4. Attitude toward Mathematics

Several studies touched upon the issue of attitudes of boys and girls toward mathematics. In a comprehensive survey of attitudes toward school subjects, Lewy and Chalfon (1973) found that there are differences between the degree of importance attached to mathematics by boys and girls. The positive attitude of boys is higher than that of girls at all grade levels, both in religious and non-religious schools. Figure 1 contains information about the magnitude of the differences.

Figure 1. Rating of interest in mathematics.

It can be seen that at the higher grade levels the differences in attitude toward mathematics between boys and girls are higher than at the lower grade levels.

In a recent study, Lewy (1981) compared the attitude of seventh-grade boys and girls toward mathematics. Students of both sexes were asked to rate various subjects from the point of view of the importance attributed to them, and to what extent they liked the subject. Table 7 contains relevant information.

TABLE 7

ATTITUDE TOWARD MATHEMATICS
(PERCENTAGE OF STUDENTS EXPRESSING
HIGH POSITIVE ATTITUDE)

Importance		Liking	
Boys	Girls	Boys	Girls
88	87	52	50

The differences between boys and girls are negligible; the majority of both genders attribute importance to mathematics, but only about 50% indicate that they also like the subject.

5. Attempts to Reduce Gaps

Hitherto, no systematic attempts have been made to reduce achievement gaps between boys and girls in mathematics. Very recently a proposal was submitted to the Ministry of Education and Culture suggesting the implementation of a project which may contribute to reducing the gap between boys and girls both in mathematics achievement and in vocational aspirations (Hadar, 1981).

The project consists of two major elements: (1) A teacher training program based on similar programs in the United States (Kreinberg, 1980). It will guide teachers in how to study mathematics and how to create an awareness of the importance of mathematics in various occupational fields. (2) A special mathematics program for girls following the patterns of Mathematics for Girls (University of California, Berkeley) and Mathematics without Fears (University of San Francisco). The project will be carried out by the Department of Teacher Training of the Haifa Technion.

6. Summary

The present paper provides a summary of facts and concerns related to gender and mathematics in Israeli society. While no systematic and theory-oriented research has been conducted in the country about this topic, one may identify several sources which contain relevant data. The Ministry of Education and the Central Bureau of Statistics provide statistics both about enrollment and achievements. Concern about sex differences in mathematics is demonstrated in official statistics and in achievement surveys. On the other hand, the topic has not raised great interest, either among politicians or among researchers. The political campaign about the status of women has not paid attention to the issue of gender and mathematics, and researchers have not studied the problem systematically. The few studies dealing with the topic represent "stand-alone" attempts rather than a definable trend.

The scattered statistics and studies produced in Israel suggest that there are no substantial differences between the genders concerning mathematics at the primary school level. The differences become amplified at the secondary school level, while at the tertiary education level the achievements again become more egalitarian.

Women are less represented in occupations which require utilization of mathematics at various levels; nevertheless, about 40 percent of secondary school mathematics teachers are women.

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Gender and Mathematics in New Zealand

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Up to the present, gender and mathematics has hardly commanded an active or wide-spread reaction in New Zealand. Rather, among some groups there has been a quietly growing interest in selected aspects and an awareness that here are issues which deserve further investigation and action. No comprehensive study has been undertaken, but specific topics have been and are currently subjects of research and investigation. There is every indication that this activity will accelerate in the future. Areas which have been studied include statistics of participation and achievement, sex-stereotyping, attitudinal differences, vocations and careers, and ability differences.

Backgroud

A study of gender and mathematics (the more familiar term in New Zealand is 'women and mathematics') must be viewed to a major extent within the context of the educational system and the changes, pressures and ideals within society which affect it. In his annual report for 1939 the Minister of Education stated:

> The Government's objective, broadly expressed, is to ensure that every person, whatever his level of academic ability, whether he be rich or poor, whether he lives in town or country, has a right as a citizen to a free education of the kind for which he is best fitted and to the full extent of his powers.

Through the next 40 years, with this policy of equal rights a basic tenet, attention in education was turned to providing facilities for attaining this goal of equal access as well as broadening the curriculum to meet individual needs. Up to the 1970s, New Zealand was generally accepted as an egalitarian and democratic society; but then there was a questioning of the reality of this assumption. All was not equal in practice; there was in evidence an uneven participation in education, a disparity in outcomes. In this context some minority groupings came under scrutiny, as to some extent did females who overall seemed to be lagging in mathematics. The 1970s brought a keener awareness of the changing role and status of women in society and in the employment field. During this past decade the women's movement has had a considerable influence; this movement, the Decade of Women, and the International Women's Year (1975) have done much to direct attention not only to women in general, but also towards particular areas, including the position of females in the education system, the extent to which they avail themselves of their opportunities, and the many determining factors. A focus has thus fallen on mathematics, a key requirement for many positions and careers.

The women's movement has been instrumental in bringing together groups of women to consider their position and promote their cause. In the course of discussion, mathematics is at times mentioned. For example, in 1975 a Conference on Women and Education was sponsored by the Committee on Women and the Department of Education, its wide recommendations including one on sex-stereotyping in mathematics texts (9).* This was:

> That when the current mathematics text books are replaced or supplemented, the new texts show an equal proportion of girls and boys in the illustrations, and that the activities assigned to the sexes in the story problems are not stereotyped.

These internal factors and influences from overseas such as articles in journals, research reports, and International Mathematics Conferences like ICME III and IV, have all contributed to the present debate about gender and mathematics in New Zealand.

In order to provide some further information regarding the background, a few selected references are given in the bibliography (1, 4, 5, 10, 17, 25, 26, 31). A useful source of historical material on the status of women in New Zealand education up to 1969 is a thesis by Cumming (7). In this comprehensve study, mention is made of mathematics in the curriculum as well as the supply of women mathematics teachers. Reference is made to official reports and other publications containing relevant material.

It is hoped that this paper records all of the more significant New Zealand projects currently under action or completed which have some concern with gender and mathematics. As can be seen, there has overall been little empirical research devoted entirely to any aspect; rather, results and information have been only part of other investigations.

These projects are broadly categorised as follows:

Students taking Mathematics

For many years statistics have been available from the Department of Education (8) regarding the numbers of boys and girls studying mathematics at each level and also of their achievement in external examinations. It was not, however, until recent years that trends have received any interested attention. The most recent figures available are tabulated below:

Percentage of Students Taking Full Mathematics in 1980

		Male	Female
Form	3	99.0	99.4
	4	99.0	99.4
	5 (first year)	90.6	84.0
	5 (other)	82.8	64.1
	6	86.7	65.5
	7	76.6	56.9

Some data are also available for tertiary education. Females still tend to take Arts courses and males, Science courses.

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*Numbers refer to items in the list of references.

First Degree Courses taken by Internal Students at Universities in New Zealand (1980)

	Male	Female
Arts	3614	6918
Science	3728	1749
Engineering	1477	44

Degrees awarded reflect the same ratios.

A paper produced by the Research and Statistics Division of the Department of Education (13) describes the relative participation rates of males and females, indicating that in the period from 1970 to 1979 the total number of students taking mathematics in Forms 3 and 4 (junior secondary) remained the same (almost 100%). Mathematics is now the second most popular choice of subject in the School Certificate, a national middle school examination with most candidates aged about 15 years. The greatest increase in numbers taking mathematics has been for girls in the Form 5 and 6 levels; for example, 46% of fifth form girls in 1970 to 84% in 1980. Despite the increases that have occurred, girls are still not as likely as boys to opt for mathematics in the sixth and seventh forms.

Literature Review

In October 1979, the National Consultative Committee on Mathematics gave its support to a proposal by the Committee on Women in Education for research on women and mathematics. The Research and Statistics Division of the Department of Education is currently undertaking research in this area. The paper mentioned above (13, 14) also examines overseas research on possible agents of variation such as attitudes, careers, types of school, home and school environment, socialising, sex typing, confidence, and perception of mathematics, and makes some comparison with the situation in New Zealand. It points out that at the primary level in New Zealand there appear to be no significant sex differences in the performance of mathematics. Yet at the higher secondary levels (Forms 6 and 7) fewer girls comparatively are to be found taking mathematics. This effectively cuts off many possible job options for the girls who have not continued to take mathematics to a high enough level.

Attitudes and Performance

In his 1950 publication, Murdoch (21) examines aspects of the content and methods of teaching mathematics in secondary schools in New Zealand. A brief section is devoted to girls and mathematics. He writes: "To the best of my knowledge there is no psychological evidence that girls cannot do mathematics as well as boys; but there is much evidence to the contrary. The subject may interest them less or have less practical value for them . . . Social considerations further encourage superior performance by boys." He observes that girls leave school earlier, and home life makes more demands on them.

One of the first theses devoted entirely to gender and mathematics is an investigation into sex differences in 1968 (16). Jelley questions whether boys are in fact superior to girls in mathematical ability or whether the latter move away from the subject and from its associated occupations because of cultural conditioning or sex role learning. He was concerned with the disproportionate female drop-out rate in mathematics established as early as the fourth form. In his findings, no significant sex differences were found at the levels studied either in attainment or in attitude, but clear sex differences were displayed in ideas about future occupations and continuation in mathematics. In his conclusions he states, "Murdoch's opinions that New Zealand girls have not been shown to be less capable in mathematics and that boys were more often encouraged into mathematics and science options, were substantiated." He also stresses the need for earlier and more fully informed school course and vocational guidance.

A study by Clark of the attitudes of senior primary school children towards mathematics was published in 1972 (6). Although the report was primarily concerned with the group as a whole, she found no statistically significant sex differences in attitudes to mathematics. Overall, the results represented very favourable attitudes to mathematics.

At the University level a recent research project by Ngee was completed on attitudes to mathematics (22). He considered two aspects of attitude, enjoyment and usefulness, and two of mathematics, theory and application. Sex was taken as a variable, as was year of study, and whether majoring or not majoring in mathematics. He found that first-year female students had a significantly more positive attitude to the enjoyment of the theory of mathematics than males in the same class. His explanation was in terms of sex roles. This was the only sex-related result showing significant differences.

In 1982 the Research and Statistics Division of the Department of Education plans to undertake a survey of the whole sixth form population to gauge attitudes to mathematics and find out why girls and boys do or do not continue mathematics after Form 5. Job intentions will also be related to the decision to take, or not take, mathematics. At present the questionnaire is being piloted in selected schools. This has been preceded by a further pilot study, restricted to primary and intermediate schools, of pupil attitude to mathematics (12). Only 6 of the 39 statements showed statistically significant sex differences for the whole sample. Boys were more positive towards "I think I will need to use mathematics after I leave school" and "When I leave school I would like a job where you have to use mathematics."

Achievement in Mathematics

Records have been kept of the comparative performances of girls and boys in external examinations (8). The grades for pupils sitting School Certificate mathematics in 1980 were as follows:

Grade	A	B	C	D
	%	%	%	%
Females	5.1	15.9	30.6	48.4
Males	7.3	16.6	29.4	46.7

Little difference is indicated except that slightly more boys received an A.

Although an analysis of a sample of the 1979 Bursary (seventh form) marks showed that the average marks for boys and girls were not too dissimilar, 57% for males and 55% for females in pure mathematics, this comparison can be misleading as a smaller proportion of girls (60%) than boys (87%) sat mathematics. Girls are hence a more highly selected group, indicating a possible wider difference in favour of boys. Further analysis of the comparable performances of girls and boys is needed at this upper level. Is it possible that some of the potentially good female mathematicians have left school or do not continue with mathematics?

Current research is being undertaken by Knight (18) as to why some students who show themselves to be extremely able in other areas find mathematics so difficult. This is a small-sample, clinical study but already there is evidence of sex-role expectation as a factor with, on the other hand, no evidence of differences in inherited ability between the sexes. Knight is unable to detect any difference in the ways in which male and female subjects conceptualise mathematical ideas and procedures.

Differences in the responses by males and females to questions in inter-school reference tests are the subject of another current investigation by Perrin (24). Results are showing some significant differences in a few areas, but causes have not yet been analysed.

Rowe, in an investigation into sex differences in arithmetic (27), tested a sample of children in the age range of 7.6 years to 8.5 years. He found no sex differences in the accuracy of their responses, the speed of their responses, or in the levels of conceptual maturity used.

Careers and Subject Choices

The career choices of women is one aspect which is at present receiving attention from a wide range of groups. Women are still concentrated in six occupational areas--clerical, typing, sales, clothing, nursing and teaching. The movement into non-traditional areas is slight and slow. Factors which cause this are many, but one reason frequently isolated is that girls do not continue with subjects such as mathematics, which is a key requirement for wide number of technical and scientific careers as well as necessary for other subjects at senior level (11). An analysis of occupational groupings which require school mathematics qualifications was undertaken by Mathew (19). She considers that "girls are getting the message: math is important", and comments on the rise in the number of girls taking mathematics at the fifth form but that the trend is not so marked at the sixth form and at seventh form the proportion has declined.

Typical is the statement, "Girls should be encouraged to continue studying mathematics and there should be a supplementary maths programme at 6th or 7th form level for both boys and girls" which is one of the recommendations from the recent Workshop for Women in Tertiary Education 1981 (28).

In the vocational guidance area there is certainly a growing awareness of the need to give relevant advice and to encourage girls to take mathematics. A thesis 1970 (3) by Bunce analysed available statistical data of the differences in subject choice of boys and girls in New Zealand with reference to overseas research. Variables besides sex included year levels and types of schools. Using a questionnaire on a pupil sample, she explored factors which could contribute to subject choice--ability and achievement, personality, career choice, sex roles, and the influence of home and school.

Sex Role Stereotyping in Text Books

A major thrust of the feminist movement has been to examine and draw attention to factors which may pre-condition the attitudes of girls and hence affect the fulfillment of their potential. Attitudes are influenced by innumerable factors, including books, especially text books which bear the stamp of official approval. In 1980 a survey was conducted by the Research and Statistics Division into the texts of three subject areas of which mathematics was one (15). One reason for selecting mathematics was "since mathematics is already often seen as a male domain, with proportionately fewer females studying mathematics as they progress through secondary school, it is important to find out whether mathematics text books reinforce this pre-conception." For equal opportunity to operate fully, material in texts should not favour one sex more than the other. Six primary and 25 secondary text books, all written or adapted for use in New Zealand, were analysed. Six areas were examined and the following table gives the results of four of these.

Area	Primary Texts Males	Primary Texts Females	Secondary Texts Males	Secondary Texts Females
	%	%	%	%
Roles and occupations described (for males and females)	78	22	80	20
Activities of males and females described	51	49	63	37
Males and females in illustrations	55	45	80	20
Famous people males and females mentioned	94	6	94	6

Numerous examples of sexism in the language used in the text books were encountered, such as the generic use of 'he' and 'man.' Overall there is strong evidence of a bias in favour of males, particularly in the secondary text books. Women are both proportionately under-represented and confined to a narrow stereotyped range of occupations and activities. Later text books in the sample, however, do show some improvement and women are now seen in more diverse roles. This is an area in which research has resulted in action. Present-day writers of mathematics text books and examiners are now showing an awareness of the problem and are sensitive to the images they are promoting in their writing. How far this extends into classroom handling of texts and resources is not known. This report has received publicity in education journals and also has been reported in two daily newspapers.

Mathematics Teachers

The continued shortage of mathematics teachers over many years has prompted two surveys.

The first, by Bull, is an investigation into the qualifications and supply of mathematics teachers based on a survey conducted in 1956 (2). This publication provides useful information and has been used as a baseline. Although in general sex of pupil and teacher was not a critical factor, included is relevant information such as that in girls' schools 46% of the Forms 3, 4, and 5 classes took full mathematics, compared with 80% in boys schools and 53% in mixed (co-educational) schools. No girls' schools offered additional mathematics.

The second survey, into the provisions for teaching mathematics, was conducted in 1977. In a monograph Werry (29) summarises his findings, giving a comprehensive picture of mathematics teaching, staffing, and pupil participation in secondary schools. Several areas in which he made a gender comparison include the numbers taking mathematics: "Of the 72 sampled schools 89% of the pupils study mathematics, but in the boys schools the mean is 94%, in girls schools 83%." About one-third of mathematics teachers are women, which he considers has sex role implications, and about one-third of those teaching mathematics in girls' schools are men. Less than one-sixth of the holders of positions of responsibility are women, indicating that the chance of a woman gaining a position of responsibility in mathematics is one-half that for a man.

The staffing of tertiary institutions also shows an uneven and under-representation of women. In a discussion of the covert curriculum, Middleton examines the figures for 1980 (20). In the Universities 8% of the lecturing staff in mathematics are women (compared with 10% for all staff), in Primary Teachers Colleges 8% (compared to 25%), and in Secondary Teachers Colleges 25% (compared to 30%). In this latter case the actual numbers are small.

Agents for Change

The New Zealand Mathematical Magazine reflected the quietly increasing consciousness of Women and Mathematics by devoting a recent issue directly to this topic with all contributors female (23). Apart from articles on mathematical topics, there were others centred on current issues such as careers, sex-stereotyping, and the disadvantages many girls have in reaching their full potential in mathematics.

Conferences will always remain places where ideas are propounded, created, and disseminated. At the First Australasian Mathematics Convention which was held at the University of Canterbury in May 1978, there were four sessions on women mathematicians, one on Women and Mathematics, and a panel discussion on the same topic, with some emphasis on equal opportunities for women at all levels. Attendance by a few New Zealanders at international conferences, in particular I.C.M.E. IV at Berkeley, has had a small but nonetheless far-reaching effect.

Present Interest in the Topic

For the purpose of gauging a sectional interest, a recent survey was made by Wily of all local Mathematical Associations and the New Zealand Mathematical Society (30). Two types of questionnaires were used, one general and the other for individuals. Only two of eleven Associations had arranged for a speaker on the topic; otherwise no aspect had been planned as part of a meeting. Rarely had aspects been raised at meetings, committee or general, and only in two cases was concern expressed about any sex imbalance relating to mathematics. Although participation of women had increased in some associations, overall only about one-fifth of the present committee members are women.

Forty-eight females and seventy-nine males responded to the individual questionnaires. Females in general indicated a greater awareness and interest in the gender situation. Seventy percent of the females claimed to have personally observed differences in attitudes between male and female students and 59% had observed differences in self confidence. The figures for men responding to this section were 49% and 37%, respectively. Only 36% acknowledged an awareness of sex-stereotyping in mathematics text books; of these, two-thirds of the females and one-quarter of the males believed that this had an effect on the pupils.

From the responses it is obvious that the topic is not generally an issue among those involved in mathematics education, but about 40% of the respondents made suggestions about areas in which action or further research should be undertaken. This may well presage an upsurge of interest, research, and action.

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Gender and Mathematics in the United States

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Although gender has long been a variable of interest in the United States in research related to intellectual functioning (see Maccoby, 1966; Maccoby and Jacklin, 1974), the most intense interest in it as it relates to mathematics has occurred in the last decade or so. The reasons for the current interest seem to be several: the social milieu as influenced by the new feminist movement; increased government attention to and funding of sex equity in education; seminal work by researchers investigating sex differences in mathematics; and the efforts of many people within the mathematics education community to raise awareness of issues related to sex equity in mathematics.

The influence of the feminist movement in the United States should not be underestimated. This movement has helped create the climate and bring pressures to bear which have caused recognition of the inequities of occupational segregation in general in our society. At the same time it has helped raise the career aspirations and expectations of many women. Concern about occupational segregation has led to increased attention to all factors which contribute to that segregation, and mathematics has stood out as a major one.

In this climate federal laws have been passed which aim to increase the participation of women in all aspects of society. These include Title IX of the Education Amendments of 1972, which prohibits discrimination based on sex in any school system receiving federal funds; the sex equity amendments of 1976 to the Vocational Education Act, which address vocational programs specifically; and the Women's Educational Equity Act of 1974, which provides funds for the development of curricular materials designed to promote sex equity in education. During the same period, the federal government has funded a number of sex desegregation centers and sex equity training institutes around the country to help local school systems meet both the letter and the spirit of the new laws. And federal agencies such as the National Institute of Education and National Science Foundation have provided funding for research projects to study sex differences and to determine factors specifically related to the participation of women in mathematics. The availability of such funding has contributed to a more serious view of research related to gender and mathematics, and has helped legitimize it in the eyes of the research community. Thus, a more positive climate has been provided for researchers in mathematics education, sociology, and psychology to investigate reasons for the extreme occupational segregation we find in mathematics and related fields. Also, intervention programs of various kinds have developed throughout the country to increase the participation of women in mathematics.

The seminal work of a number of people helped alert mathematics educators and the public at large to the importance of mathematics in the occupational segregation still extant, albeit improving, in the United States. To illustrate that segregation, census figures from 1978 (Bureau of the Census, 1980) show that 23% of computer specialists, 3% of engineers, 18%

of life and physical scientists, 10% of physicians, 3% of machinists, and 1% of mechanics were women. In contrast, 71% of employed teachers (except college and university) and 93% of nurses were women. At a time when women comprise 42% of the workforce in the U.S., these figures illustrate the continuing domination of technical careers by men. In an attempt to understand the continued concentration of women in a few job categories, Lucy Sells (1973) looked at the high school mathematics background of first-year students at the University of California-Berkeley. She found that 57% of the men but only 8% of the women had had sufficient mathematics to enter the calculus sequence. At that time UC-Berkeley had no precalculus course, and calculus was required for most majors. Thus, Sells identified mathematics at the high school level as the critical filter which effectively keeps many women out of those careers in which they are underrepresented in our society.

Elizabeth Fennema (1974) was one of the first to question the then-prevailing view that male superiority in mathematics achievement was almost always found (see, for example, Glennon and Callahan, 1968). Reviewing data available at that time, Fennema concluded that: no sex differences in mathematics achievement were found in the early elementary years; differences were not always apparent in upper elementary and early high school years, but when differences appear they are more apt to be in boys' favor for higher level cognitive tasks and in girls' favor for lower level cognitive tasks; and no conclusion could be reached concerning high school students. Thus the whole area of sex differences in achievement in mathematics became an open one and research efforts in this direction, discussed below, increased.

The work of Sheila Tobias (1976, 1978) on mathematics anxiety must be mentioned for the broad national focus it brought to that issue and to avoidance of mathematics more generally. Her work reached the popular press, thereby bringing the whole area of gender and mathematics to the attention of lay people.

These and many other researchers and activists were instrumental in making sex equity in mathematics an important focus at all levels of our educational system. Research has centered on trying to understand the reasons for the relatively small number of females who choose to study optional mathematics and pursue careers in mathematics or related fields.

With this background in mind, we can look at the empirical research itself. A comprehensive review of the relevant research in the U.S. is impossible to do in a short paper. The interested reader should see more extensive reviews (Fennema, 1975, 1977; Fox, 1977; Fox, Brody, and Tobin, 1980; Jacobs, 1978; Sherman, 1977) and specific research reports mentioned throughout this succinct report for more details. This report will try to give the reader an idea of the breadth of research which has been done and what the current state of our knowledge is.

Theories as to why women opt out of mathematics may be put into two broad categories: biological and socio-cultural. The biological theories hold that sex differences in mathematics learning and course-taking are a result of ability differences, presumably genetic. These theories include such factors as hormonal effects, X-linked inheritance of high potential in quantitative and spatial abilities, and brain lateralization. Sherman (1977), in an extensive review of the literature in this area, found that evidence for most hypotheses was very weak. Earlier left cerebral dominance in females was the only hypothesis, with some support in data. Preference for verbal learning, reinforced by the environment, may hamper use by females of the right hemisphere for spatial tasks involved in mathematical problem solving. Sherman recommended more research in this area. However, as she pointed out, differences between the sexes in intellectual functioning are small, and could not possibly explain by themselves the small number of women in mathematics-related fields.

Socio-cultural theories also have been proposed to explain sex differences in achievement in and study of mathematics. The socialization experiences of males and females may differ and result in differing attitudes toward mathematics and about one's abilities in it, thus affecting one's achievement. Before looking at research relevant to these theories, it is important to review the current knowledge concerning sex differences in achievement and participation in mathematics.

Although there has been an increase in the number of women studying optional mathematics in high school since the initial Sells study (Armstrong, 1980), there are still sex-related differences in electing to study mathematics (Brush, 1980; Fennema, 1980), particularly in college and beyond (Ernest, 1976; Skypek, 1980). Fennema (1980) hypothesized that sex differences in achievement resulted from this differential study of mathematics.

As Fennema has pointed out (Fennema, 1977), large-scale studies such as the 1972-73 National Assessment of Educational Progress, which found sex differences in favor of males, did not control for course-taking. Because males usually have studied more mathematics than females, these studies compared males and females with unequal mathematical background. In a careful study of over 2500 students in grades 6 through 12 from four high schools and their feeder middle schools, which controlled for course-taking in the upper grades (Fennema and Sherman, 1977, 1978; see also Sherman and Fennema, 1977), Fennema and Sherman examined sex-related differences in achievement, spatial abilities, and affective factors. For students in grades 6 through 8, one of the four groups had females performing better in computation; for a second group, males performed better than females on two higher-level cognitive variables. At the high school level, only two of the four schools had males performing significantly better than females on the mathematics achievement test, but differences were small. Fennema and Sherman concluded that, when relevant factors are controlled, sex differences in favor of males do not appear often, and are small when they do occur.

Armstrong (1980) analyzed achievement data from the second National Assessment of Educational Progress in 1977-78 (which tested 24,000 each of 13- and 17-year-olds), and another large national sample (which included over 3,200 students of age 13 or in grade 12). Comparing grade 12 or 17-year-old males and females <u>within</u> level of participation in mathematics, Armstrong found a fairly consistent pattern of males outperforming females on problem-solving items, but few differences occurring on lower-level items. For 13-year-olds, females did significantly better than males in computation.

Thus, recent studies of achievement in mathematics, which do control for amount studied, do not consistently show sex differences in favor of males, as had been presumed earlier. However, when sex differences do occur, they tend to favor males in higher-level cognitive skills, especially in the high school years, and females in computation in earlier years. These sex differences in problem solving merit further study.

The Fennema-Sherman and Armstrong studies also looked at the spatial abilities of the subjects. Again, spatial ability was an intellectual function presumed to show differences in favor of males starting in early adolescence (Maccoby and Jacklin, 1974). Although the relationship between mathematics learning and spatial ability is not clear, spatial representation is certainly involved in mathematics, particularly geometry. In the Fennema-Sherman study, few sex-related differences in spatial-visualization ability were found; the data did not support the idea that differences in spatial ability explain sex differences in achievement, although the two were highly correlated. In the Armstrong study, no sex differences in spatial ability were found for grade 12; for 13-year-olds, females actually did significantly better on the spatial tasks. It seems that as tests and methodology improve, sex differences in spatial ability in favor of males are not appearing with the frequency and consistency found in earlier studies.

A large body of studies has investigated a variety of attitudinal and environmental factors which may be related to young women's participation and achievement in mathematics (see Fox, 1977). The patterns of findings suggest that socio-cultural factors are important in explaining sex differences. However, the complex interaction of such factors with each other has not been sorted out, nor has their causal significance been determined. But there are several theories of how socialization may contribute to sex differences. Two major ones and supporting evidence will be discussed here.

First, sex typing of mathematics as a male domain may inhibit female achievement and interest in mathematics. Second, the cultural reinforcement hypothesis, which also assumes mathematics is sex-typed as male, holds that females receive less encouragement from all aspects of society to achieve in mathematics as part of their sex-role socialization. Both of these theories would be consistent with sex differences in affective variables which have been identified.

In the Fennema-Sherman study (1977), the only high school with two significant sex differences in cognitive factors also showed the highest number of sex differences in affective variables, such as confidence in learning mathematics and attitude toward success in mathematics. In fact, covarying out the differences in affective measures eliminated sex differences in mathematics achievement.

Although males seem to sex type mathematics as male more than do females (Fennema and Sherman, 1977; Sherman and Fennema, 1977), other variables identified as critical to the choice of future mathematics courses by females seem related to sex typing. One such variable is the perceived usefulness of mathematics (Armstrong, 1980; Fox, 1977; Haven, 1972; Hilton and Berglund, 1974; Lantz and Smith, 1980; Pedro, Wolleat, Fennema and Becker, 1981; Sherman and Fennema, 1977). Females tend to view mathematics as not useful to their future plans, and so do not persist in its study. The lack of role models and adequate career information may contribute to this view.

Another variable important to mathematics participation is confidence in one's ability to learn mathematics. Fennema and Sherman (1978) found that, in grades 6 through 11, males were consistently more confident of their ability to do mathematics than females at equal achievement levels. Wolleat, Pedro, Becker, and Fennema (1980) found that females at all achievement levels more strongly attribute their success in mathematics to effort, not ability, but attribute failure to lack of ability; for males, the situation is reversed. Thus females feel less in control of their mathematics learning, and are not apt to persist in its study.

The role of "significant others," those, such as parents, teachers, counselors, who may influence the course and career choice of students, also has been identified as an important one (Lantz and Smith, 1980). Parents of gifted girls (Brody and Fox, 1980) were less likely to view a mathematics/science career as appropriate for their child than parents of gifted boys. Haven (1972) and Casserly (1979) found that counselors provided no encouragement and/or actually discouraged females from taking advanced mathematics courses. Supportive teachers were pinpointed by Casserly as important in female enrollment in advanced courses. However, the mathematics classroom environments experienced by males and females may differ in ways which would discourage females and reinforce sex-typing of mathematics as male (Bean, 1976; Becker, 1981; Stallings, 1979).

These and other socio-cultural factors acting together may exert a powerful influence on the academic choices students make. How they may cause sex differences in participation and achievement is not yet understood, but that they are important seems clear.

Deep concern about the unequal participation of women in the study of mathematics and the resultant diminished opportunities for women to participate in all aspects of U.S. society engendered much of the research discussed above. The knowledge, although still incomplete, gained from these research studies has been used to design intervention programs across the country to increase the study of mathematics and science by women. In particular, identified socio-cultural factors have been targeted in career workshops which use role models to interest young women in careers in mathematics and science (e.g., Liff, 1978); in accelerative programs for mathematically gifted girls (Brody and Fox, 1980); in inservice teacher-training workshops to sensitize teachers to the role they play in providing sex equity (Kaseberg, Kreinberg, and Downie, 1980; Fennema, Wolleat, Pedro, and Becker, 1981); and in mathematics anxiety reduction workshops and courses in colleges to help students who have avoided mathematics (Afflack, 1978; Lark, 1980; MacDonald, 1980). National groups, such as the Association for Women in Mathematics, and Women and Mathematics Education, provide support for efforts to increase the number of women in mathematics. One perceives increased interest and activity down to the local school level in the past few years. Both scholarly research to answer still-puzzling questions concerning sex differences in achievement and participation in mathematics, and careful design and evaluation of intervention programs to provide equal opportunities in mathematics, will continue to command attention. Hopefully, action on both fronts will serve to promote change and ensure that sex equity in mathematics moves from a worthy goal of society to a reality.

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III. Selected References on Gender and Mathematics

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The following set of references on gender and mathematics has been selected primarily from the articles and documents published in the countries participating in this review. Some of the references are cited in the reports from individual countries; additional resources were selected from our files. The intent was to provide a set of references which might be of help to those pursuing the topic. They include background papers, research reports, project information, and teaching suggestions.

Not unexpectedly, many of the articles and documents were published in the United States. Obviously, the authors of this list have more access to materials from the U.S.A., and the Educational Resources Information Center (ERIC) provides a computer base of documents which aids in the compilation of references. Moreover, there are numerous publishing outlets, and the topic, as Becker notes, has been of widespread concern in the U.S.A.: thus, articles are readily accepted for publication. We hope, however, that the references will prove useful to those in many countries, for we have attempted to delete those which seemed to be exclusively regional in nature.

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