Future Learning 4

Promoting Equity in Maths Achievement

The Current Discussion

Selected contributions from the proceedings of the Barcelona (25 January, 07) and the Paris (25 April, 07) Workshops

PREMA Consortium

Edited by: Maria Chionidou -Moskofoglou, Andrea Blunk, Renata Siemprinska, Yvette Solomon, Renate Tanzberger

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Introduction

Maria Chionidou-Moskofoglou
Yvette Solomon
Renate Tanzberger
Andrea Blunk
Renata Siemieńska

These proceedings are the outcome of two workshops held by the European project Promoting Equality in Maths Achievement –PREMA– under Dr. Kathy Kikis-Papadakis, PREMA Project Coordination (FORTH). The workshops took place in Barcelona in January 2007 and in Paris in April 2007. We invited submissions from the 30 authors of papers presented in these workshops and we also sent out a call to workshop participants via the PREMA website http://prema.iacm.forth.gr/main.php. 19 submitted papers have been through a review process run by the PREMA scientific experts focusing on the following workshop themes: 1. Reports on PREMA Research Findings; 2. Contesting Mathematics: Motivation and identity 3.Classroom Processes and Gender-Sensitive Pedagogy: Methods, applications and tools to support gender-sensitive maths teaching. 4. Outside the Classroom: Policymaking, career choice and social context in gender differences in mathematics education.

Part 1. Reports on PREMA Research Findings

In Part I, a synthesis of the partners' national reports from Austria, Greece, France, Poland, Spain and the United Kingdom is presented by Jim Ridgway and Sean McCusker Each partner conducted empirical research concerning the processes of student decision making, pedagogical factors, socio-cultural factors, and the impact of computers regarding women and mathematics. Jim Ridgway and Sean McCusker discuss outcomes which are relevant to policy makers and practitioners by proposing some crucial recommendations. These include:
A mathematics curriculum which is more interesting to students: high quality teaching and a vibrant curriculum are key to enhanced engagement with mathematics.
If pedagogy is to be reformed, there is a need for simple tools to support teachers who want to observe their own classrooms, and specific guidance on appropriate remedial activities (such as asking more complex questions to girls, and attending to the needs of all students in the classroom, not simply those students who are most demanding).
Information about successful women mathematicians should be included in mathematics lessons.
Legislation that requires mathematics-, science- and ICT-based professions to be more family friendly should be introduced, or enforced.
More variety in teaching and assessment methods, including group work.
Also, Sara Silvestre Anglès and Mario Barajas Frutos's article aims to deepen understanding of the factors that we need to address in order to reduce gender differences in mathematics and the emerging digital divide in order to benefit girls. As part of the PREMA Project, the purpose of this article is to present a comparative analysis of the legislative frameworks for education and training (for mathematics) and to reflect on these. The article points out discrepancies in administrative and regulatory frameworks, as well as differences between the participant countries. The focus is on the type of activities proposed for the

implementation of the curriculum. The initial idea is to analyze the relationship between legislative framework provisions and teachers' needs in Austria, Greece, France, Poland, Spain and the United Kingdom. Three main foci were selected for the comparative exercise: the regulatory legal framework of educational systems in the six contributing European countries; the position of mathematics within secondary education; and the training of teachers with respect to gender issues.

Finally in part one, Danièle Hourbett and Georges-Louis Baron's paper about a literature search for Gender issues in mathematics education aims at highlighting some salient points that were pointed out and they discuss some issues that arose while they made this review. After some methodological considerations, they present the different salient themes that have appeared, before discussing gender-related aspects.

Part 2: Contesting Mathematics: Motivation and Identity

When students and teachers enter a classroom they bring with them experiences, stories and beliefs about mathematics which are enacted in ways which make particular identities available to particular learners. Yvette Solomon's paper 'Developing gendered identities of exclusion and inclusion in mathematics' tackles two related issues: the first concerns how different groups of learners might experience different kinds of teaching and so gain different levels of access to mathematical knowledge. The second concerns differences between girls and boys within the more privileged of these groups in terms of the kinds of mathematical identities that they develop. She draws on interview data with 27 secondary school students aged 11-15 to develop an understanding of how pedagogic practices and gender discourses interact in these students' positionings of self. In the UK, the majority of schools group by ability –that is, higher-scoring students are taught in different groups from lower-scoring students. Research shows that there is no real benefit in dividing learners in this way, and lower-ability groups suffer in particular– they score even lower in public examinations at the age of 16 than their scores two years earlier predict. The students' accounts of their mathematics classes show why this might be the case –there are important differences between high and low ability groups in terms of the teaching they receive: high ability groups learn to negotiate mathematical meaning with their teachers and so have greater access to creative mathematics, while low ability groups take a passive role and often see mathematics as useless. It is also shown that many students believe in a "natural aptitude" for mathematics and, more generally, those structural constraints such as ability grouping influence the identity building process and beliefs about mathematics. However, there is an extra complication: girls in higher ability groups do not see themselves as good at mathematics, and are often unhappy in their groups. Their stories of doing mathematics show that although they are in high ability groups, they are positioned, and position themselves, in terms of a range of available discourses about gender and ability which constrain their perceptions of themselves as good at mathematics, and so contribute to the development of their excluded identities.

Also, Heather Mendick's work demonstrates the power of the above process –as she says: dominant discourses 'inscribe mathematics as masculine, and so it is more difficult for girls and women to feel talented at and comfortable with mathematics and so to choose it and to do well at it' (2005: 216-217). In her Barcelona presentation she showed how powerful our assumptions are, and how they can be hidden from us –so even though the PREMA project found that there were very noticeable beliefs about boys' versus girls' abilities in mathematics in Poland but no obvious beliefs of this nature in England and Austria, we need to take care –research suggests that they are nevertheless operating in our choices of what to study and how to teach. Her paper "'I could always just play: gender and mathematical ability" also deals with students' mathematical identities and with the construction of the masculine image of mathematics. She presents empirical results on students' beliefs about "being good at maths"

which show that many more boys than girls think they are good at mathematics. The processes of "writing themselves as mathematically able" are studied in terms of the process of "storytelling". Building on a theoretical background of queer theory, this paper is based on Judith Butler's concept of being "always already" gendered, and the author describes herself as having been "always already" a mathematician. Popular culture has a considerable influence on the image of mathematics in public, and Heather Mendick explains relationships with mathematics with the use of examples from popular culture, such as the film "Good Will Hunting", from which the phrase 'I could always just play in the paper's title is taken. Anna Chronaki addresses similar issues in her paper 'Sciences entering the 'body' of education: women's experiences in masculine domains of knowledge investigates the gendered dimensions of women's experiences in educational practices'. She raises questions about women's choices and everyday struggles by examining the narratives of three women who live at different times, at different parts in the world, come from different social classes, and hold different positions. Starting with the observation that education has in many ways become feminized and yet power is still held by men, she considers how these three women position themselves with respect to masculine discourses about science and mathematics. She describes firstly how a university professor resists the dominant discourse of science and masculinity and appropriates it into her own professional life. Secondly, she shows how a working-class mathematics teacher subscribes to gendered discourses about mathematics and family life, but at the same time is frustrated and imprisoned by the gendered space of her workplace. Thirdly, she describes how an adolescent girl similarly experiences contradictions in her choice of mathematics study and her sexuality. Anna Chronaki argues that their narratives show the deep tensions for women in science education.

So how are assumptions about the gendered nature of mathematics reproduced in classroom pedagogy? Research suggests generally that boys receive more questions, praise and (constructive) critical feedback than girls, and as Maria Chionidou-Moskofoglou and Kyriaki Chatzivasiliadou-Lekka showed us in Barcelona, the situation in Greece appears to follow this pattern. They reported that, although primary school teachers said that they believed boys and girls to be equally capable, and that they gave equal attention to each, they also believed that boys are 'naturally' better at mathematics, that they challenge and engage with it more. These kind of assumptions make it very likely that boys and girls do receive crucially different teaching –this has been demonstrated in the UK by Laura Black's (2004) work, for example. What is important about these data, however, is the fact that Greek teachers appear to be unaware of the nature of their own beliefs, the contradictions within them, and the effects they might have. So, for example, although the teachers said that they believed that boys and girls are equally capable and that they did not treat them differently in the classroom, they nevertheless claimed that boys are 'brighter' and more 'talented' in mathematics, and are better logical thinkers. They also drew contrasts between boys and girls as learners: boys, they said, enjoy mathematics more, are able to work faster and are usually more accurate, are more likely to find alternative solutions and to challenge ideas. Girls are more likely to give up, and tend to just follow rules. These findings are striking when viewed alongside other research: these kinds of assumptions about difference are precisely those which lead to teaching which enables some students to gain ownership of mathematical knowledge while excluding others. As the authors point out, the classroom observation will be important in the next stage of this research.

Concerning pupils' subject priorities in secondary education, Mare Leino *et al.* from Estonia, argues that for 47.3% of girls, one of their favourite subjects was maths; 68.3% of boys named sport as one of favourite subjects. Esthonian girls are academically so eager because they hope to cope better in the man-centred post-soviet society. Soviet school was quite academic, and this is not changed very much till now.

Part 3: Classroom Processes and Gender-Sensitive Pedagogy: Methods, Applications and Tools to Support Gender-Sensitive Maths Teaching

There are many possibilities in teaching mathematics for attaining the aim of gender sensitivity. It is important to be aware that sex/gender is a powerful category in everyone's life but one has to be careful not to make the mistake of thinking that all girls (or all boys) need the same experiences or that they are all alike. Equally, the aim of gender sensitive mathematics teaching is not to introduce some form of 'compensatory education' directed towards girls only but to change mathematical education in a way makes sense for both girls and boys and to be aware of the barriers (internal and external) that prevent girls and boys from liking and enjoying mathematics and/or being successful in mathematics. Andrea Blunck, Jalon Ranchal Carmen, Maria Chionidou-Moskofoglou, Iliada Elia, Kathrin Helling & Mag. Christian Petter present papers concerning a variety of teaching approaches for use by teachers in primary, secondary or tertiary mathematics classrooms.

Andrea Blunck's paper 'Research on mathematics and gender: implications for teaching' has a clear message about the role of the gendered image of mathematics in our approaches to the subject, with particular application to teaching of mathematics generally and, more specifically, to teacher training. Her paper draws on some important literature on feminist approaches to mathematics and on students' beliefs about, and experience of, mathematics which shows the long-term impact of perceptions of mathematics as essentially masculine. In the first part of her paper she introduces the various branches of research on mathematics and gender: didactics, history, sociology, science studies. Gender-related studies in the history of mathematics are mainly concerned with women in the history of mathematics, their lives and works, and their contributions to the discipline. Two interesting women, Maria Gaetana Agnesi (1718-1799) and Ruth Moufang (1905-1977), are discussed. However, there are not only studies on individual, exceptional women, but also studies on groups of women. In sociology, mathematics and mathematicians are investigated in terms of gender: researchers look for gender differences or gender gaps, e.g. in career paths, and try to show ways out of it. Some recent German studies in this area and their main results are presented. In the area of science studies, feminist approaches consider the influence of gender, gender relations and gender stereotypes on mathematics and its language and culture, and how these may even influence the choice of new research topics or methods, and acceptance of new ideas. Her paper also demonstrates how many women mathematicians over the years have been rendered invisible, not just because of prejudice, as in the case of Ruth Moufang, but because of widespread assumptions about the nature of science and mathematics and women's place in them. With this in mind, she argues that in addition to teaching about, for example, gender-sensitive pedagogy, it is also necessary to shift perceptions of mathematics as largely male by making fundamental changes at the level of the teaching of mathematics itself in terms of its content and pedagogy. In her paper she gives us a taster of her own practice as a research mathematician and teacher-trainer in devising courses which emphasise mathematics in its historical and social context. She suggests that teacher education which helps prospective teachers to develop a new perception of what mathematics really is by reflecting on the subject from outside, e.g. via gender topics could also help to change the (male) image that mathematics has in public. People in general regard mathematics as abstract, difficult, unchangeable, impersonal: mathematicians are imagined most often as men. A change of the image of mathematics might encourage more women to start a career in mathematics, and it might help to overcome typical problems that teacher students have with the discrepancy between school mathematics and university mathematics.

The next paper "Female mathematicians calendar as means of increasing students' motivation" by Carmen Ranchal and Tere Valdecantos Dema from Cordoba-Spain is another good example for gender-sensitivity in education. The invisibility of female mathematicians in general and in class-

rooms in particular motivated Carmen Ranchal and Tere Dema to make a wall calendar. They started in the year 2004 with a calendar of female mathematicians. Three thousand calendars were distributed in 87 Secondary schools and 283 Primary schools in the province of Córdoba. In the years 2005 and 2006 they followed this with calendars showing female scientists and the project was a big success. Students (male and female) learned that there have been female mathematicians "all the time" (so "sex" is not a reason for being good or bad in mathematics) and they learned about the difficulties women experienced in studying and doing mathematics, and about prejudice and attribution.

Another teaching approach which aims at classroom gender sensitivity but also for meaningful mathematics and pluralistic learning which recognises pupils' and students' preferences is presented by Maria Chionidou-Moskofoglou paper "New issues and perspectives in mathematics teaching approaches for Gender Sensitivity". This paper makes recommendations for policy and practice which provides students with opportunities for involvement in cross-thematic mathematical activities via Philosophy, ICT, History, Language, Science and other disciplines and through which they will not only make generalizations and connections but also adapt positive attitudes and values towards mathematics as a cultural heritage contributing to harmony in aesthetics and personal development.

Iliada Elia's paper "Multiple representations in mathematical problem solving: Exploring differences between boys and girls in primary school" deals with the question of how different modes of representation have effects on additive problem solving. She describes how the Department of Education of the University of Cyprus studied 1491 pupils in the first, second and third grade of primary school. The role of informational pictures and the use of the number line were investigated in contrast to the use of plain verbal description for the solution of one-step addition and subtraction problems. The research questions addressed in the paper were the following: What are the effects of different types of representation on the solution of additive mathematical problems? What are the interactions of the different types of representations with mathematical structures and more specifically with the placement of the unknown in the problems? How do performance and the structure of the processes involved in the solution of additive problems vary between boys and girls? Although they found little difference between girls and boys in the first and second grade, they found that third grade girls outperformed boys.

Finally, in Part 3, the paper by Kathrin Helling, & Mag. Christian Petter presents research results from an analysis of Austrian online mathematics teaching material. The proportions of 'male', 'female' and neutral expressions in text-based exercises were investigated. The results show a gender bias which disadvantages girls and women –'female' expressions are consistently underrepresented. They report a strong bias towards boys with respect to items referring to professional identities that the majority of jobs depicted men. Presuming that the use of online mathematics teaching material will increase in future, it is necessary to make content developers and providers aware of gender as a quality criterion for teaching materials.

Part 4: Outside the classroom: Policymaking, career choice and social context in factors contributing to gender differences in maths education

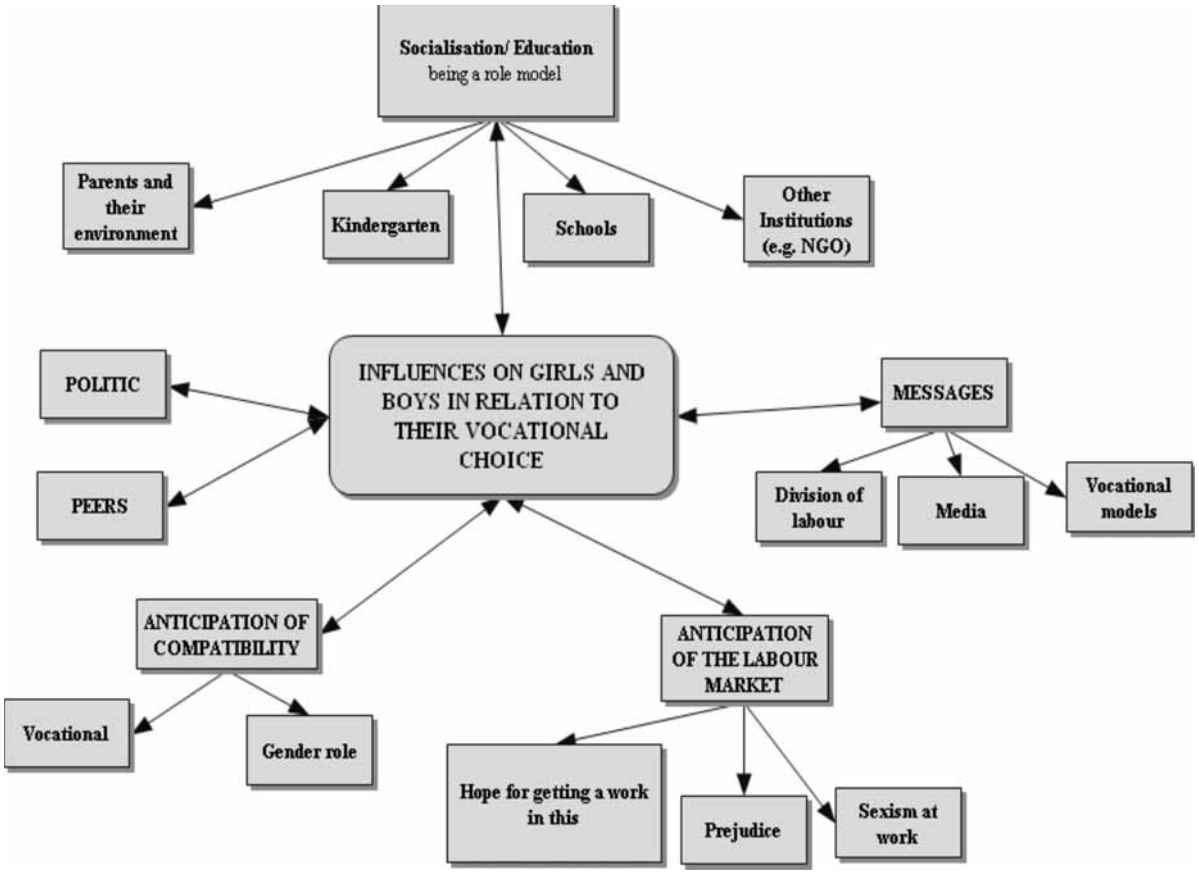
Renate Tanzerberg's Paris workshop statement featured an important contribution concerning the terms 'sex' and 'gender' and social factors that influence gender sensitivity in mathematics education. In the workshop she argued that:

"there is a big confusion about the meaning of the terms "sex" and "gender". Maybe the confusion is even bigger because of a different use in different languages but I know that even within one country (in my case this is Austria) there is an inexact use of these two terms. We, in Austria, also use the English words sex and gender. When translating them we say "biologisches Geschlecht" (= sex referring to the body) and "soziales Geschlecht" (= gender referring to society).

In the history of feminism it was very important to make a difference between sex and gender in order to make it clear that, for example, skills like thinking rationally are not connected with being a man but that it is a attribution of our society that men are rational and women are emotional. As long as it is thought that being a woman means automatically that you are emotional, caring, near to nature, and so on, and that being a man means automatically that you are rational, competitive, near to culture and civilisation, and so on, it is inevitable that women and men will have different jobs, will be differently responsible for children, will experience relationships differently, and will have less or more power in society. In 1887, when women (and some men) were fighting for the right to higher education the famous mathematician Möbius said: "Being a woman and doing mathematics is against nature". He was subscribing to the concept of gender which means that in our society there is a set of rules and expectations how a man/woman/girl/boy has to be, how he or she has to behave, what is expected from her or him, what kind of clothes he or she is allowed to wear, how he or she should walk and so on.

History shows that skills or behaviours that seemed to be inextricably connected with being a man or a woman have changed. The concept of sex/gender alerts us to the fact that it is not our body which enables or disables us in mathematics or determines whether or not we are interested in technology or in a career as a mathematician but the influence of society.

A critical point of the concept of sex/gender is seen in the dichotomy that maintains that sex is the part that cannot change whereas gender is able to change. The captive unambiguousness of the body also has to be questioned. The biological classification into male and female is not as unambiguous as it seems, there are people who call themselves "intersexuals". We used to think that there are only two sexes but perhaps there are more than two, or there is a continuum between the sexes.



But coming back to the beginning. When reading the papers for the national and the final reports I read sentences like "The question if pupils are successful or unsuccessful in school is related to their characteristics and not to gender" or "As predicted, gender differences in preferences were observed" or it said gender (f-m) when describing how many teachers were female and how many were male.

I want to make my point clear with the sentence "pupils tend to form gender-homogenous groups" that I read in a national report. I think the author meant that girls formed groups with other girls and boys with other boys. For me "gender-homogenous groups" would mean that the pupils formed groups of "male-gendered" pupils and "female-gendered" pupils. For example, let's say that in our society playing soccer is seen as male. Then boys and girls who would like to play soccer would form a group.

Or interpreting the above sentence "As predicted, gender differences in preferences were observed" (e.g. boys more often than girls chose computer courses): I think what was meant was that boys and girls preferred different things (= sex differences). If it really meant gender differences they should have asked if a girl believes herself to be "male-gendered" and then look if "male-gendered" girls for example more often choose computer courses than "female-gendered" girls. There is for instance research on the question whether girls who describe themselves in a way that is –in our society– expected from boys are more successful in physics than girls who describe themselves as "feminine" (Kessels 2002).

I know that this confusion is not easy to change because there is for instance the common use of the word "gender gap" whereas in my opinion "sex gap" would be more precise. But what I wanted to point out: I think that people who deal with gender aspects should be familiar with the concept of sex and gender (and with the criticism at the concept) and should use the word "gender" carefully.

School is not the only factor that influences girls and boys with respect to their vocational choices in general and to their interest in mathematics/science in particular. The above map indicates the complexity of the social structure concerning gender."

Studies concerning some of the factors outlined by Renate Tangerberg in the Paris Workshop contributing to gender differences in mathematics education are presented in this final part of the proceedings by Annemarie van Langen –Hetty Detters, Athanasios Gagatsis, Dominika Walczak– Anna Domaradzka and Renata Siemieńska.

In their paper Aneemarie van Langen & Hetty Dekkers, investigate the reasons for the existence of cross-national differences –the result of an in-depth study in Sweden, the UK and the Netherlands, in the study of mathematics and gender. The article concludes with an overview of the social and system features that explain the general and sex-specific STEM choice differences between the countries studied in their research.

In his paper, Athanasios Gagatsis from the University of Cyprus describes the large proportion of Cypriot women participating in undergraduate studies in contrast with the male dominance in university academic staff and attributes this to the fact that male students leave Cyprus and go to study abroad –so a crucial research question arises: Why do female students remain in Cyprus to study at the university while men leave?

From, another point of view, Dominika Walczak and Anna Domaradzka present partial results of a larger study concerning junior high school students' leisure time preferences and chosen activities. They discuss two areas of research: the first concerns actual ways of spending leisure time as opposed to ideal ways of spending free time, while the second focuses on the choice of in-school and out-of-school extracurricular activities. Finally, they predict pupil educational choices in later life, which could prove fruitful in expanding the number of women in mathematics-related fields of study.

Finally, how are general beliefs about the gendered nature of mathematics reproduced in educational pathways and professional careers Renata Siemieńska's paper 'Gendered educational paths in Poland: causes and consequences' presents the bigger sociological picture in providing a context for the perceptions of mathematics that we see in operation in many classrooms, drawing on major statistical trends literature and

on Bourdieu's analysis of social reproduction to explain her findings. She begins by sketching out the important economic and social developments in Poland since 1990, and trends in higher education in particular. Against this backdrop, she presents the results of a large-scale study of the educational aspirations of boys and girls with particular attention to differences in the choice of education and career pathways which are considered to be traditionally male or female. Although there has been a major increase since 1990 in education levels in Poland and in particular of Polish women, she shows that women and men still enter the same fields of study, and the deficit of women in technology or engineering persists. She makes the important point that social/cultural context has a major role in education pathways, so that, while women may aspire to the same educational level and achievements as men, the reality is that they attain a lesser education.

Also, Renata Siemieńska summarises many of the issues in her roundtable statement, and we end with this here. She asks: What should we do to make children interested in careers based on mathematics?

From the perspective of general theories of socialization

Many researchers emphasize that an important role in the process of socialization is played by the family as the environment in which the individual grows up, as well as the broader social environment in which it is embedded. It has been found that for example in the case of the American society, the environment in which the individual grows up is twice as important in the sense of the influence that it exerts, than that in which they live as a grown-up (Miller, Sears 1986). Some authors find that it is not socialization, but vertical and horizontal mobility and discrepancies in social status which, by becoming a source of tension in the individual, cause them to become, for example, radically conservative or radically egalitarian. But the results of other studies suggest on the other hand that attitudes and values in such cases are found –so to speak–"half way" between what they have taken from the environment of early socialization, and what is typical of the environment in which they find themselves later on. Still other researchers stress that low levels of similarity in attitudes and political orientations between parents and their children (Jennings, Niemi 1974) is evidence of a lesser role for parents in the socialization process than is usually assumed. It has nevertheless been shown that such a conclusion is only justified when socialization is understood simply as duplication of knowledge and attitudes of the parents. It is necessary to take into consideration such situations, in which –even if we assume that the parents fully and successfully control their children's socialization process– they might not want to pass their values on to them. In such a case, the socialization process, carried out according to these intentions, will demonstrate differences between the values of children and parents (Bronfenbrenner 1965; Inkeles, Smith 1974). What is more, as Kagan (1962, 1969) shows, the persistence of certain traits from childhood to adulthood may take various forms, while the appearance of the same behaviors in various periods of life may have a different meaning.

Everyone seems to agree that the school as an institution should play an important role in the socialization process, since by definition it exists in order to mould the younger generation by passing on certain features of knowledge, value systems and life aspirations. Yet many studies show that in fact its role is much more modest (Beck 1977) than one would think, both with respect to passing on attitudes, as well as information and abilities. Usually the school prepares the younger generation for life in a way which is in accordance with the expectations –as a rule– of the elite in the given society.

It is also pointed out that peers play an important role in the socialization process, as a product of the similarity of problems which confront a particular generation, both with respect to the expectations of the older generation, as well as adaptation to the conditions in which it is growing up. But the nature peer group influence is different in different countries: sometimes it reinforces orientations and attitudes promoted by the

school, at other times peers offer completely different, evidently contradictory, models (Nathan, Remy 1977).

Gendered role models

These agents of socialization pass on aspirations concerning level and type of education as well as conceptions of role models played in private and public spheres by men and women in adult life, pointing out what is proper for each of them. The influence of the agents is unequal. Studies conducted in several countries and also cross-cultural comparisons (e.g. PISA) show that (1) girls are as good as boys at solving problems in mathematics, (2) despite achieving the same results in tests, girls and boys plan their further education and their future professions differently. Boys often select shorter periods of education. Despite planning to stay in education for longer, girls choose professions traditionally considered as feminine. In other words, neither family nor school is successful in changing traditional gender models. Of course, we can question whether this is a genuine aim. Studies show that girls have less access to computers at home than boys. Also, some studies show that schools do not pay enough attention to engaging boys and girls equally in classes, exercises and extra –curricular activities based on mathematics. It can be argued then that teachers too often assume that girls are not interested in mathematics or new technologies and that they do not like the subject, thus allowing lack of participation and in reality discouraging them from being active in the area.

School textbooks, teachers' behavior, and parents' opinions and behavior reinforce traditional social patterns, sometimes unconsciously. To change the situation it is necessary to lessen psychological barriers by (1) making children aware in everyday school practice that boys and girls are equally capable of getting good results in mathematics, (2) giving examples of how many women are successful in professions which were not so long ago considered as exclusively masculine. These examples of successful women should be taken from two levels: women who became famous in their fields (e.g. Maria Curie-Sklodowska), and also women who are successful as managers of companies in new technologies, as engineers, and as scientists, and who are if possible living in their communities and can be invited to visit schools. The role models offered to children and their parents should give pupils opportunities to ask themselves 'maybe I can be one of them in future'.

PREMA: Evidence From Six Countries

Jim Ridgway and Sean McCusker
University of Durham

PREMA was established to explore the under-representation of women in science, technology, engineering and mathematics (STEM). In particular, we were keen to explore the processes of student decision making, pedagogical factors, socio-cultural factors, and the impact of computers. Each partner conducted empirical research in order to help us understand something of their national situation regarding women and mathematics, with the intention of using this understanding to form the basis for advice to policy makers and practitioners. This paper summarises the evidence drawn from six countries, and makes recommendations for policy and practice.

INTRODUCTION

PREMA was established to explore the under-representation of women in science, technology, engineering and mathematics (STEM). In particular, we were keen to explore:

- processes of student decision making
- pedagogical factors
- socio-cultural factors
- the impact of computers

Our first ambition was for each partner to conduct empirical research which would help us understand the situation in a number of EU member states, regarding women and mathematics. Our second ambition was to use the understanding we gained to form the basis for advice to policy makers and practitioners which would help bring about changes in the current situation.

A number of sources of information have been used to inform different National Reports. Different partners had different levels of resource to carry out the empirical work; different countries gather information about education in different ways; and some questions are not appropriate in some cultures. National Reports made use of some (sometimes all) of the approaches below:

- semi-structured interviews with policy makers
- analysis of national data on performance in high-stakes examinations
- analysis of school questionnaire data from students in schools
- analysis of university questionnaire data from students studying mathematics and/or other subjects
- semi-structured interviews with teachers and students in schools and universities; in this sample, there was an emphasis on high attaining students i.e. those students well qualified to continue with mathematics.

Protocols for interviews and questionnaires are presented as Appendices; the analytic frameworks can be found on the PREMA website http://prema.iacm.forth.gr/main.php.
The National Reports that provided the basis for this synthesis can also be found on the PREMA website.
A summary of the data collected in each country is shown in Table 1.
We make no claims for the generalisability of some of the data (notably, the surveys and the interviews). In what follows, if the text says (for example) 'In England...' this should be interpreted as a shortened form of 'Students in England interviewed for this study reported...'.
Nevertheless, some interesting patterns emerge which can form the basis for future policy and

educational practice in individual member states, and across the EU.
Table 2 shows the percentages of tertiary type A qualifications awarded to females in Science Technology, Engineering and Mathematics (STEM) fields of study in 2001.
These data show that women are under-represented to a large degree in STEM, and that there are considerable differences between countries (compare, for example,
Poland at 75% women in mathematics and statistics with 22% in Hungary).

NATIONAL INITIATIVES

This section is based on the interviews with policy makers.
Countries differ a great deal in the extent to which they pay attention to the educational attainment of different subgroups (e.g. by gender, social class, ethnicity), and in the extent to which they have initiatives to address any imbalances. France provides an interesting example of cultural changes in attitudes and actions. The principle of "Egalité" (equality for all) led policy makers and teachers to consider students as citizens who are treated equally in all respects, without taking into account ethnic or social background, religion or gender. This, paradoxically, directs attention away from gathering evidence on sex differences in attainment and access. In contrast, the concept "Egalité des chances" (equality of opportunity) –developed from a concern that the education system tends to reproduce elites from a narrow social group– directs attention to differences in attainment and access by sex (and ethnic origin etc.). In France, it was difficult to contact decision makers; one of the people interviewed showed a deep interest, the other showed rather little.
In England, the overall lack of engagement of women with Science, Technology, Engineering, and Mathematics is a national priority, and some initiatives are in place to improve the current situation. All groups (including girls) who are under represented are foci for policy initiatives.
In Greece, there was a very mixed response from policy makers; some refused to be interviewed (using a version of the 'Egalité' argument –"we do not deal with the gender issue– we do not distinguish between boys and girls"), others were concerned about the issues raised by PREMA.
PREMA has implications for policy makers: all states should have mechanisms to monitor the take up of STEM by women, and any other groups of citizens likely to be under represented; initiatives to encourage greater participation that have been effective in some member states should be considered for adaptation in other states.

WHAT INFLUENCES THE CHOICES THAT STUDENTS MAKE ABOUT THEIR COURSES?

Data from PISA (2003), and analyses of national data in some of the PREMA partner states, shows that in no country can differences in the take up of STEM by men and women be attributed to poorer performance by girls in school mathematics in the compulsory phase of education. We must, therefore, look to factors influencing the choices made by girls and boys.

Parent and teacher influences

In Austria and England, girls and boys believe that parent and teacher influences largely encourage them to be autonomous.
In France, students who were interviewed commented that parents allowed them to choose their courses of study.
In Spain, in High School, students feel that their parents will support any decisions they make; in vocational studies, girls feel more pressure to conform to role stereotypes. This is mirrored in the attitudes of the boys in each educational stream.

Specific choice factors

In Austria, England, Spain and France, at least two different sorts of reasons can be identified for following courses in mathematics. First is a natural rapport with the subject –being good at it, and enjoying working with mathematics. Second is the need to study mathematics as part of a larger programme of studies, or because it is essential to a future career –in astronomy, for example.

In England, overall, male and female students judge the same factors to be important when making decisions about future courses of study.
In Austria, most students want to achieve high grades for their school leaving certificate.
In Austria and England enjoyment and interest are important in the choices of future courses.
In Spain, personal interest is seen as the main reason for the choice of studies and future career.
In France, at the beginning of senior secondary education, a greater proportion of boys than girls affirm they like mathematics, say they like competitive situations, and the rigour of mathematics. This was true even when socio-economic status was taken into account.
In Greece, very few boys who are well qualified in STEM and Arts related subjects actually follow the Arts trajectory; it is much more common for well qualified girls to do so.
In England, students studying mathematics at

Table 1: *Data collected in each partner country*

	Austria	England	France	Greece	Poland	Spain
Schools						
pupil interviews	5	20	11	30	8	21
teacher interviews	5	7	3	23	3	11
questionnaires	0	1128	225	111	0	0
Universities						
student interviews	5	0	0	0	32	14
professor interviews	1	6	0	0	3	7
questionnaires	0	165	0	0	0	0
Policy Makers	2	1	2	2	0	0

Table 2: *Percentages of tertiary type A qualifications awarded to females in STEM fields of study in 2001. (Source, OECD data provided to Annemarie van Lagen and shown at the PREMA conference in Barcelona)*

Country	Engineering, Manufacturing & Construction	Physical Sciences	Mathematics & Statistics	Computing
Austria	17	27	41	11
Belgium	20	35	46	16
Czech Republic	30	38	46	7
Denmark	23	35	45	19
Finland	19	45	39	34
France	24	38	43	19
Germany	21	28	44	12
Hungary	28	37	22	21
Ireland	26	48	49	39
Italy	28	42	63	27
Netherlands	12	26	27	14
Poland	24	65	75	23
Spain	29	51	55	23
Sweden	28	43	36	40
United Kingdom	19	40	40	25
United States	21	38	45	29

degree level placed even greater emphasis on the importance of enjoyment and interest, and reported high levels of both, in mathematics when at school.
In England and Spain, university teachers viewed enjoyment as a major reason for their engagement with mathematics.

Choices available

In Greece, teachers report that girls who are good at mathematics are also good at a range of subjects.
In England, girls outperform boys in almost every school subject, so have a wider range of courses to choose from.
In England, some new curriculum subjects are particularly interesting to girls (psychology –now as popular as mathematics– provides a vivid example). The relatively low take up of mathematics by girls may well be exacerbated when students are offered (or become aware of) a wider range of possible subjects to study.
In England and Greece mathematics at school is not seen to be particularly interesting or enjoyable to the majority of students.

Impact of specific programmes

Respondents in Austria and England at university and beyond reported that they had been influenced by specific initiatives to encourage women to enrol in STEM courses at university.

Career and family

In Spain, girls in vocational training (and some in High School) explain that one of the reasons that they don't want to go to university because they don't want to postpone the possibility of living with their boyfriend or forming a family.
In Greece, only girls made any reference to a future family when considering their choices of subject to study at university.
In Austria, some students and teachers referred to the need to find a career that would be compatible with family life, and argued that this was a motivation towards (say) teaching and away from jobs not seen to be family friendly.

SUMMARY

In no country can differences in the take up of STEM by men and women be attributed to poorer performance by girls in school mathematics in the compulsory phase of education. In many countries, students believe that they make choices autonomously, with parental support. Girls have higher attainment that boys in most subjects, so their choices are less constrained. In most countries, interest and enjoyment are important factors when choosing courses of study. Mathematics is not seen to be particularly interesting or enjoyable by the majority of students. Some students do not believe STEM-related courses and careers will fit with their desires for family life. Specific programmes to encourage women to take up STEM were judged to be influential by some women. There are clear implications for policy and practice; mathematics curriculums need to be made more interesting to students; 'girls into STEM' initiatives should be evaluated, and perhaps extended; STEM-related careers need to be made more attractive (perhaps via legislation) to people (especially women) with families.

PEDAGOGICAL FACTORS

Curriculum structures and curriculum materials

Major differences between countries were observed in terms of some aspects of curriculum practices and materials, and in terms of beliefs about boys and girls.
In Poland, at Primary level, boys and girls are taught in separate classes some of the time; boys acquire technical knowledge, learning ironwork and carpentry, while girls are trained in cooking, baking and knitting. In textbooks, men and women are depicted in traditional roles –further, women are show as unattractive homemakers.
In Spain, teachers perceive that there is still some sexism in didactic materials.

Teacher perceptions of boys and girls learning mathematics

In Poland, all teachers perceived differences between the way that boys and girls learn mathematics:

- girls are reluctant to ask for explanations
- girls generally are more afraid to solve tasks on the blackboard in front of a class
- girls have less developed mathematical-logical intelligence than boys
- girls are more diligent and motivated to obtain high scores
- all teachers consider women as more diligent and more careful over detail
- many girls try to simply memorize topics in order to pass them while boys more frequently make efforts to understand issues and look for practical applications.

In Poland (and nowhere else) two teachers argued that there are differences in the way that the brain processes information in the case of boys and girls, and that this influences the way that they learn mathematics (according to these teachers it favours boys). Two teachers said that they were unconvinced that girls should enter mathematics related careers.
In Spain, teachers believe:

- girls are more motivated to get high marks than are boys, and girls compare their grades more than do boys
- girls are tidier and more steadfast in their studies, and so get better results
- some teachers say boys are faster understanding mathematics, more creative, and they believe it is innate
- some also believe that girls are more 'people focused'.

In Spain, there was a difference in the perceptions of teachers who had studied and done research on gender issues in education, and those who had not. The latter group saw no problems, and no sexism; the former group did.
In Greece, there was no overall consensus amongst teachers about girls and mathematics, though some general themes did emerge:

- girls are more 'instrumental' and learn what they have to learn and are more focused on getting good grades
- boys demand more attention
- some teachers say that girls give up more easily than boys when they face challenges, others that girls are more persistent
- girls ask fewer questions; when they have difficulties, they are more likely to try to resolve problems by discussing the issues amongst themselves than by asking the teacher (some teachers report exactly the opposite observation!)

In Greece, about half of the teachers interviewed reported that they treat boys and girls in the same way. The other teachers report that they praise girls more, try to convince girls that they can do better, and try to enhance girls' self esteem.
In Austria and England, the most important feature of all the interviews with teachers in school and at university was the lack of strong signals concerning the nature of girls and boys in relation to the study of mathematics. In England, sex differences, when they were described at school level, were usually focused on more confidence, question asking and answering, and more disruption by boys, and a more diligent approach by girls. In Austria, girls were seen to be more diligent, more accurate and to work harder. Opinions differed in the extent to which girls and boys ask questions; sex was seen to be largely irrelevant to success in mathematics.

Student perceptions of boys and girls learning mathematics

In Spain, students believe:

- girls are more competitive about grades
- girls work harder
- girls are more interested in humanities and arts subjects that give them contact with people.

For example, one boy remarked "We men are only competitive in football. Women are competitive in more important things".

In Greece, students believe:

- girls study more
- girls try to be good in all subjects
- girls care more about school
- girls are more systematic in their work
- boys make much more noise
- boys are more willing to volunteer answers, and to solve problems on the board
- teachers have to "gain boys' attention" –in contrast with girls whose attention is taken for granted
- when a more challenging question is posed it is usually answered by boys.

In England, as with teachers, the most important feature of all the interviews with students in school was the lack of strong signals concerning the nature of girls and
In Austria, boys are seen to pay less attention, and to talk (off task) in class. Girls are better organised, and are more accurate (and so are probably better than boys).

Student perceptions of being a 'good student'

In Austria, England and Poland, accounts of successful and unsuccessful students focussed on effort, interest and the pursuit of understanding, rather than aptitude.

Student perceptions of male and female teachers

In Greece, the majority of the pupils believe that there is no difference between male and female mathematics teachers. The few that see differences mention that females are more friendly, easier to contact, more patient, try to make the lesson understandable by the average pupil, try to simplify the lesson in contrast to the males who are more "scientifically" oriented.
No differences were reported by students in either Spain or England. In Austria, few differences were mentioned; one student reported a teacher who favoured high attaining students, and particularly boys.

Student perceptions of 'good teaching'

In Austria, England and Greece, mathematics was not considered to be an interesting subject.
In Spain, at university level, teachers believe that the curriculum should be designed to be more interesting to students –an awareness that this might not be easy, given the diversity of student interest.
In Austria, England and Spain, mathematics lessons generally followed a fixed pattern, dominated by teacher explanations to the whole class and students practicing exercises.
In Austria, England and Poland, accounts of good teaching focussed on generic teaching skills such as clear explanation.
In Austria, the quality of explanations, and showing relations between topics were seen to be important. Good teachers show an interest in the problems of individual students. Some students said they would like a wider variety of teaching styles, such as more group work. Some would like more examples of applications.
In Austria and England, there were no clear preferences for particular teaching styles by girls and boys.
In Spain, there was no consensus that group work was better than exposition.
In Spain, about half of the teachers report that they motivate boys and girls in the same way; the other half say that they try to build girls' self esteem, and to convince girls that they can do better
In every country, students and teachers reported that, overall, girls and boys were treated in the same way in class [this does not mean that this is the case!].

Summary

In terms of classroom activities, there were some findings that seemed common to all countries, though apparently manifest to different extents in different places. Boys are judged to be more disruptive and more badly behaved. They also ask more questions. Girls are seen to be quieter, to be more diligent, to work harder, and to be systematic and neat.
There were major differences in inherent sexism

in different countries, with Poland at one extreme (different classes for boys and girls, stereotyping in text books, and some teacher beliefs about inherent sex differences) and Austria and England at the other.
Generally, perceptions of good teaching and being a good student referred to generic skills such as producing good explanations, or learning for understanding, not by rote.
Where differences were reported in teacher behaviour, these were likely to be that boys were asked more questions, and more intellectually challenging questions.
Mathematics is not seen to be an interesting subject. Mathematics teaching in some countries followed a common pattern in almost every lesson where teacher exposition is followed by student practice. Most students want mathematics to be more interesting, relevant and enjoyable. Student preferences for a range of possible alternative classroom activities (such as group work) were not uniform.
High quality teaching and a vibrant curriculum are keys to enhanced engagement with mathematics. Curriculum reform should be explored. Appropriate professional development should be pursued. If pedagogy is to be reformed, there is a need for simple tools to support teachers who want to observe their own classrooms, and specific guidance on appropriate remedial activities (such as asking more complex questions to girls, and attending to the needs of all students in class, not simply those students who are most demanding).

SOCIO-CULTURAL FACTORS

There are very big differences between countries in the extent to which mathematics is viewed as being a male subject. Across the countries represented in PREMA, there were big differences between the most traditional country (Poland) and the most progressive country (England). There were differences in:

- raising political awareness of differences in attainment and career choices between males and females
- beliefs in 'essential differences' between men and women, for example, in the ways 'their brains work'
- political campaigns *against* feminism
- parental pressure towards or away from 'suitable' academic subjects, or support for students' own choices and autonomy
- supportive or unsupportive employment legislation regarding the rights of parents (usually women) to child care, flexible working hours, and the like.
- there were big national differences in the perceived influences of parents, other students, cultural influences such as the acceptability of a 'career woman'.

Interestingly, these cultural differences do NOT show up in international comparisons, where data are available country by country on the relative attainment of girls and boys. In PISA (2003), for example, girls in Poland perform as well as boys; in England, international comparison studies (PISA, TIMSS) show differences in favour of boys. Countries conventionally judged to be egalitarian such as the Netherlands and the Nordic countries show differences in favour of boys.
In Poland, there are important historical and socio-cultural factors that influence the (very low) entry by women into STEM related careers. For example, in 1931, 27.9% of Polish women were illiterate. A study by Siemieńska conducted in 1995 –97 revealed that 70% of Poles feel that women can only achieve fulfilment as mothers and approximately 33% of the population also believe that a university education is more important for men than for women. In another study, 40% of respondents categorically supported the idea that the family and household should be the principal domain of women's activities.
Poland has also witnessed a rebirth of an ultra-conservative ideology, advocated by the Catholic Church and its political allies. Feminism has been accused of being a source of all social and moral evil, and women's higher education and professional aspirations have often been criticized as "corrupt equality", incompatible to the true nature of women, and the largest contributing factor of women's personal unhappiness.

From the Polish National Report

According to research by Wójcicka and Dominiczak, there are strong cultural beliefs about the nature of men and women, that are played out in child rearing practices. Girls and boys are seen to have different personalities; they have different needs, and different values, and are suited to different social roles. Girls are brought up "to be tender, polite, caring, submissive, and willing to make sacrifices, in order to be good wives and mothers". Boys are brought up to be able to cope with life's challenges and to prepare for professional careers, competing to achieve success. These practices are reinforced by an education system where girls take courses to develop domestic skills, and boys take courses to develop technical skills.

In Greece, there was evidence of a belief that girls are not interested in mathematics, and do not work at it. Women are more oriented towards the household, or careers in medicine or teaching. Some teachers believed that some mothers hate mathematics, and actually discourage their daughters from working hard at it.

In Austria and England, few socio-cultural factors were apparent in the interviews in schools. Students believed they made decisions autonomously, and there was little evidence of stereotypes either about the nature of boys and girls, or that mathematics was 'gendered'. Friends' choices were seen to be irrelevant when making decisions.

In Austria, some pupils and teachers expressed the assumption that boys understand mathematics faster and are more interested in natural sciences. There were also several interviewees who stated that girls are better at mathematics because of their orderly and accurate approach.

In Spain, teachers perceive the research and academic world to be structurally sexist. For engineers (not so for mathematicians) the professional field is seen to be structurally sexist. All of them see rapid changes towards equality.

In Spain, not a single student or teacher claimed that mathematics or science are inherently masculine fields. However, a policy maker discussed 'intelligent renunciation' – where girls avoid fields such as SMET (and ICT in particular) where there is a cultural belief that women do not belong.

In England, the construction by university lecturers of 'mathematician' is essentially 'university mathematician' –someone who pursues academic rather than applied issues. This may be a barrier to enhancing the influence of mathematics, socially and culturally. In Austria, the one university teacher discussed the ambiguity of the image of 'mathematician' for potential students.

In England, Austria and Spain, there was some concern that university cultures in (at least) mathematics departments are 'male' –individualistic, competitive, and doing little to support family life. Overall, the impression from these interviewees are more positive than those found in larger scale, earlier studies (e.g. by Burton, 2004). Nevertheless, in Austria, leaders of *Frauen in die Technik* said that more women than men gave up courses in STEM, and offered reasons that included the ridicule of women students in STEM, and a lack of supportive networks.

In Austria and Spain, there was a concern that it is harder to reconcile family and work in STEM related careers than in non-STEM related careers, and that this discourages women from STEM.

In Austria, there was some evidence that women do not want to identify with typical male professions. Some teachers referred to the influence of cultural stereotypes on student choices.

In all the interviews that took place, there were very few students who could name a female mathematician.

Summary

The socio-cultural construction of mathematics varies a great deal across countries. However, construction of mathematics as 'masculine' was not associated with lower attainment by girls at school, or with lower entry to university courses. Many socio-cultural factors are hard to change. However, some may well be amenable to influence from policy makers and practitioners. Information about the take up of STEM by women, and information about successful women practitioners may well have an effect as part of career guidance. Information about successful women mathematicians can be included in mathematics

lessons. In many countries, university mathematics courses (and mathematicians) can do more to avoid portraying mathematics as a masculine domain; networks to support women can be established. Legislation that requires STEM-based professions to be more family friendly can be introduced, or enforced.

IMPACT OF COMPUTERS (ICT)

In Spain, there is a general perception that women do not have a role in ICT.
In France, using ICT in mathematics and being good in using ICT were judged to be more important for boys than for girls.
In France, a higher proportion of boys than girls say they wanted to do ICT; in England, far more boys than girls take post-compulsory courses in ICT. In Spain and England, far more boys than girls study ICT at university.
In Austria and England, there was very little use of ICT in mathematics classrooms.
In England, ICT was seen to be irrelevant to mathematics by both university students and students at school.
ICT is seen to be a male domain in every country for which we have evidence. However, ICT is also seen to be unrelated to mathematics, and so the 'maleness' of ICT is unlikely to be a factor that discourages women from choosing courses in mathematics.
Two issues emerge from these results. First is a set of questions about the wisdom of increasing the use of ICT to teach mathematics, if ICT is seen as a male domain. The second issue is the low engagement of women with ICT. As in the case of mathematics, ICT and commercial activities based on ICT are associated with economic progress at a national level, and good employment prospects at a personal level. A PREMA-style project is needed as a matter of urgency.

ADVICE TO POLICY MAKERS AND PRACTITIONERS

In some countries, the lower take up of STEM by women is part of a larger problem of the decreasing take up of STEM by all students. Many of the suggestions below are relevant to solving this larger problem.
Systems to monitor the attainment and take up of STEM by males and females (and other under represented groups) are necessary, if the problems are to be understood and remedied.
Sexist curriculum materials and practices should be changed.
More advice should be given to students about the implications of the subject choices they make. Emphasising 'freedom of choice', without imparting appropriate knowledge about the consequences of different choices, can be seen as a neglectful approach to the well being of young people. It is appropriate to provide more and better careers guidance, especially about the nature of mathematics and its application to a variety of occupations, at the time when students are making important career-related decisions.
The relative dullness of mathematics as a subject at school was a central issue in most countries; this needs to be addressed as a matter of urgency. Some topics in mathematics should relate directly to student interests. We need to reform the mathematics curriculum to make it more enjoyable and interesting –for example by placing more emphasis on the creative aspects of mathematics, by introducing (say) contexts from psychology (or the mathematics associated with mobile phones or MP3 players, for example) to complement those from physics. This approach should not be confused with 'dumbing down' mathematics– the contexts should be chosen to be more interesting to girls, but the same academic standards should apply. It may be the case that ICT can be beneficial; however, it has already been noted that the use of ICT might reduce girls' interest in mathematics.
Good quality teaching is the key to engagement with mathematics. There is a need for professional development of non-specialist teachers of mathematics (at all phases of education) which build their confidence with mathematics, as well as their subject knowledge.
Good teaching is associated with clear explanations, good teacher subject knowledge, and engagement with mathematics. It is necessary to

- pay appropriate attention to girls and boys in class –for example by asking equally demanding questions of boys and girls
- increase the variety of teaching styles used in mathematics lessons
- put more emphasis on motivating young children at home via games (such as logic games) and toys, and a general emphasis on mathematics for recreation
- develop student enjoyment of mathematics
- build student confidence in their mathematics

Gender issues should be part of teacher preparation and in-service professional development programmes. There is a general lack of 'critical pedagogy' where the treatment of boys and girls in class is concerned. Courses could

- provide information on the gender gap in STEM related careers, and the economic consequences for women
- provide simple tools for classroom observation, to provoke teachers and students to reflect on existing practices

Existing initiatives to encourage women into STEM at university should be evaluated, and good practices should be adopted across member states.

Network structures to support women at university and in their professional careers should be developed and strengthened.

Employment legislation that is 'family friendly' in STEM related professions should be promoted, and existing legislation which is already in place should be monitored and enforced.

Socio-cultural factors are rather hard to change. Approaches might include:

- raising political awareness of differences in attainment and career choices between males and females
- providing references to distinguished women mathematicians in curriculum materials, and in the media
- providing better information for students about possible career pathways
- simply asking teachers and students about their stereotypes as a way to influence attitude and behaviour
- looking for, and removing, stereotyped images in text books
- elimination of sexism in language (and interesting and conceptually complex challenge in some languages!).

As a footnote, we draw attention to the lack of engagement of women in ICT and ICT related enterprises; this is worthy of a PREMA-style investigation.

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Survey Instruments and the associated analytic frameworks can be viewed on the PREMA website-http://prema.iacm.forth.gr/main.php

Wójcicka J. and Dominiczak A. Edukacja kobiet, Raport Centrum Praw Kobiet. (title translation: Education of women). Cited in Piotrowski and Wójcik (2007).

Useful Resources [to be exended/taken from website]

FIT-Frauen in die Technik
(http://www.bmbwk.gv.at/FIT)

fFORTE-Frauen in Forschung und Technologie
(www.fforte.at)

MUT-Mädchen und Technik

APPENDIX A: SCHOOL QUESTIONNAIRE

Male/Female	School:	Class:

Thinking about Mathematics

For each of these statements, please mark on the scale beside it:

how much you agree with it

how important it was in deciding to/not to take further courses in mathematics.

1: I enjoyed mathematics as a subject at GCSE	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
2: I was good at GCSE mathematics	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
3: I was interested in mathematics at GCSE	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
4: I am good at ICT	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important

5: I did well in GCSE mathematics examinations	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
6: I liked the 'certainty' of mathematics at GCSE, knowing where you were, and when you had learned things	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
7: I disliked the 'routineness' of maths at GCSE – too boring	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
8: I liked getting better results than others in GCSE maths	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
9: I thought advanced mathematics would make a lot of use of ICT	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
10: I could show people how clever I was by being good at mathematics at GCSE level	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐

11: I enjoyed challenges– mathematics had lots of interesting questions at GCSE level	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
12: I thought I would need maths for my future career	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
13: I wanted to do AS maths	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
14: My parents/guardians wanted me to do AS maths	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
15: My teachers wanted me to do AS maths	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
16: I thought my friends would be studying maths at AS Level	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐

17: My teachers gave me confidence to make my own decisions about courses and career	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
18: My parents/guardian gave me confidence to make my own decisions about courses and career	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐

Results

GCSE	Grade
MATHS	
ENGLISH	

Results / Current Courses

AS Level	Grade

Current Courses

A2

APPENDIX B: UNIVERSITY STUDENT QUESTIONNAIRE

Gender: Male/Female	University:	Course:

Thinking about Mathematics

For each of these statements, please mark on the scale beside it:

how much you agree with it

how important it was in deciding to/not to take further courses in mathematics.

1: I enjoyed A' Level mathematics as a subject.	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
2: I was good at A' Level mathematics	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
3: I was interested in mathematics at A' Level	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
4: I am good at ICT	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important

5: I did well in A' Level mathematics examinations	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
6: I liked the 'certainty' of A' Level mathematics, knowing where you were, and when you had learned things	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
7: I disliked the 'routineness' of A' Level maths.	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
8: I liked getting better results than others in maths at A' Level	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
9: I thought advanced mathematics would make a lot of use of ICT	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐
10: I could show people how clever I was by being good at mathematics at A' Level	Strongly Agree Strongly Disagree ☐ ☐ ☐ ☐ --- Not Important Very Important ☐ ☐ ☐ ☐

11: I enjoyed challenges – A' Level mathematics had lots of interesting questions.	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
12: I thought I would need maths for my future career	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
13: I wanted to do A' Level mathematics	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
14: My parents/guardians wanted me to do A' Level mathematics	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
15: My teachers wanted me to do A' Level mathematics.	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
16: I thought my friends would be doing A' Level mathematics	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important

17: My teachers gave me confidence to make my own decisions about courses and career	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important
18: My parents/guardian gave me confidence to make my own decisions about courses and career	Strongly Agree ☐ ☐ ☐ ☐ Strongly Disagree --- Not Important ☐ ☐ ☐ ☐ Very Important

Subject/s I am studying at degree level				