Doing gender in mathematics education

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Gender, mathematics and prestige

What are the gender issues in mathematics education about and why are they important to study? The purpose of this chapter is to throw light on different aspects of these questions by means of an analytical framework, some statistics and previous research.

In Sweden today, men and women are almost equally active at the labour market but they are working in different sectors. The economic activity rate is 90 percent for women aged 20–44 and 94 percent for men with the same age. The occupational sex segregation at the Swedish labour market is obvious. In 2009, women form 83 percent of the personnel in social work and 75 percent in the educational system, whereas, men form 92 percent of the working force in construction industry and 76 percent in manufacturing and mining. Among students at higher education, females have overtaken males. In 2008/09, the sex distribution is about 60 percent women and 40 percent men, and their choice of subject is also gendered. Broadly speaking, women study health related science and teacher education while men study technology (SCB, 2010). According to Gerd Brandell (2008), female students make up a little more than one third of all students at mathematics or other mathematics intensive courses at undergraduate level, including e.g. engineer and teacher education. Looking at the upper secondary level, there has been an increase of female students in the natural science and the technology programmes, at upper secondary level, since the beginning of the 1990s. The part of female students has been between 45 and 51 percent at the natural science programme during the whole period, except for at few years where the technology programme was integrated and the female share decreased (Brandell, 2008). In 2009/10, the female percentages in the two mathematics intensive programmes are 49 percent (natural science) and 20 percent (technology) (Skolverket, 2010).
Within the frame of a Danish research programme on gender in the academic organisation, Inge Henningsen (2000) calls attention to a connection between gendered choice of subject and prestige in the scientific world. She has selected important dimensions in natural science research to form a relational room with two axes (see figure 1). At the horizontal axis, scientific subjects and subject areas are placed in relation to the concept pairs "applied-theoretical"; "concrete-abstract"; and "complex-simple". At the right end we find subjects like pure mathematics and physics, while biology and applied mathematics are situated at the left end of this axis. At the vertical axis, disciplinary subject areas are placed in relation to the pairs "invented-natural"; "artificial-existing"; and "constructed-organic". This axis, for example, separates pure chemistry and biochemistry. The subjects characterized by high prestige are situated in the upper right quadrant whereas the subjects with low prestige are in the lower left quadrant. Henningsen claims that the relational room is also a room for female and male preferences as indicated in the figure.

![Figure 1](image-url)

**Figure 1.** Dimensions in the research field of natural sciences (after Henningsen, 2000, p. 68)

Within the field of mathematics, figure 1 mirrors the fact that pure mathematics is more prestigious and powerful than applied mathematics, at the universities in Sweden, as argued by Brandell (in press). She has made an overview of female professors in
Sweden within mathematical sciences which, for this purpose, is defined as mathematics, mathematical statistics, applied mathematics and numerical analysis and other female professors at mathematical departments including professors in mathematics education. In 2008, there were 13 female professors corresponding to less than one tenth of the male professors (138) within the same areas. In relation to the discussion about hierarchy and prestige of sciences, it is interesting to note that a large majority of the female group are situated within applied mathematics. The largest area is mathematical statistics (five professors) followed by mathematics education (three), applied mathematics (two), pure mathematics (two) and numerical analysis (one). Almost half of the 138 male professors (67) are situated within pure mathematics (algebra, geometry and analysis). Furthermore, I find it relevant to note that the only two female professors in pure mathematics have graduated in Spain and in Ukraine, not in Sweden.

In her article "Progress and stagnation of gender equity: Contradictory trends within mathematics research and education in Sweden", Brandell (2008) documents that women in Sweden, during the last decade, have reduced men’s dominance in undergraduate and post-graduate mathematics education and in professional carriers as mathematicians. But she also illustrates that the development is uneven and slow. At the highest levels, for examples as professors in mathematics, the number of females has increased only marginally. Thus, Brandell puts the following question:

Why (…) is progress so slow after almost 20 years of active work from the Women and Mathematics movement in Sweden¹ and within a society in which gender equity is highly valued at the societal and political levels? (Brandell, 2008, p. 659)

¹ IOWME (The International Organization of Women and Mathematics Education) established in the late 1970s is an international network of individuals and groups who share a commitment to achieving equity in education and who are interested in the links between gender and the teaching and learning of mathematics (See http://extra.shu.ac.uk/iowme/). Since the beginning of the 1990s, the international debate on gender in mathematics education has been reflected in the Swedish "Women and mathematics" (Kvinnor och matematik) conferences. The first national conference, within the framework of IOWME, was organised by Barbro Grevholm in Malmö, in 1990 (see Grevholm, 1992). The title of this conference as well as the following six conferences held in Sweden (1993, 1996, 1999, 2002, 2005, 2009) was "Kvinnor och matematik" (Women and mathematics). A national Swedish network was established at this conference as a sub-organisation of IOWME and it attracted more than 700 members in 1996. When the
She argues that an understanding of the development of equity in relation to mathematics requires that a larger context of equity in society and education in Sweden is taken into account.

To illustrate some of the points on prestige and power distribution made by Brandell (2008) and Henningsen (2000), I have found a droll example from Norway: In 2002, the Abel Prize\(^2\) was established, as a parallel to the Nobel Prize in Economy, to award outstanding scientific work in the international field of mathematics. On that occasion, a nicely designed booklet on the Abel Prize was produced to inform the public. Turning the pages, one might wonder if high prestige mathematics is merely a world for white, middle aged men. The booklet is richly illustrated with just men doing mathematics except for one photo with a female teacher and a group of girls "playing" in the sun.

Two pages copied from the Norwegian booklet *Abelprisen*, 2003.

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\(^2\) Niels Henrik Abel (1802–1829) was a Norwegian mathematician who proved the impossibility of solving algebraically the general equation of the fifth degree. To do this he developed group theory and did this independently of Galois. Furthermore, Abel wrote a monumental work on elliptic functions.
In her pioneering book *Counting girls out*, Valerie Walkerdine (1998) called attention to the gender stereotyping of mathematics – not only in school and society but also in research. In the following, she puts it to extremes:

Women, after all, are clearly irrational, illogical and too close to their emotions to be good at Mathematics. Or so the story goes. Endlessly repeated variations on the theme are still being reworked, in one empirical investigation after another. (…) When examining these issues one can fall into the trap of attempting either to prove exactly what girls lack so that it can be put right, or to demonstrate that there is no lack at all. (p. 15)

Like Walkerdine, I find that such approaches tend to trap us and, in this chapter, shall not refrain from examining possible differences in boys’ and girls’ attainment levels but instead investigate the societal and individual gender stereotyping of mathematics in a historical and cultural context. The chapter is dedicated to perspectives on gender in mathematics education and research. First, I present and discuss conflicting perceptions based on different views on mathematics and gender; followed by an example of a theoretical framework for analyzing and understanding gender and mathematics in a societal context. Second, I discuss the question ”How to study gender in mathematics education” by presenting and comparing different approaches and resulting findings in research. My focus is the state of affairs in Sweden but it is a point that men’s and women’s relationships with mathematics vary in time and space. Finally, the theme is future directions guided by the principle of gender mainstreaming (jämställdhetsintegrering). But first a short comment on terminology.

**Terminology**

Today, we talk about gender and mathematics issues. From the 1970s until the late 1980s, the main focus was ”women as a problem in mathematics” (Leder et al., 1996). In the 1990s, a transition took place in the debate on women and mathematics: from using the word ”sex” with a connotation of biological aspects, the debate turned to ”gender” with a focus on the sociological aspects of both men’s and women’s relationship with mathematics (see e.g., Burton, 1992; Grevholm & Hanna, 1995; Kaiser & Rogers, 1995; Hanna, 1996; Leder, Forgasz & Solar, 1996; and also Damarin & Erchick, 2010). Today in the Swedish discourse on gender and education, a
distinction is made between the two terms *sex* (können), which refers to female and male, biological differences, chromosomes, hormonal profiles, versus *gender* (genus), which refers to feminine and masculine, characteristics and culture dependent traits attributed by society to men and women. There are many approaches to define and theorize gender and people have many choices of how to live and be at the beginning of the 21st century. "As women and men exercise these choices, gender is best viewed as a process; in the words of a common slogan, *gender is more a doing than a being*" (Damarin & Erchick, 2010, p. 318, italics in original).

The gender issues in mathematics education

There are not one but many gender issues in mathematics education. The so-called gender and mathematics problem varies with time and with cultural and societal context. This is the conclusion drawn by Paul Ernest (2007), who is one of the few male researchers who have looked critically at gender in mathematics education. Not only do the achievement levels and participation rates in mathematics vary, there also exist contradictory perceptions of what constitutes the problem. In his book *The Philosophy of Mathematics Education*, Ernest (1991) distinguished five points of view or educational ideologies identified with interest groups in the UK. From different positions and with different interests, the five groups bring answers to key questions like "Why teach and learn mathematics" (perception of aims of mathematics education) and "What is mathematics" (views of the nature of mathematics). Ernest (2007) suggests that each of the five positions cause related views of the "gender and mathematics" problem (see table 1).

<table>
<thead>
<tr>
<th>Interest group</th>
<th>Perceptions</th>
<th>Aims of mathematics education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial trainers</td>
<td>Radical &quot;New Right&quot; conservative politicians and petty bourgeoisie</td>
<td>Back-to-basics numeracy and social training in obedience (authoritarian)</td>
</tr>
<tr>
<td>Technological pragmatists</td>
<td>Meritocratic industry-centred industrialists, bureaucrats, industrial mathematicians</td>
<td>Useful mathematics to appropriate level and certification (industry-centred)</td>
</tr>
<tr>
<td>Old humanist mathematicians</td>
<td>Conservative mathematicians preserving rigour of proof and purity of mathematics</td>
<td>Transmit body of pure mathematical knowledge (maths-centred)</td>
</tr>
<tr>
<td>Progressive educators</td>
<td>Professionals, liberal educators, welfare state supporters</td>
<td>Creativity, self-realisation through mathematics (child-centred)</td>
</tr>
<tr>
<td>Public Educators</td>
<td>Democratic socialists and radical reformers concerned with social justice and inequality</td>
<td>Critical awareness and democratic citizenship via mathematics</td>
</tr>
</tbody>
</table>
Absolutist set of decontextualised but utilitarian truths and rules | Unquestioned absolutist body of applicable knowledge | Absolutist body of structured pure knowledge | Absolutist body of pure knowledge to be engaged with personally | Fallible knowledge socially constructed in diverse practices

| View of "gender and maths problem" | Fixed biological differences make males better at maths | Utilitarian problem to be ameliorated for benefit of society even if females are inferior | Maths ability inherited and primarily male but ablest women to be encouraged as mathematicians | Girls/women lack confidence and hold themselves back, i.e. an individual problem | Gender inequity due to underlying sexism and stereotyping in society in maths

**Table 1.** Five interest groups and their views of the "gender and mathematics problem" (after Ernest, 2007, p. 6, with a few technical modifications).

Ernest (2007) elaborates on the different views of gender and mathematics of the five groups like this: *The Industrial Trainers* believe that fixed biological differences are the sources of gender differences in mathematical ability, and in particular, make males better at maths. *The Technological Pragmatists* see the gender and mathematics problem as a utilitarian problem to be ameliorated for the benefit of society, since a well educated workforce of both men and women is needed, even if females are inferior at mathematics. *The Old Humanists* are conservative mathematicians committed to preserving the purity of mathematics. This group see mathematical ability as inherited, and primarily concentrated among males. However, in the interest of mathematics, they also want the ablest women to be encouraged to be mathematicians. *The Progressive Educators* are traditional liberal supporters of education. Mathematics problems are located within individuals, and in particular the gender and mathematics problem is understood to be due to the lack of confidence and poor mathematical attitudes of girls and women. Thus, the solution is to encourage and support girls and women more.

*The Public Educators* are radical reformers concerned with social justice and equity. Gender is socially constructed and inequity is seen, among other things, as a consequence of the stereotyping of mathematics as male. The result is the construction of gendered identities which embrace and welcome mathematics (mainly masculine

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3 *Absolutism* views mathematics as an objective, absolute, certain and incorrigible body of knowledge, which rests on the firm foundations of deductive logic. Whereas *fallibilism* views mathematics as the outcome of social processes and understands mathematical knowledge to be fallible and eternally open to revision, both in terms of its proofs and its concepts (Ernest, 1991).
identities) or exclude it. When solutions to the ”problem” are proposed it is important to remember that the gendered identities are local constructions and that there are variations according to the contextual differences.

The five contradictory positions coexisted in the British society and we may localise similar positions in Sweden. However, I think that it will be difficult to find any ”Industrial trainers” today except for the idea of basics numeracy as the aim of mathematics education.

In Gilah C. Leder’s (2004) sketch of changing lenses – from liberal feminism to radical feminism – through which gender and mathematics education have been viewed one finds elements from the view of humanist mathematicians, progressive and public educators. According to the deficit and assimilationist model, male (white and Western) norms of performance, standards and participation levels in mathematics education were in general accepted uncritically. Females, whose mathematical ability was insufficient, were to be encouraged and helped to assimilate and to attain achievements equal to those of males. This model which was in harmony with liberal feminism dominated throughout the 1980s. However, at the same time different voices were beginning to be heard in the debate at the same time. The feminists began to formulate new questions:

Should we accept, uncritically, the way in which subjects such as science and mathematics were taught, valued and assessed? Should young women strive to become like young men or should we acknowledge and celebrate their goals, ambitions, and values? Should we accept only learning styles, materials and conditions favoured by males? (Leder, 2004, p. 106)

Emphasis began to be placed at the power structures imposed by males for males and the radical feminists considered that the long-term impact of theses structures on relations between men and women could only be set right through fundamental changes of society. (Read more about the historical development of gender perspectives and curriculum development in mathematics education, in Leder, Forgasz & Solar, 1996.)

It is obvious that there is not a single but many different perspectives on gender and mathematics. In this landscape, I position myself as a radical reformer seeing aims like critical awareness as important in mathematics education; mathematics socially constructed knowledge; and gender inequity as due to underlying stereotyping of
mathematics in school and in society. On this background, I have put forward an analytical framework that might be helpful for understanding what is going on in mathematics education today.

**Four aspects on gender**

What is formulated as a problem in the relation between gender and mathematics varies with the underlying conceptualisation and the theoretical perspective adopted: You get what you’re asking for (Som man ropar i skogen får man svar). According to Gabriele Kaiser (2003) the social construction of gender forms the theoretical base of many new empirical studies dealing with the topic of mathematics and gender. In the Nordic countries, the underlying issue is always equal opportunity whether the topic is gender difference or gender equity. Taking this into consideration one realises that The Public Educators’ standpoint – as defined by Ernest – should be widespread in mathematics education and research.

The question "What is gender?" might at first look as an easy one to answer. Of course "gender" means men and women, boys and girls, and all the differences between them. However, the question is much more complex as we not only assign gender to people with a different sex but also to jobs, school subjects, colours, clothes and leisure activities. In order to study different dimensions of the gender issue in a European study on gender in scouting, Harriet Bjerrum Nielsen (2003) introduces four aspects: structural, symbolic, personal and interactional gender.

The first aspect is *structural gender*: Gender constitutes a social structure when for example men and women are unevenly distributed in terms of education and occupations; men earn more than women, who also hold fewer leading positions in society; women do more housework in most families. Above, I have noticed unequal distribution of gender in different sectors at the Swedish labour market and in higher education. Statistics also shows that there is a clear connection between wage and gender (SCB, 2010). Another example of structural gender is the clear division of gender in the Swedish higher secondary school (gymnasieskolan) in 2009/10. The programmes Building, Industry and Transport are mainly chosen by men while Children and leisure and Caring and nursing are primarily chosen by women (Skolverket, 2010).

The second aspect is *symbolic gender*: The gendered structures gradually form the
gender symbols and discourses (symbolic meaning) in people’s heads. It becomes, for example, normal and natural that men take the leading positions in society and women have part time jobs to take care of home and family. "Thus, symbolic gender will have consequences for the further development of structural gender, and vice versa” (Bjerrum Nielsen, 2003, p. 18). Structural and symbolic gender tells us what is normal and what is deviant for men and women, girls and boys whether we personally consent to these norms or not. At the beginning of the Twentyfirst Century, mathematics in the Swedish higher secondary school has its own place in the symbolic gender dualism of the society where the world and its qualities are divided into masculine and feminine, and where everybody has integrated this dualism whether they want to do it or not. When for example symbols like ”pure” and ”hard” are used for both masculinity and mathematics, it contributes to the construction of symbolic gender (Brandell, 2008).

The stereotyping of mathematics as a male domain is an example of symbolic gender which also results in teachers’ and researchers’ spontaneous ideas about female and male students in the mathematics classroom. At a Nordic seminar on gender, mathematics and technology, Anne Berit Fuglestad (2006) presented findings based on the question ”Is there any difference between boys’ and girls’ attitudes towards and thoughts about using computers in mathematics education?”, from studies in Norway (1995 and 2004). During the session, she distributed a couple of pages with students’ responses to the questions ”why did you like this problem?” – ”what tool did you use and why?” – ”what did you learn?” The participants were invited to decide if the different answers were from boys or girls. In the following debate, they were quite sure that for example the following reply came from a boy: ”I liked this problem because it was solved really fast on the computer”, and that this came from a girl: ”Computation of interest is fun and very useful. Our teacher has attached much importance to computation of interest and, hence, the problem is very easy to solve”. It turned out that it was precisely the other way around. Hence, during this exercise, symbolic gender was illustrated through the participant teachers’ and researchers’ stereotyping of boys and girls. We also find a similar gender stereotyping in Lovisa Sumpter’s (2009, p. 11) study where the majority of the students from higher secondary school ranked the statement ”The graphic calculator saves time and work” as male.
A third aspect is *personal gender* where gender is seen as a personal matter and a reality for everybody. People are not passive bricks in social and cultural structures. They shape their lives within these structures, discourses and norms, and gender in the world is more diverse than the often dichotomous and stereotyping gender in our heads. "Personal gender concerns the way we fit into (or do not fit well into), identify with or protest against available cultural models of gender” (Bjerrum Nielsen, 2003, p. 22).

Analytically, it is possible to distinguish two sides of personal gender: *gendered identity* (I am a woman/man hence I act like I do) versus *gendered subjectivity* (I am me hence I act like I do). The gendered identity is something you "have" while the gendered subjectivity is something you "are" (Bjerrum Nielsen & Rudberg, 1994). When women in Sweden choose to be a nurse, they might do it both because it confirms their gendered identity (it is feminine to help others), and because their gendered subjectivity has the effect that they feel in fact that it is meaningful and confirmatory to them as persons to help others. While men choosing to be an electrician might do it because it confirms their gendered identity (it is masculine to work with electrical power and energy), and because their gendered subjectivity has the effect that they feel in fact that it is meaningful and confirmatory to them as persons to be occupied with electricity.

Findings in the study "Upper secondary school students’ gendered conceptions about mathematics" of Sumpter (2009) can exemplify elements in the two sides of personal gender and possible tensions between them, in a narrow and specific context. She has explored Swedish Natural Science students’ ideas of beliefs about gender and mathematics by means of two questionnaires. In the first one, students rank statements (e.g. "My own reasoning is not a safe strategy" and "You should finish a task before starting with a new one") being more likely to be true for girls than for boys, or whether there is no gender difference. In the second questionnaire, students are asked to rank the same statements from their own standpoint as being true, neutral or not true. In the first questionnaire most statements were ranked as "No gender difference" but seven of them showed some differences. A majority of both female and male students ranked the statement "You should finish a task before starting with a new one" as "Girls more likely than boys". Only 10 percent ranked this statement as "Boys more likely than girls". If we look at the second questionnaire, where the same statement is ranked from the students’ own point of view, 50 percent of the females answered "Not true" while 50
percent of the males said "True”. At first, I see this as a sign of a tension in a group of
the students between gendered identity based on an idea of how men/women act or
think and gendered subjectivity as the reason for how I act or think. However, this is not
a representative group of girls as they have all chosen the Natural Science programme.

A fourth aspect is interactional gender where gender is seen as something created
and reproduced continuously through social interaction (negotiation). This aspect
highlights gender as something we ”do” in interaction with others whereas the personal
aspect emphasises gender as something we ”are”. When people interact they
continuously negotiate who they are and who others are. They position themselves and
others as gendered, and they get feedback on these positions. In Denmark, in the late
1980s, girls did not have the same legitimate access to high status in the mathematics
classroom as the boys. Hansen (2000) observed for example a girl in technical
secondary school who did not get a high status although she was the best in
mathematics. The students went against their direct classroom experiences and did not
define the clever girl as being in this position. Also the teachers found it difficult to
recognize the girls’ mathematical competences even when they were obvious. Good
performance of a girl was often followed by a doubtful shake of the head: ”She was
certainly very hard-working”. Other studies have also shown how mathematics teachers
labelled high-performing girls like this whereas they could understand poor-achieving
boys as ”bright” even though they presented little evidence of high attainment (e.g.

These four aspects on gender (structural, symbolic, personal, interactional) do not
refer to different acts or situations. They are different analytical aspects to be applied to
the same activity or situation for doing gender. Fitting well with this analytical
perspective, I have adopted a theory of practices ”in which, instead of a unitary, fixed
model of the human possessing skills in contexts, linked to models of learning and
transfer, we might understand subjectivity itself as located in practices” (Walkerdine,
1990, p. 51).

Gender in mathematics education research

My starting point is an overarching view of mathematics education research as ”the
collective effort to study and to shape the relationship between humans, on the one
hand, and mathematics, on the other” (Fischer, 1993, p. 113, italics in original); and this relationship has a societal dimension as well as a cognitive and an affective dimension. Thus, complexity is a characteristic of the problem field in mathematics education, especially if one bears in mind the four gender aspects presented above. None of the problems in or related to teaching and learning mathematics can properly be isolated from the others. At any given moment, the researcher has to concentrate on one of the problems without ignoring the others. Diversity in mathematics education (gender, ethnicity, social class etc.) leads to one kind of complexity which calls for certain research methodologies. In any study, it is the purpose, theory and research questions that determine the focus and methodology. When the research problem is formulated and the method and the sampling strategy are to be decided, the researcher has to choose among a series of factors and dimensions to reduce complexity. Gender is one of the key perspectives to decide upon.

**Gender in the foreground or in the background**

In any scientific study on mathematics education, as mentioned above, it is necessary to reduce the complexity of the problem field. Two principles might be used for omitting to handle the gender perspective: (1) Would it be *appropriate*, from a scientific point of view, as regards the trustworthiness (validity and reliability) of the study? Is it right to investigate this particular problem without involving a gender perspective? Is gender a relevant or even necessary variable/dimension in the study? (2) Would it be *legitimate*, from a political point of view, to disregard the gender issue? Here one has to remember the principle of gender mainstreaming (see below) and that the recognition of what we have so far considered to be the standard – or the usual approach – is not necessarily gender neutral. In both cases one should examine whether the gender dimension might influence the situation to be investigated. Thus, the two principles lead to the same choice concerning the gender perspective in a study on mathematics education: whether to involve gender as a dimension or a variable or not.

Some studies are designed to investigate gender and mathematics – meaning that gender is focussed in the research question; i.e. gender is a dimension in the *foreground*. The research interest in the Swedish GEMA study (see below) was to investigate a possible gender indication of mathematics and the connection between this phenomenon
and women not choosing the subject in higher education (Brandell et al., 2005). In other studies, gender is just an independent variable among others; i.e. gender is a variable in the background. If the researchers at a given moment want to focus on gender, it is possible because the data are available. The Programme for International Student Assessment (PISA) claims to measure to what extent 15 years old students have acquired knowledge and skills necessary for full participation in society. Gender is one of the variables in the survey. This makes it possible to compare boys’ and girls’ test results just as their measured interest and motivation in learning mathematics (see Skolverket, 2004).

In a recent overview of international research literature on gender in mathematics education, it is concluded that there is a tendency to use ”gender” as a synonym for ”sex” and to inquire whether there are sex differences in performance (Damarin & Erchick, 2010). The authors are surprised at the absence of attention to the complexity of gender.

**Methodology**

When purpose, theory and research questions with gender in the foreground have been decided, it has consequences for methodology. For example Evans and Tsatsaroni (2008) have argued that research into gender within a social justice agenda requires both quantitative and qualitative methods; e.g. a combination of a survey with semi-structured interviews.

Quantitative methods have been used internationally to investigate structural and symbolic aspects on gender in mathematics education, mainly in terms of gender differences. An example will show the decisive influence of items and scales used in a survey: From the mid 1970s, Fennema and Sherman’s Mathematics Attitudes Scales (MAS) were used to measure gender differences in, for example, self-confidence, mathematics anxiety and ideas of mathematics. One of the scales was named ”Mathematics as a Male Domain” and the students were to rank statements like ”Girls can do just as well as boys in mathematics”; ”I would trust a woman just as much as I would trust a man to figure out important calculations”; and ”Males are not naturally better than females in mathematics” (Fennema & Sherman, 1977). In the late 1990s Forgasz, Leder and Gardner (1999) re-examined the scales and showed that several
items of the "Mathematics as a Male Domain" scale were no longer valid. When the scale had been developed there was no reason to believe that mathematics could be considered as a female domain, and a negative response to the items was interpreted as an attitude to mathematics as a neutral domain. The scale was revised into a "Who and Mathematics" scale, which allows mathematics to be viewed as female, male or gender neutral, and it was tested in a Swedish study, where the revision showed up to be relevant (see Leder & Brandell, 2004; Brandell et al., 2005; Brandell, Leder & Nyström, 2007).

Thus, questions and scale constructions are vital for the results in quantitative studies. So is the number of variables and the way they are combined and controlled. In a survey on adult students’ school mathematics performance (10 items) in a social science degree programme at London Polytechnic, Jeff Evans (1995) scrutinised myths about gender differences. First, men’s and women’s average score were compared, producing a fairly substantial difference of 3/4 of a question in favour of the males (statistically significant; p<.001). Next, Evans controlled for qualification in mathematics (i.e. course-taking), age (more of the women were mature students) and so on, and he found that the difference for younger students (aged 18–20) was no longer statistically significant and for mature students the difference was borderline. This is an illustration of the importance of involving more factors than gender in the analysis of possible gender differences, e.g. age, education, and occupation, because they can be confounding factors. In the same vein, Henningsen (2008) has showed that gender can also be a confounding factor in quantitative studies; meaning that the effect of some factor of interest may change if the analysis is carried out separately for men and women. As an example, she has taken the international OECD surveys on adult literacy and numeracy where one of the findings is the connection between literacy level and earnings. Here, Henningsen points to the fact that income is gender dependent even after controlling for literacy skills.4

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4 Henningsen has illustrated the principle of gender as a confounding factor. If you forget to split up the population in males and females and just take the average then you risk doing serious mistakes. For example concluding that mascara protects against testis cancer, since very few mascara users get testis cancer. (see “Marts 2000” in Henningsen & Wedege, 2000).
A few research findings

Findings involve people’s gendered cognitive, social and affective relationship with mathematics, i.e. performance, participation and attitudes. The first book for more than 10 years with international perspectives on gender and mathematics education presents a contemporary snapshot of the continuing scholarly research in this field (Forgasz et al., 2010). According to Leder (2010) there are two broad and consistent findings on gender differences in achievement and participation from the 1970s and forwards:

First, that there was much overlap in the performance of females and males; consistent between-gender differences were invariably dwarfed by much larger within-group differences. Second, students who opted out of compulsory mathematics courses typically restricted their longer term educational and career opportunities. (p. 447)

Achievement. In her research overview presented at the 11th International Congress of Mathematics Education, Leder (2008) develops this statement further claiming that when gender differences in performance are found – typically in favour of males – they are small and influenced by many factors, including the students’ grade level and the format, scope, content, and setting of the test. And she adds that gender differences in favour of boys are also more likely to be found for students in advanced post compulsory mathematics courses, and when above average performance is considered.

Participation. Many courses and employment fields include specified levels of mathematics achievement among their entrance requirements, whether these levels are actually relevant for such studies and work or not. But mathematics has also a function as a gate-keeper in a non-formal meaning of the word. From life-history interviews, we know that to many adults ”Mathematics that’s what I can’t do”. Even though they manage mathematical challenges in their everyday life, the door named mathematics leading to further education is closed for them (Wedege, 2003). Mathematics plays a role of critical filter not only for females but also for males. Henningsen (2008) points to research showing that mathematics education creates ”communities of failure” with an over-representation of boys – not because more boys fail at mathematics but because failing at mathematics matters more to boys. She also refers to findings from a study of medical students in Norway in 1995: Male students believed that inferior results in mathematics in higher secondary school would influence negatively on their
performance as doctors. None of the women had similar anxieties. The men saw achievement in mathematics as a measure of their general ability, whereas the women had no such belief. Henningsen concludes her reflections like this: "These observations all point to the possible understanding that mathematics represents the danger of failure for men and an opportunity for success for women" (pp. 35–36).

However, after this talk about fiasco, I would like to stress that the reason for a teacher student not to study mathematics does not necessarily have to be: "I had serious problems with mathematics in school". An alternative rationale can be "I have never seen mathematics as intellectually stimulating” if this is given as an option in the questionnaire (see Andersson, 2008). A segregated labour market can be another reason for females and males to choose theoretical mathematics or not at higher secondary school. In New Zealand, Fiona Walls (2010) has followed ten children from the beginning of schooling as seven years old into their upper secondary and occupational decision-making as eighteen years old, in a longitudinal ethnographic study. She studies how "sexuate" occupational identities are produced through the learning of mathematics and interactions with friendship groups and family.

**Attitudes.** Analysis of people’s achievement and participation in mathematics education throw light on the structural and symbolic gender aspects, whereas studies of their beliefs, attitudes and emotions towards mathematics concern symbolic gender and personal gender. The Swedish GEMA (Gender and Mathematics) project has focused on students’ attitudes towards mathematics. The main research question is "Do Swedish pupils in compulsory and upper secondary school perceive mathematics to be a male, female or gender-neutral domain; and are there any gender differences in response?"

The instrument "Who and mathematics” mentioned above is used for gathering data. In the survey, students are asked to read thirty statements in a questionnaire like for example "Mathematics is their favourite subject”; "Give up if they find a mathematics problem too difficult”; and "Think mathematics will be important in their adult life”, and then they indicate if they find that the statement is more likely to be true for girls, more likely for boys, or equally relevant for boys and girls (Brandell, Leder & Nyström, 2007). The result, in the study of students in year two of upper secondary school, shows that a majority of students answer "no difference” to most of the items. However, there are a significant number of students considering mathematics to be either "female” or
"male" in some regards. The main finding is that many positive ideas of mathematics (e.g. challenging, interesting, and important) are connected with men, and several negative ideas (e.g. boring and difficult) with women (Brandell et al., 2005).

In this section, most of the findings presented concern structural and symbolic aspects of gender and mathematics. But how about personal and interactional gender aspects within the Swedish mathematics classrooms? How are female and male mathematics teachers and students doing gender within the frame of the Swedish school and society? In a new doctoral dissertation, examples are shown of how students in early childhood teacher education constitute mathematical subjectivity through complex networks of social relations, gender, learning discourses, time, space and place, and interdisciplinary practices (Palmer, 2010). More research is needed and I hope that this chapter can inspire some readers, among the Swedish mathematics teacher students, to put gender in the foreground in empirical studies for their theses.

Gender mainstreaming

In the ground-breaking article "Doing gender", Candace West and Don H. Zimmerman (1987) presented an understanding of the interactional work involved in being a gendered person in society. According to their definition, doing gender means "creating differences between girls and boys and women and men, differences that are not natural, essential or biological" (p. 136). When these differences have been constructed, they are used to reinforce the so-called nature of gender. According to West and Zimmerman, a person’s gender is not simply a side of what one is, but more fundamentally it is something that one does continually in interaction with other men and women. In this chapter, I have chosen the approach of "doing gender" in mathematics education by looking at structural, symbolic, personal and interactional aspects on gender related to mathematics (Bjerrrum Nielsen, 2003). The focus of this framework is how teachers, boys and girls, men and women, negotiate gender in the world and in their heads. The idea of "doing gender" has been used also to include "being gendered" and "interpreting gender". With this choice of approach, I wanted to indicate that all major problems in mathematics education are strongly interdependent. Comprehensive thinking in research
and in education is one way to avoid inappropriate reductions of complexity in the
problem field and to ensure that no difficulty or dilemma is considered in isolation.

It is obvious that gender is an important aspect of the teaching and learning of
mathematics and that gender equity is an issue in mathematics education that it is
difficult to get round. Nevertheless, it seems as if the interest in gender issues has been
low at the political and expert level in Sweden in recent years (see Brandell, 2008). In
the late 1990s, the European Commission adopted the principle of gender
mainstreaming, i.e. the integration of the gender perspective into every step of policy
processes – design, implementation, monitoring and evaluation – with the aim of
promoting equality between men and women. But apparently this has not had any
discernible consequences for mathematics education (Henningsen, 2008). It was
striking, for example, that the comprehensive report commissioned by the former
Swedish Government with the aim of improving participation and achievement in
mathematics education, in general, did not include any suggestions concerning gender
equity (SOU 2004:97). A relevant observation from a gender perspective could have
been that compulsory mathematics courses are shared at the Natural Science and Social
Science programmes at upper secondary level. The consequence has been that the
mathematical content is mainly relevant to the natural sciences and that the examples of
applied mathematics and of mathematical modelling are seldom found in social science.
The result is that it can be hard for the female students, who are in the majority at the
Social Science programme, to see the relevance of mathematics. Hopefully, this will
change with the higher secondary level reform 2011 (Gymnasiereformen). As I am
writing this, it seems that the future will bring three different courses in mathematics:
one for the Vocational programmes; one for the Economy, Aesthetics, Humanities &
Social Science programmes; and one for the Natural Sciences and Technique
programmes.

The year after the conclusion of Matematikdelegationen, the committee Gender
Mainstreaming Support (JämStöd) was set up ”to provide information about gender
mainstreaming and to develop practical methods and models for mainstreaming gender
into central government activities” such as education (SOU 2007:15, p. 3). The overall
objective is that women and men must have the same power to shape society and their
own lives. The two first short-term objectives relevant to the gender issue in mathematics go like this:

1. Equal division of power and influence between women and men. Women and men shall have the same rights and opportunities to be active citizens and to shape the conditions for decision-making.

2. Economic equality between women and men. Women and men shall have the same opportunities and conditions with regard to education and paid work that provide lifelong economic independence. (p. 15, from Proposition 2005/06:155. Makt att forma samhället och sitt eget liv – nya mål i jämställdhetspolitiken)

At first, one would think that these criteria are fulfilled in Sweden but taking into consideration the findings from mathematics education research it is obvious that the process is slow and that there is much work to be done (see Brandell, 2008).

However, the world of mathematics education does change and so do the structural, symbolic, personal and interactional aspects on gender. A report, published in the context of the new Swedish initiative DEJA (Delegation for gender equality in schools) discusses how we should go about understanding the phenomenon of boys, as a group, tending to perform at a lower level than girls in school (SOU 2010:53). When girls and women are progressing quickly through the educational system, and reforms in mathematics education are more closely allied to feminine values, boys and men will have to find new ways of doing gender in mathematics. We have many constructions of gender, dependent on class, ethnicity and culture. When girls and boys enter school they are classified and categorised, according to Walkerdine (1990). The interpretation of their performance and behaviour in mathematics are highly gender-specific. Ample evidence has been presented “to support the view that even when girls displayed the characteristics valorised in boys this did not mean they were judged as being successful” (p. 55). The principle of mainstreaming is an argument for setting to work with an explicit gender aspect (structural, symbolic, personal and interactional) in the practice of and research on mathematics education and doing this with due respect for diversity.
References


