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ORIGINAL ARTICLE

# Gender and Mathematics: recent development from a Swedish perspective

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**Abstract** A fairly large study of attitudes towards mathematics among Swedish students at secondary level was conducted during 2001–2004. A newly developed instrument was used that was designed to capture gender stereotyped attitudes among students related to various aspects of mathematics in education and future life. The new scale and its development are described with reference to the original Australian studies. The scale builds on the Fennema–Sherman attitude scale ''Mathematics as a male domain'' but allows mathematics to be viewed as female, male or gender neutral, reflecting a different societal and educational situation than in the seventies when attitudes towards mathematics as a male domain were first investigated. The Swedish study shows that mathematics is perceived as gendered, mostly as a male domain, by large minorities of students at secondary level. However, the results are complex, with clear differences in responses from female and male students. Furthermore, mathematics is also viewed as female in some aspects. A comparison with Australian data shows that Swedish students are less inclined to view mathematics as a female domain than Australian students of the same age. The relevance of the study is related to the lack of equity in mathematics in education and as a professional field in the Swedish society, documented by earlier research.

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## 1 Introduction and background

Since the mid 1970s, much societal and research attention has persistently been focused on the ways in which gender-role stereotyping has shaped and constrained the realisation of educational and career potential. Studies of early childhood socialisation indicate that children are encouraged to assume gender-stereotyped roles and behaviours from birth onwards (Lipman-Blumen, 1984). In the 1970s, the focus was on the 'liberation' of females from their expected roles of supportive domesticated wives or lowly paid workers in a limited range of employment fields. Legislation was enacted and educational programs aimed at redressing past inequalities were financed. In many countries, various areas of female disadvantage were identified (Jacobs, 2001; Leder, 2001). This included academic areas in which females were under-represented. The overtly male-dominated spheres of mathematics and science were targeted in particular. In recent times there has been growing recognition that males, too, are constrained by societal expectations of behaviour and expectations (e.g. Connell, 1995).

### 1.1 Mathematics

In Sweden mathematics is one of the most gender unbalanced areas in undergraduate and graduate education, among academics and as a professional field. The segregation starts already at upper secondary level where fewer females than males study the more advanced mathematics courses.

Within higher education in mathematics the so-called leaky pipeline seems, regrettably, to be working efficiently. In 2005 females constituted 30% of all undergraduate students in mathematics, 26% of the graduate students, 20% of the senior lecturers and 6% of the full professors in mathematics, all subfields included, according to official Swedish statistics published on-line by the Swedish National Agency of Higher Education (2006). Corresponding figures for earlier years indicate that development over time has been slow. Certain areas of mathematics are even more segregated. Females, for example, seem far more attracted to applied mathematics such as mathematical statistics than to pure mathematics. According to Barbro Grevholm (1996) there was a small rise in the participation of female graduate students in mathematics during the period 1985–1992, but the rise was concentrated to applied mathematics, while pure mathematics did not show any development.

One may ask why the issues of equity in mathematics education attract relatively little attention from policy makers in Sweden. A clear understanding of development of equity within mathematics education requires a positioning within a larger context of equity in society and education. Sweden still exhibits a strong pattern of sex segregation within its workforce, both among unskilled and professional workers, and in the educational system, in spite of a strong policy aiming at equity in all parts of society (Gonäs, 2005). Young females tend to be better educated than men, but get less well-paid jobs. Young professional females can look forward to facing more obstacles in their future careers than their male colleagues and can expect to earn less money (Eurén & Nordin, 2006).

Mathematics is one particularly clear example of a field with strong sex imbalance in Sweden. This situation has motivated teachers, researchers and politicians—some with a clear feminist agenda—to investigate the situation and make efforts to counteract possible factors within the educational system causing females not to choose or withdraw from a career in mathematics.

### 1.2 The women and mathematics movement

In 1990 the first Swedish conference *Women and Mathematics* was held in Malmö, addressing issues of inequity in mathematics education and documented in proceedings (Grevholm, 1992). The conference has been held every third year since then and has attracted mostly females but also males from all levels of mathematics education. (Brandell, Dunkels, Liinanki, & Wallin, 1994; Grevholm & Lindberg, 2004; Grevholm, Sigstam, & Vretblad, 2001; Lindberg & Grevholm, 1998). Students, teachers, mathematics educators and mathematicians attend the conferences and remain in the network created around the conferences. Internationally well-known and distinguished researchers in mathematics education with a gender perspective in their work have given lectures at the conference. The network has been active at many levels, influencing various professional and official organisations and authorities. The structure and activities of the network have been described by Grevholm (1997).

Frequent themes for all the conferences have been the possibilities for teachers to address inequalities in their practices in mathematics classrooms and for mathematicians, mathematics educators and policy makers to make interventions at various levels in the educational system. Examples of strategies for more gender-inclusive teaching and learning have been abundant.

It seems clear that the network and the conferences inspired much of the efforts to address issues of gender equity in conferences for mathematics teachers and within in-service teacher training. But the problems of gender inequity in mathematics still do not get enough attention in Sweden. One reason may be that mathematics is strongly linked to science and technology in the Swedish tradition. There have been several initiatives on a national level with the aim to raise women's participation in science and technology. One example was a ten-year-long Science and Technology project (NOT) aimed at students in the compulsory years of schooling that started in 1993. Svein Sjøberg, in an independent evaluation of the first half of the NOT-project, suggested that mathematics should be integrated into a continuous program, but that did not happen (Sjøberg, 1999). So far there has not been any corresponding intervention on a national level focussing on mathematics at secondary level. The network *Women and Mathematics*, as well as others, has advocated that resources should be set aside for similar specific enhancement programs for equity in mathematics education. However, it seems as if the interest in gender inequity in mathematics is low at the political and expert level. In a recent report commissioned by the Swedish government there are no specific suggestions concerning gender equity, although the commission was a very broad one with the aim of improving participation and achievement at all levels (Matematikdelegationen, 2004).

## 2 Defining the problem

Thus, as in many other countries, gender equity concerns have represented a significant item on the research agenda of Swedish (mathematics) educators. As has already been mentioned, both in Sweden and elsewhere, in early research much emphasis was placed on areas in which females appeared disadvantaged: enrolment in the most advanced mathematics subjects, courses which needed such subjects as pre-requisites, and gaining high scores. In more recent work the interacting roles of class and culture have also been highlighted. Male norms, and acceptance of difference without value judgments, have been more likely to be challenged. More radical feminist perspectives are now more likely to be incorporated into the design of research studies, females are less frequently considered as a homogeneous group, and scholarly evaluations of interventions are becoming more prevalent. At the same time there is a clearer recognition of the extent to which the personal beliefs and theoretical orientation of the researchers undertaking the work influence inclusion and exclusion of variables and modes of data gathering. No longer is it simplistically assumed that the planning, execution, reporting, and interpretation of research are value free.

### 2.1 Clarifying the problem

More recently considerable attention has been placed on the educational disadvantages faced by boys. Views of boys' disadvantage, even in the traditionally male preserves of mathematics and science, are receiving increasing media publicity and coverage (Kimmel, 2006). The impact of gender on performance and participation in mathematics continues to be of concern to the community.

In Sweden, too, this debate has surfaced. Traditionally boys have had better grades in mathematics and also performed better on standardized tests. However, in the early years of schooling the former advantage of boys in results in mathematics has levelled out during the 1990s and turned into slightly better results for girls. The gender difference is now insignificant on national tests and small but not negligible in grades given at the end of compulsory school (Skolverket, 2006). At upper secondary level girls have equally good or better results in the various courses.

The problem of boys' underachievement—not so much in mathematics but in many other subjects, especially in reading—has begun to attract attention in Sweden. Mats Björnsson (2005) in an overview of current Swedish and international research commissioned by the Swedish National Agency for School Improvement described girls as more willing to invest in education in a changing society and more apt to meet new expectations on communicative skills and responsibility in a reformed school. He warned against the idea that a focus on girls' interests and concerns about girls' invisibility in classroom somehow could be a reason for boys' declining results in school and pointed instead to the changing role of schools in a new society, recent pedagogical reforms and the impact of issues of identity, masculinity and attitudes towards education among boys. Nevertheless, the view of boys as ''losers'' because of efforts to support girls has emerged in the debate in Swedish media.

The new social and schooling contexts for both sexes are noteworthy and raise the question whether previously devised traditional measurement instruments to assess students' beliefs about aspects of education, e.g., those related to the learning of mathematics, are able to capture these changing societal expectations.

### 2.2 The starting point

The Fennema–Sherman (F–S) mathematics attitudes scales (MAS) (Fennema & Sherman, 1976) were published in 1976. The assumptions underpinning the development of one of its subscales, the *Mathematics as a male domain* subscale (MD), are particularly relevant for this paper. They were described by Elizabeth Fennema and Julia Sherman (1976) as follows:

> The less a person stereotyped mathematics, the higher the score. This is done to fulfil the purpose of the scale development as it was assumed that the less a female stereotyped mathematics as a male domain, the more apt she would be to study and learn mathematics (p. 7).

The corollary of this assumption is that low-scoring females believe mathematics to be a male domain and would thus be less likely to study and learn mathematics. Given the prevailing Western societal views of the 1970s, when the scale was developed, it is not surprising that no allowance was made for beliefs that mathematics might be considered a female domain. However, as noted before, low scores on the MD can no longer be interpreted as necessarily reflecting the stereotyping of mathematics as a male domain. Recent media reports and research studies have indicated that significant numbers of people, both males and females, who reject the notion that mathematics is a male domain, do so because they believe that females are higher achievers in mathematics than men. Substantive evidence is presented in Forgasz, Leder, and Gardner (1999). Clearly, the earlier scale is in need of revision.

## 3 Developing new scales

In response to these concerns, two new instruments—the *Mathematics as a gendered domain* instrument and the *Who and mathematics* instrument—were developed. These scales were designed to overcome the identified limitations in the original *Mathematics as a male domain* subscale, part of the F–S MAS (see *The starting point*) and required a re-conceptualisation from mathematics as a *male domain* to one of a *gendered domain* as reflected in both item content and response format in the new instruments. The *Mathematics as a gendered domain* instrument followed the response format used for the Fennema–Sherman scale. The response format created for the *Who and mathematics* instrument, described below, was designed to allow students to designate mathematics not only as a male domain but also as a female or neutral domain if they considered this more relevant. Details of both scales and their psychometric properties are given in Leder and Forgasz (2002).

An innovative response format was adopted for the *Who and mathematics* version of the instrument. Thirty statements were presented. For each statement, students had to select one of the following responses:

BD—boys definitely more likely than girls
BP—boys probably more likely than girls
ND—no difference between boys and girls
GP—girls probably more likely than boys
GD—girls definitely more likely than boys

The items devised related to: ability, career, general attitude, environment, peers, effort, and task. The full list of items is shown in Fig. 5.

Administration of the instruments to samples of high school students in various countries have yielded findings in broad agreement with those reported for Australian students to whom the revised scales were first administered, as well as indications of subtle cultural differences. Relevant publications include Leder and Forgasz (2000)—Australian students—Barkatsas, Forgasz and Leder (2001)—Greek students—Forgasz, Leder and Kaur (2001)—Singaporean students—and Forgasz, Leder and Kloosterman (2004)—American students.

Data from a recent Swedish study incorporating this new instrument are discussed in the remainder of this paper. A comparison between Swedish and Australian results is included. Other parts of the Swedish project are reported elsewhere (Brandell & Staberg, submitted).

## 4 The Swedish GeMa study

The Gender and Mathematics (GeMa) project has focussed on students' attitudes towards mathematics. The instrument *Who and mathematics* has been the principal means for data gathering. The GeMa-project was carried out during 2001–2004 and is reported in detail by Brandell, Nyström, Staberg and Sundqvist (Brandell et al., 2004; Brandell, Nyström, & Staberg, 2002)[1].

The main research questions are the following:

Do Swedish pupils in compulsory and upper secondary school perceive mathematics to be a male, female, or gender-neutral domain?

Are there any gender differences in response?

Whether there appears to be a connection between females' possible view of mathematics as a male domain and a tendency among female students not to choose mathematics in upper secondary level and in higher education to the same extent as male students was an additional question explored.

Both questionnaires and interviews were used in the GeMa study. Two studies were undertaken. The first, in 2002, involved students in year nine (age 15), i.e., at compulsory school level. The second study with students in year two of upper secondary school (age 17) was conducted in 2003. In each study the quantitative survey was followed up by a series of interviews after a preliminary analysis of the responses to the questionnaires. Thus the study is not longitudinal but cross-sectional and involved different groups of students.

The *Who and Mathematics* instrument, carefully translated into Swedish, formed the main part of the questionnaire in both studies. Students were also asked to supply some background information and to complete some items which explored their personal attitudes to mathematics.

In this paper we present results from the first study (year nine students) and limit ourselves to the analysis of the *Who and Mathematics* part of the questionnaire and the interviews. Results from the second study are described elsewhere (Brandell & Staberg, submitted).

In order to be able to generalise to the whole population schools were chosen to represent different socio-economic and regional conditions. Schools were chosen from municipalities in three different regions in Sweden in such a way that geographical spread was guaranteed, as well as distribution to large and smaller cities. To achieve this, a number of steps were taken. First, for each municipality a list was compiled of schools with at least 40 students in year nine in the 2000/2001 school year.

Next, lists of relevant statistics for all schools in the chosen municipalities, available from the central Government authority for official statistics (Statistics Sweden), were used in order to get representative samples. Every school was classified in one of three levels depending on

[1] The full project team consists of the authors of this article, Sara Larsson, Lund Univ, Anna Palbom, Royal Institute of Technology, Else-Marie Staberg, Stockholm and Christina Sundqvist, Luleå University of Technology.

the average combined educational level of the parents of the students. This resulted in nine groups (depending on region and parents educational level) from which a stratified sample of schools was randomly selected, in total 17 schools. We approached the head of each selected school and asked her/him to pick out two classes or teaching groups in year nine, whose teacher would be willing to participate in the study. Thirty-four classes were thus selected and participated. This method gave us some background information on group level for each of the schools as well as a sample of students, representative of the whole population.

One member from the GeMa-group visited and distributed the questionnaires at the selected schools. The students were informed that they participated in a national study concerning gender and that similar studies had been conducted in other countries. To avoid influencing the results the aim of the study was not revealed to them at this stage. Altogether 747 students in year nine filled out the questionnaire.

As already indicated, a sub sample of students was also interviewed after a preliminary analysis of the data from the questionnaire had been completed. Part of the interview was used to get more insight into how students interpreted the items and what meaning they attributed to their responses.

Specifically, 24 students (12 females and 12 males) from six compulsory and strategically chosen schools were interviewed. Teachers were asked to turn to students who had participated in the first part of the study and to ask them to act as interviewees. Students were interviewed in single-sex groups of two students from the same class at a time. Different members of the project group conducted the interviews in pairs in each of the three municipalities.

The interviews were conducted after a preliminary analysis of the results from the questionnaires. Interesting themes were identified and a few main questions defined, each complemented by a number of loosely formulated additional questions. Some of the themes were chosen to clarify students' interpretations of items of the questionnaire, but most of the themes concerned the answering pattern appearing in the analysis of the questionnaires. The interviews were semi-structured in such a way that all themes were covered in each interview, and time left for the students to elaborate and associate freely. Each interview lasted about 1 h. The interviews were transcribed word for word, and analysed by one of the senior members of the project team together with two other members. All of them had conducted some interviews themselves. The analysis consisted of two steps according to a method described by Robert Bogdan and Sari Biklen (1982), first identifying categories or themes, and then attaching utterances to a relevant category. The method is easily adapted for computer use. The process was iterated a couple of times.

In the next section of this article, some extracts from interviews are presented to illustrate the results. They are translated from Swedish into English. The translation attempts to retain the meaning of the original sentence. However, it is not always easy to capture in translation the exact nuances of the spoken word which may have idiomatic overtones of culture, social class, regional language, or teenage language. At times the translation inevitably reads slightly more like a written language.

## 5 Results of the GeMa study

The items in the *Who and mathematics*-instrument have a format where students are asked to read a short statement and then indicate if they think that the statement is more likely to be true for girls, more likely for boys, or equally relevant for boys and girls (see *Developing new scales*). As noted above, the response alternatives were given as

BD—boys definitely more likely than girls
BP—boys probably more likely than girls
ND—no difference between boys and girls
GP—girls probably more likely than boys
GD—girls definitely more likely than boys

In order to facilitate the presentation of results, the five alternative answers are assigned the numbers 1–5 with 1 representing ''boys definitely more than girls'' and 5 representing ''girls definitely more than boys''. A mean value of 3 indicates that the answers are more or less symmetrically distributed around the answer ''No difference''. Statistical inference is used in order to investigate if the mean values deviation from 3 is likely to represent an answering pattern in either direction for the whole population. Significance is signalled on two levels, ** means that the deviation from 3 is significant with $P < 0.01$, and * means that the deviation from 3 is significant with $P < 0.05$. Methods used are both parametric ($t$-test) and non-parametric (Mann–Whitney), with basically the same result.

### 5.1 General comments

For a majority of the items, more than half of the students answer that there is no difference between girls and boys concerning the statement given. The diagram in Fig. 1 illustrates the distribution of answers for such an item. This specific item is formulated as ''Enjoy mathematics'' and students were asked to indicate whether they found this most likely to be true for girls or for boys.

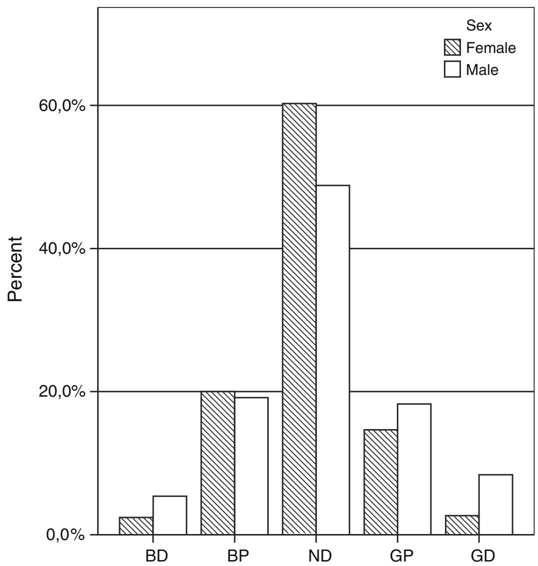


**Fig. 1** Bar chart over responses to the item ''Enjoy mathematics'' according to sex. *BD* Boys definitely more likely than girls, *BP* boys probably more likely than girls, *ND* no difference between boys and girls, *GP* girls probably more likely than boys, *GD* girls definitely more likely than boys

The diagram illustrates an item where the groups of female and male students have a distribution of answers that is symmetrical around the answer ''no difference''. Another example of these *gender neutral* responses to statements refers to the item ''Get more questions from the mathematics teacher''.

Even though the responses to some of the statements were gender neutral, many gave rise to gendered patterns of answers. For the latter group, students (male as well as female) more commonly answered in a way consistent with a view of mathematics as a male domain. However, mathematics was also viewed as a female domain in certain ways. It is also noteworthy that female students more frequently chose the answer ''no difference'' while male students tended to use the more extreme answers to a higher degree.

The interview part of the study confirmed that the perception of mathematics as a male domain exists in school year nine. When expressed, this view seems to be related to whether male or female students are the more high-achieving in mathematics.

Members of the project group who visited schools in connection to the distribution of the questionnaire noted that some students reacted negatively against the whole idea of gender differences.

For optimum clarity we have grouped the items in the following sections according to the degree of similarity in answers between male and female students, and also to the direction of gendered answering patterns—in the male or female direction.

## 5.2 Items with similar answers from male and female students

There are eight items in the questionnaire for which both female and male students have a tendency to attribute the statements *more to boys than to girls*. One example of the distribution of answers in this group of items is shown in Fig. 2. It represents students' responses to the statement ''Like using computers to work on mathematics problems''.

This is yet another illustration of the fact that the answer ''No difference'' is selected frequently. However, the diagram in Fig. 2 also shows that among the students who state that there is a difference, more students answer in the ''boys more often than girls'' direction.

The eight items are presented in Table 1, ordered by degree of gendering. For the first two items in the table, more than half of the students in the sample answer that the statements are more likely to be true for boys than they are for girls.

Both items pertaining to the usefulness of mathematics in adult life are attributed more to boys than to girls: ''Need mathematics in order to maximize future employment opportunities'' and ''Think mathematics will be important in their adult life''. These statements are related, but not intended to be the same.

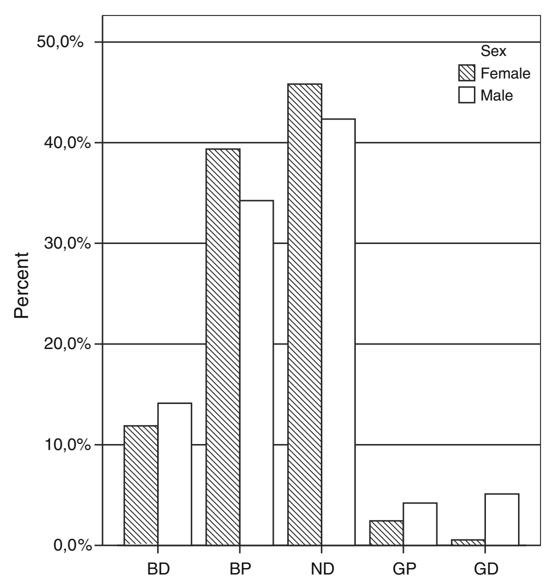


**Fig. 2** Bar chart over responses to the item ''Like using computers to work on mathematics probelms'' according to sex. *BD* Boys definitely more likely than girls, *BP* boys probably more likely than girls, *ND* no difference between boys and girls, *GP* girls probably more likely than boys, *GD* girls definitely more likely than boys

**Table 1** Statements that female and male students agree on are more often true for boys than for girls

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 16 Distract other students from their mathematics work | 2.20** | 2.43** | 2.31** |
| 24 Like using computers to work on mathematics problems | 2.40** | 2.52** | 2.45** |
| 21 Tease boys if they are good at mathematics | 2.62** | 2.68** | 2.65** |
| 11 Like challenging mathematics problems | 2.75** | 2.72** | 2.73** |
| 10 Need mathematics in order to maximize future employment opportunities | 2.90** | 2.67** | 2.80** |
| 30 Tease girls who are good in mathematics | 2.78** | 2.94 | 2.86** |
| 18 Find mathematics easy | 2.88** | 2.91 | 2.89** |
| 14 Think mathematics will be important in their adult life | 2.93 | 2.86** | 2.91** |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys' direction and mean values significantly larger than 3 indicate a group response in the girls' direction

The interviews made it possible to elaborate on the difference between mathematics for professional life and mathematics for adult life in general. A majority of the interviewed students indicated that they interpret these two statements differently, but there are also students who do not view them as two different aspects of mathematics in adult life. There are no identifiable differences between the interpretation of items of male and female students. Concerning everyday life, the interviewed students agree that everyone needs mathematics, women just as much as men. For professional life however, the most common opinion is that mathematics is more important for men than it is for women. A female student expresses her view that those who work professionally with mathematics mostly are men:

> I believe that there are as many girls as boys who find mathematics interesting and think it is as easy or as hard. My image is that those who have difficult mathematical jobs and do research, that they are men. (Female)

According to a substantial number of students ''Get on with their work in class'' is a statement that is *more likely to be true for girls than for boys*. The three items with a similar response pattern are presented in Table 2 together with their mean values. Both female and male students think that these statements are more likely apply to girls, even though the degree of gendering differs.

The results in Tables 1, 2 indicate a fairly widespread view that girls work harder in mathematics and that boys disturb others more often than girls. These perceptions were further elaborated and confirmed in the interviews with students. Furthermore, the interviews also support the conclusion that female students, more than male, tend to worry about not doing well in mathematics. However, the interviews also show that the views differ within the groups of female and male students.

One of the interviewed males commented on the view that girls worry more while another talks about perseverance as typical for boys but not for girls.

**Table 2** Statements that female and male students agree on are more often true for girls than for boys

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 28 Get on with their work in class | 3.48** | 3.27** | 3.39** |
| 22 Worry if they do not do well in mathematics | 3.58** | 3.12* | 3.36** |
| 12 Are encouraged to do well by the mathematics teacher | 3.09** | 3.30** | 3.19** |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys' direction and mean values significantly larger than 3 indicate a group response in the girls' direction

> Girls worry more. I think boys get on more easily; 'things will come out all right'. Maybe girls worry more; 'I have to manage this'. (Male)
> I think that boys are more persistent than girls. Girls are like 'No, now I don't want any more, now I won't bother with this'. But it (to give up) is (supposed to be) cool, that's how I have got it. (Male)

Female students have differing views on boys' commitment to hard work:

> Yes, they (boys) find it boring, never do anything during mathematics classes; they run around and can't cope with it. (Female)
> Girls easily give up, 'No I can't.' Boys don't do that, they try hard. That's the difference between boys and girls. (Female)

Concerning differences between girls a female student states that

> There is a difference between girls and girls, some want to be good in school and some do not give a sh-t. (Female)

The interviews, as well as the questionnaire responses, reveal that there is a large range of views within the groups of female and male students. Sometimes different views can be attributed to differences between the mathematics classes that these students are experiencing. If, for example, students experience a class where many girls are high-achievers in mathematics, while most boys achieve fairly low, this can affect the gendering of mathematics. However, the within-group differences in interviews have not been explored enough to be able to interpret them in such a context.

### 5.3 Patterns of answers characteristic for female students

Female students tend to find ‘‘Think it is important to understand the work in mathematics’’ more typical for girls than for boys. Male students’ response to this item is gender neutral on a group level. There are in all nine statements presented in Table 3, for which female students response is that they are more likely to be true for girls, while male students disagree. The list in Table 3 is ordered so that the degree of gendering in the direction of ‘‘girls more than boys’’ is stronger at the top of the list.

Male students display a different answering pattern. The four statements ‘‘Think it is important to understand the work in mathematics’’, ‘‘Care about doing well in mathematics’’, ‘‘Think they did not work hard enough if they did not do well in mathematics’’ and ‘‘Parents think it is important for them to study mathematics’’ do not deviate significantly from a gender neutral position for male students while they find the five remaining statements more often likely to be true for boys (see Table 3).

Many females consider that boys find mathematics more interesting and more of a favourite subject than girls do. Male students answer in a gender-neutral way. See Table 4 for average responses to these items.

One distinct result from the questionnaire is that almost half of the female students express that it is more important for girls to understand what they are doing, than it is for boys. Again, the interviews basically confirm this conclusion. Two students—one female, one male—argue that girls are thinking while boys are doing:

> Boys do not think as much about what has happened while the girls think: ‘What has happened and why did it turn out this way?’ Girls think: ‘Why am I doing like this?’ Boys just do it. (Female)
> The girls in our class are more like ‘Why is it like this?’, the boys are more, they only calculate and think that this is the way it should be but the girls need explanation ‘Why is it like this?’. (Male)

Some students contrast a competitive and less patient attitude among boys with a wish to understand.

> Boys do not think so much about understanding math but it becomes like a competition. Girls are more into understanding the different concepts in mathematics. (Male)

**Table 4** Statements that the female students—but not male—find more often true for boys than for girls

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 29 Find mathematics interesting | 2.90** | 2.97 | 2.93* |
| 1 Mathematics is their favourite subject | 2.91* | 3.05 | 3.03 |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys’ direction and mean values significantly larger than 3 indicate a group response in the girls’ direction

**Table 3** Statements that the female students—but not male—find more often true for girls than for boys

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 2 Think it is important to understand the work in mathematics | 3.41** | 2.93 | 3.18** |
| 7 Care about doing well in mathematics | 3.24** | 2.94 | 3.10** |
| 8 Think they did not work hard enough if they did not do well in mathematics | 3.23** | 3.02 | 3.13** |
| 27 Find mathematics difficult | 3.22** | 2.89* | 3.07* |
| 9 Parents would be disappointed if they did not do well in mathematics | 3.13** | 2.88** | 3.02 |
| 26 Consider mathematics to be boring | 3.13** | 2.72** | 2.94 |
| 5 Have to work hard in mathematics to do well | 3.09* | 2.84** | 2.98 |
| 20 Need more help in mathematics | 3.08* | 2.84** | 2.97 |
| 19 Parents think it is important for them to study mathematics | 3.07** | 2.93 | 2.99 |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys’ direction and mean values significantly larger than 3 indicate a group response in the girls’ direction

> This has something to do with the fact that they have difficulties to concentrate right now in lower secondary school, they want to move on and not stay with one task all the time. (Female)

A male student, well aware of the political incorrectness of his statement, talks about girls being more emotional than boys:

> They (the girls) are more into social science and history and like people. So when it is a (mathematical) task of course you have to understand that as well. They would manage much better if a mathematical task was built on feelings and decisions and had a love story in it. Perhaps you are not supposed to talk like this. (Male)

One example of how the answers from female and male students can differ is presented in Fig. 3. The bar chart shows the distribution of answers to the statement ''Worry if they do not do well in mathematics''. Female students show a distinct shift to the right, i.e. many female students state that they find it more often true for girls than for boys to worry if they do not do well in mathematics. The answers from male students are more symmetrically distributed over the five alternatives, with more than half of the male students stating that there is no difference between boys and girls in this respect.

### 5.4 Patterns of answers characteristic for male students

Male students find that it is more likely to be true for boys to consider mathematics to be boring. Female students answer in the opposite way (see Fig. 4).

Again, the most common answer is ''No difference'' but the answers from male students have a different distribution than the answers for female students.

There are five statements for which male students have the same response pattern (in the boys' direction), while females show a different pattern. These are presented in Table 5. Again the statements are ordered based on the degree of gendering.

The statement ''Give up when they find a mathematics problem too difficult'' is gender neutral for female students, while they find the other four statements more likely to be true for girls.

There are two statements that male students consider to be more likely to be true for girls, while female students consider it to be gender neutral (see Table 6). Both concern teachers.

According to the questionnaire results students tend to believe that mathematics teachers encourage girls more than boys (Table 2). In addition, male students tend to think that the mathematics teacher gives more time to female students and that teachers believe that girls (more than boys) will do well in mathematics while female students answer in a gender-neutral way to these statements. Interestingly, these three statements that male students

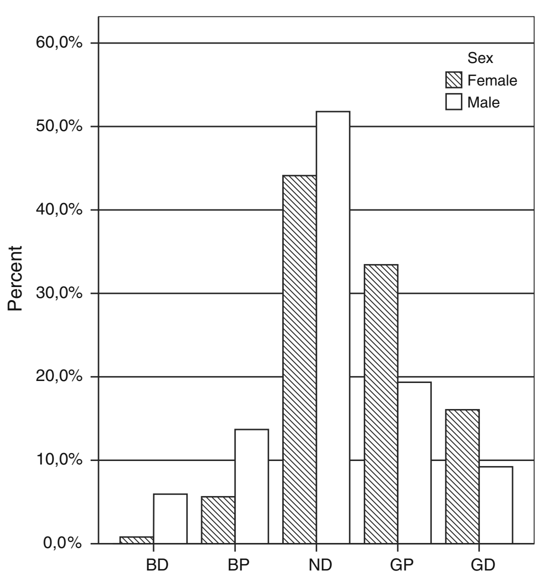


**Fig. 3** Bar chart over responses to the item ''Worry if they do not do well in mathematics'' according to sex. *BD* Boys definitely more likely than girls, *BP* boys probably more likely than girls, *ND* no difference between boys and girls, *GP* girls probably more likely than boys, *GD* girls definitely more likely than boys

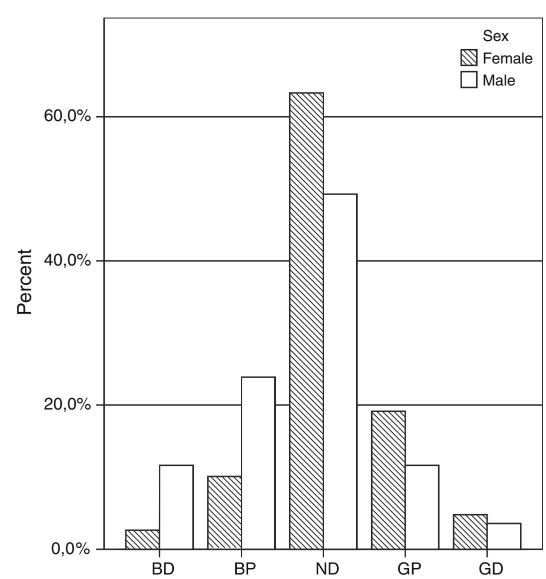


**Fig. 4** Bar chart over responses to the item ''Consider mathematics to be boring'' according to sex. *BD* boys definitely more likely than girls, *BP* boys probably more likely than girls, *ND* no difference between boys and girls, *GP* girls probably more likely than boys, *GD* girls definitely more likely than boys

**Table 5** Statements that the male students—but not female—find more often true for boys than for girls

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 26 Consider mathematics to be boring | 3.13** | 2.72** | 2.94 |
| 4 Give up when they find a mathematics problem too difficult | 2.98 | 2.81** | 2.91* |
| 20 Need more help in mathematics | 3.08* | 2.84** | 2.97 |
| 5 Have to work hard in mathematics to do well | 3.09* | 2.84** | 2.98 |
| 9 Parents would be disappointed if they did not do well in mathematics | 3.13** | 2.88** | 3.02 |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys' direction and mean values significantly larger than 3 indicate a group response in the girls' direction

**Table 6** Statements that the male students—but not female—find more often true for girls than for boys

| Statement (item) | Mean values for subgroups | | Overall mean |
|---|---|---|---|
| | Females | Males | |
| 25 Mathematics teachers spend more time with them | 3.03 | 3.38** | 3.21** |
| 13 Mathematics teachers think they will do well | 3.03 | 3.17** | 3.10** |

A mean value of 3 indicates a gender neutral position for the group. Mean values significantly smaller than 3 indicate a group response in the boys' direction and mean values significantly larger than 3 indicate a group response in the girls' direction

view as more typical for girls all are about the teachers' attitudes and actions.

A couple of the interviewed male students do not think that teachers treat boys and girls differently. The other males say that they could see a difference and they give different reasons for the teachers' actions. According to them the teachers' focus on girls could be understandable on the basis that girls do not perform as well as boys in mathematics or because girls are better behaved than boys. Some of the interviewed females take the position that girls get more help from the teacher. One of them explains that girls get more questions because they quite simply are better in mathematics, while others think that girls are generally better liked because they work well and hard. One female student says:

> But those who try to work; they are the ones encouraged by the teacher. They [teachers] do not encourage students who do not care a bit about mathematics. (Female)

## 5.5 Socio-economic and regional variations

Schools were classified in one of three categories according to the average socio-economic level of the school district and according to three geographical regions (see *The Swedish GeMa study*).

There are differences for a few of the items between the responses of students from the three socio-economic categories. The grouping is done on the level of school district, i.e., not on individual level. These differences are difficult to interpret within the general context of the whole questionnaire. There are substantial gender differences and these may interfere with possible variations according to socio-economic status.

From other research we know that socio-economic factors heavily influence choice of education and achievement in school. The GeMa study was designed to take socio-economic and regional factors into consideration on a group level. The inclusion of these factors allows us to generalize to the whole population. However, the study was not designed to take socio-economic factors into account on an individual level.

For quite a number of items responses from students in the southernmost region differ from those in the other two regions. However, as in the case of socio-economic variation, we could not draw any justified interpretations from these data.

## 5.6 Mathematics as a male domain

Based on the experiences from visits to mathematics classes during the questionnaire part of the study, the interviews also dealt with the general issue of perceiving mathematics as a male domain. When female students are asked to comment on mathematics as a male domain they mention that this could be a legacy of earlier times when there was less equity between the sexes.

> I believe that a reason is that it has not been equal always, and that girls have been inferior but now it starts to happen that girls, I believe, are coming back. It becomes more equal but still girls think that boys are the ones who study math. (Female)

Other female students commented on boys' desire to be good in mathematics and on girls' negative feelings:

> I think many more boys wish to be good at math and therefore I believe that it may easily happen that a boy feels envious if a girl is better at math. (Female)
>
> I believe that girls can be a little afraid of ... that the boys are better. They think that 'math is not for

me'. It was not anything for women previously. (Female)

In the interviews female students express an awareness of the existence of prejudice and that even they themselves may carry these gender stereotyped views on mathematics. Students also mention parents as carriers and reproducers of gender stereotypes.

I am not sure but I recognise that. My mother always tells my little brother: 'you are so good at math', but says that I am bad ever since I started first grade. ... My mother has always said that; 'you have to practice math more'. But it has turned out that I am fairly good at math. So now she has taken it back because she was herself bad in math. Dad is good in math and then she thinks that my little brother is good in math and I am bad, but she has had to take that back now. (Female)

One male student, who considers girls to view mathematics as a boys' subject, recognizes that gender patterns may be changing:

It is good that more girls go on (with mathematics), it should not be just one sex in the business of mathematics, and it ought to be mixed. If it continues like this (as it is now), (...) girls will get less self-confidence. (Male)

## 5.7 Swedish results compared to Australian

Data from the original Australian study using *Who and Mathematics* (Forgasz, 2001) can be compared with the

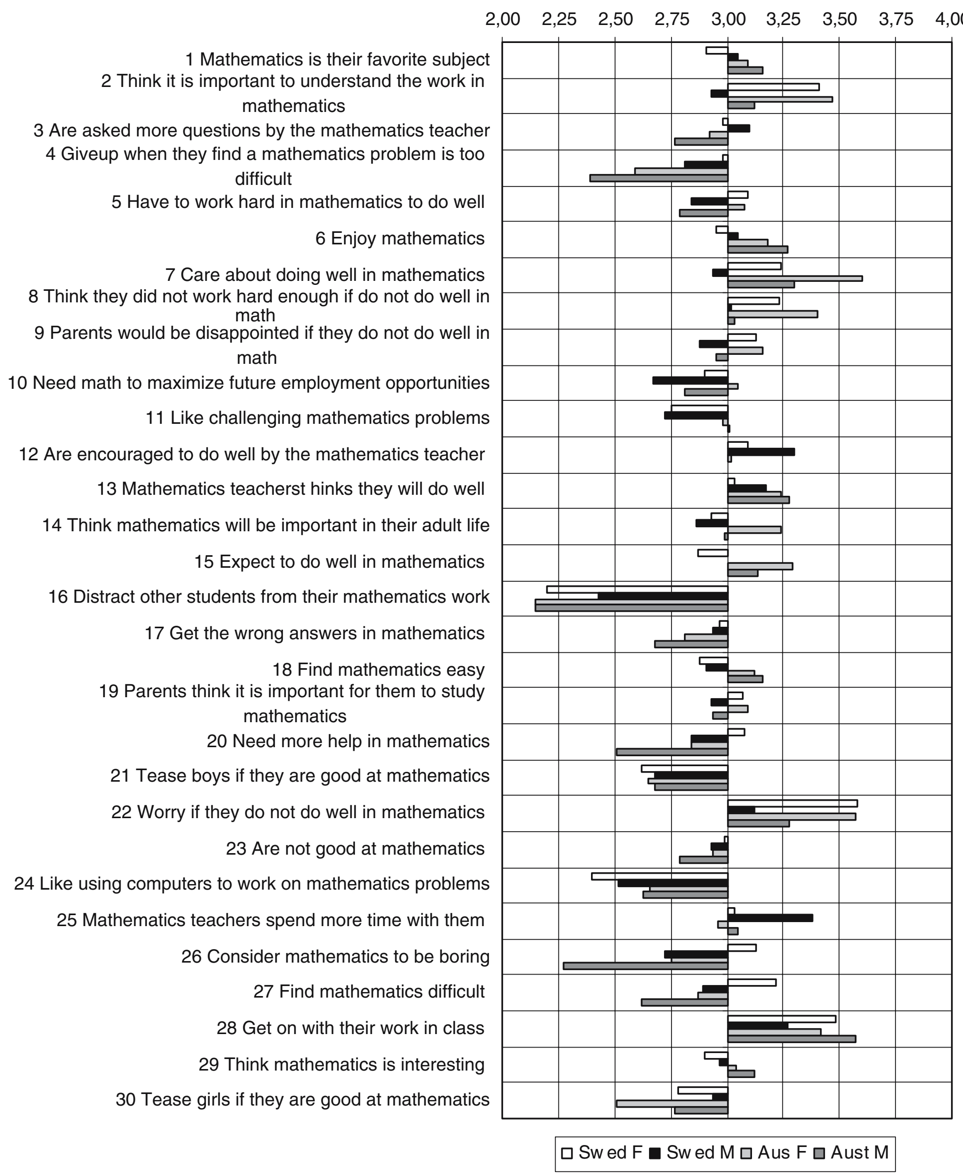


**Fig. 5** Chart over responses to all items according to country (Sweden and Australia) and sex

corresponding data from GeMa. The studies are comparable in size and the students are about the same age, 14–15 years. For an overview of the responses to the items, see Fig. 5 that shows a diagram with the mean values on each item for each sex in the two samples. The items are displayed in the same order as in the questionnaire. It is obvious from a quick glance that the two samples differ in their response patterns. We will comment on some of the similarities and differences that we find especially interesting.

There are similarities between Swedish and Australian pupils concerning schoolwork (items 16, 21, 28). This is not surprising since studies for many years have shown roughly the same pattern for the behaviour of girls and boys in several countries. There is also a remarkable similarity concerning the beliefs of the students regarding the parents of other students. Parents are perceived not to make any difference between daughters and sons by both samples. However, there is a small but significant variation between sexes (items 9, 19). In both countries the responses show a tendency to attribute parents' concerns about doing well in mathematics and about the importance of mathematics more to the sex of the respondent. As expected there is also a similarity concerning computer use; interest in using computers for work in mathematics is coupled with boys (item 24).

The differences are more interesting. In several aspects the group of Australian students regard mathematics as a female rather than a male domain, while the Swedish ones are of the opposite opinion. This pattern is visible in many of the items in Fig. 5, and we give some examples: Swedish students—females and males—believe that boys more often than girls like challenging mathematical problems while Australian students are gender neutral. Boys more often than girls find mathematics easy, according to Swedish students, while Australian students find the opposite is true. Australian students answer that boys are more likely than girls to get wrong answers in mathematics, while Swedish students' answers are gender neutral. Australian students show strong opinions concerning boys who are perceived as more likely to give up when a mathematics problem is too difficult. Swedish students, however, are clearly less convinced in this case, Swedish females even answer gender neutral. Girls enjoy mathematics more often than boys according to Australian students, while Swedish students respond in a neutral way (items 11, 18, 17, 4 and 6).

Swedish females diverge even more in this direction. They perceive, for example, that boys more often have mathematics as a favourite subject, while the other groups answer in favour of girls. They also respond that girls more often find mathematics to be boring and difficult, while the other groups agree on boys on these items (items 1, 26, 27).

The responses from Swedish male students differ from other groups in a couple of respects. Unlike the other groups they do not believe that girls more often find it important to understand mathematics and to care about doing well. Furthermore, the Swedish males consider teachers to encourage girls more and give more time to girls, while the other groups answer gender neutral (items 2, 7, 12, 25).

Australian females differ from other groups in that they do *not* think that boys more often need mathematics in order to get a good job (item 10).

## 6 Discussion

### 6.1 Mathematics: gendered or not?

The general image of mathematics as a gendered domain is divided according to the findings from the GeMa study. In short, female students are perceived to work hard, to wish to understand their work, to worry if they do not do well and to care about doing well. Male students are perceived to find mathematics easy, interesting and useful in their adult life.

The conception among students of mathematics as a male domain is consistent with the findings from many earlier studies using the original MAS instrument (Hyde, Fennema, Ryan, Frost, & Hopp, 1990). According to the GeMa study female and male students consider mathematics as male in certain ways. One aspect concerns mathematics for future employment and adult life. A reason why students find mathematics more important for boys could be that some respondents are aware of the male dominance in professions related to mathematics intense work. The GeMa project did not investigate this question, but a couple of students indicated such knowledge during the interviews. Other male domain aspects are related to school mathematics. Boys like to work with computers, like challenging problems and find mathematics easy more often than girls, according to the students. Female students furthermore find that mathematics is more often boys' favourite subject and they perceive that boys are more likely to find mathematics interesting. Such perceptions are part of the symbolic gender of mathematics in the sense of Harding (1986). In the interviews it was not clear for the students from where they get this conception of mathematics as male domain: teachers, parents and cultural reminiscences from earlier times were suggested.

Girls are associated with hard work and worries by the students in the GeMa study, while boys are associated with disturbing behaviour and teasing. These conceptions of females and males in the classroom are well established in earlier research literature. According to Valerie Walkerdine (1998) girls' hard work is used to explain both success and failure in mathematics. The hard work may be seen as a sign of lack of talent. In recent research Ann Howe and Sarah Berenson (2003) ask, ''What is wrong with working hard in math class?'' discussing the results from a large study among females in years seven and eight. The female students have learnt to work hard but get disappointed when their efforts are not valued. One example of the disturbing behaviour of boys is a classroom observation study by Helen Forgasz and Gilah Leder (1996) in which the authors conclude that boys' lack of effort may even be rewarded by the teacher. Michèle Cohen addresses the issue from a historical perspective and finds discussions about boys' ''healthy idleness'' already during the 1920s in England (Cohen, 1998). Ulla Johansson finds similar results about boys in her historical study of Swedish secondary schools during 1927–1960 (Johansson, 2000).

Female students in GeMa perceive girls to be more eager to understand their work. Girls' ambition to understand mathematics has been observed in earlier research. Jo Boaler (1997) found in a large study of teaching style and organisation of learning in mathematics that female students show a strong will to understand. Students were of approximately the same age as in the GeMa study. Swedish researchers have reached similar results with students of the same age (Staberg, 1992; Wallin, Sjöbeck, & Wernersson, 2000). However, these Swedish studies concern science, not mathematics, but the results may hypothetically be generalised to mathematics.

Not every aspect of mathematics is gendered. Important non-gendered aspects concern parents and teachers. Teachers give equal attention (encouragement, number of questions) to girls and boys according to females. Male students agree about the number of questions asked. However male students find that teachers give more attention to girls (encouragement, time spent). From earlier Swedish research it is known that students' observations of teachers' behaviour may be influenced by irrelevant factors. If dominance of male students over females in the classroom is common, then some students may interpret a sex neutral position of the teacher to be in favour of girls (Molloy, 1987). On the other hand, in a meta-study Elisabet Öhrn (2002) concluded that new patterns have emerged in some Swedish classrooms during the last 10–15 years. Female students are more visible and may even hold a dominant position in the classroom. Teachers consciously give equal attention to both sexes. The responses captured in the GeMa study may mirror this new situation.

Students have adopted a position of gender equity by frequently giving the answer ''No difference''. Some students show strong opinions on the issue of equity in written comments on the questionnaire, in sayings during the visits to classrooms to gather data and finally in interviews. ''Mathematics has nothing to do with being a girl or a boy'' is a comment from one female on the questionnaire. It is apparent that the equity discourse has reached the young and that many of them adopt this discourse. Students know that sex is a structuring factor, but have accepted the ideal of equity.

On the other hand, the results from GeMa exhibit a conflict between the rhetoric and the conceptions of the students. Many students know what is ''right'' but are also aware of the reality; mathematics is gendered. Monique Volman and Geert Ten Dam (1998) captured similar tensions in the Netherlands, where the government also promotes equity in education. In a study concerning identity the authors showed that students had definite opinions of sex differences, but when they were explicitly asked about such they rejected their existence. Yates (1998) points to the difficulty in making students see ''gender at work in the world''. For young students this lack of equity is an issue of no relevance, instead belonging to a stage that has long since passed.

## 6.2 Variation between groups

As stated earlier, male students exhibit more marked opinions. Differing answering patterns may not reflect a difference in opinion, but different attitudes towards questionnaires. Therefore we wish to be careful and not draw conclusions based on the exact magnitude of the deviation from the gender-neutral average 3. We will discuss only those items for which females and males answer in different ''directions''.

There are some items for which females answer in the girls' direction and males in the opposite. Females find that it is more often true for girls to consider mathematics to be boring and difficult, to need more help and to have to work hard. Males express the opposite: boys more often find mathematics boring, difficult, need more help and must work hard. There seems to be a contradiction in the latter attitude compared with other responses (also from male students) concerning mathematics being easy and about challenging problems. One possible interpretation is that the responses refer to different groups of male students, with different constructions of masculinity and different attitudes towards mathematics. One construction of masculinity includes being intellectual and smart, *academic achievers*, while another construction of masculinity is based on physical strength and manual work, *macho lads*, according to Màirtín Mac an Ghaill (1994). In the second case mental work is associated with femininity. Although some research on masculinity in schooling has been done in England and Australia (Connell, 2002; Skelton, 2001) we have not found any study addressing the relation between different masculinities and mathematics.

### 6.3 Sweden–Australia

We will confine ourselves mainly to the differences between the responses from Swedish and Australian students.

Australian students perceive mathematics more as a female domain than Swedish students. One reason for the different attitudes may be that the Australian equity policy has been more energetic than the Swedish one. We have no possibility to decide whether that is true. The school systems vary between the countries and in Australia there are also between-state and within-state variations. As an example of the Australian policy we can name the document *The National Policy for the Education of Girls* from 1987 that concerned all state schools, but was accepted also for private schools (Yates, 1993). Even before the publication of this document many different initiatives were introduced by the states. According to Yates (p. 24) the field 'broadening options' was given most attention with the overarching goal to increase girls' participation in mathematical, scientific and technological subjects. The Swedish campaigns have been more directed to science and technology. Mathematics has not received the same attention in Sweden.

Swedish male students exhibit a diverging view in some respects (understanding, doing well). Can it be that the Swedish male students, more than the Australian, perceive mathematics as a male domain? If girls are indeed more eager to understand this could indicate that they are more interested and involved in mathematics. Do Swedish males' responses that they find teachers to favour girls indicate that they believe that this occurs at the boys' cost? These are hypothetical questions that we are not able to answer here.

Australian females view mathematics as more important for girls than for boys in their adult life and for jobs. Maybe Australian girls have been influenced by the Australian campaigns aiming for girls to get a profession? This issue may have been given prominence later in Australia than in Sweden. It is, however, not enough to look upon school and school politics regarding this question. School policy must be related to other structures. Not only gender but class and ethnicity must be discussed according to Madeleine Arnot, Miriam David and Gaby Weiner in *Closing the Gender Gap* (Arnot, David, & Weiner, 1999), in an analysis of this issue in England and Wales. In their conclusions they claim (p. 150ff) that economic and social changes as well as feminism have influenced girls. The norm for girls during the 1990s became 'getting on and getting out'. The circumstances in Australia and Sweden have differed and there is no simple explanation for the different results concerning future jobs.

The results indicate that in Australia and Sweden parents are perceived as regarding learning mathematics equally important for girls and boys. This is an interesting result, since the students themselves show marked gendered attitudes Parents may have more gender-neutral views in this respect than have the younger generation.

### 6.4 Recruitment to higher studies

Is gendering of mathematics among students in compulsory school one reason why Swedish female students pursue studies in mathematics to a much lesser extent than male students do? The GeMa study only indirectly addresses this question. The results from the first part of the project do not rule out such a connection. The second part of GeMa involving upper secondary level students sheds more light upon the connection between gender marking and choice of mathematics (Brandell & Staberg, submitted).

### 6.5 The new instrument

All possible alternatives in the new gender neutral instrument *Who and Mathematics* are utilized by respondents in the various studies described or referred to in this article. This fact in itself is a proof of the usefulness and relevance of the scale. Mathematics is perceived in various aspects as female, male and/or gender neutral in a complex pattern that varies between countries and groups of students. The detailed discussion above with comparisons of results from Australia and Sweden illustrates the strength of the scale as an instrument for analysis of cross-national investigations.

Although some students put forward criticism from an equity position against the scale, this did not prevent them from answering in a serious manner. Extremely few questionnaires seemed to be answered frivolously or insincerely and thus few responses had to be ignored. On the contrary, students in the GeMa study found the questionnaire easy to fill in. Few needed help or explanations during the data gathering. Teachers can certainly use the instrument in their classroom with their own students. It is easy to administrate, fairly straightforward to evaluate, and—importantly—is able to capture changes in prevailing social norms and gender stereotypes.

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