A measure of mathematical self-concept in young adults 16 – 24 years old: A cross-cultural comparison with a focus on gender and numeracy

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Abstract

Girls attend less education in mathematics than boys when the subject becomes an elective in upper secondary schools and above. One explanation for this might be gender differences in mathematical self-concept, which are the focus of the present study. Data from the Adult Literacy and Life Skills Survey (ALL) were used to examine whether young adults' mathematical self-concept is dependent on gender. The Norwegian results were compared to findings in Canada, Italy, Switzerland, and USA. The ALL-data presented indicate that in all of these countries, females in general are less likely than males to state that they are good with numbers and calculations. The gender differences in mathematical self-concept were largest within Switzerland and Norway. Hierarchical regression analyses showed that gender influenced mathematical self-concept, even when controlled for numeracy skills. To our knowledge, this is the first time representative cross-country samples are used to explore the relationships between gender, country and young adult's mathematical self-concept.

Key words: mathematical self-concept; gender; numeracy; mathematical skills; ALL; comparative study.

Introduction

Mathematics is considered an important area of skills, which can affect the individual's opportunities in education, employment and everyday life. In primary and secondary education, mathematics is a compulsory core subject in most countries (Mullis, et al., 2008). This applies to Canada, Italy, Norway, Switzerland and the US (Le Métais, 2002, 2003; Mullis, et al., 2008), where data for the present study were collected through Adult Literacy and Life Skills Survey (ALL) in 2003. ALL is a cross-country survey of adults' literacy-, numeracy- and problem solving skills, and were coordinated by Statistics Canada and supported by OECD (Statistics Canada & OECD, 2005). The participating countries are hereafter referred to as the ALL-countries.

Mathematics has been considered a masculine subject and a generally accepted view has been that mathematics is a discipline first and foremost for boys, and that boys perform better than girls in mathematics (Ernest, 1991; Georgiou, Stavrinides, & Kalavana, 2007; Harris, 2000; Spencer, Steele, & Quinn, 1999; Walkerdine, 1998). In Norway, boys received more weekly lessons in arithmetic than girls for years and it was not until the curriculum reform in 1974 that all girls and boys in Norway were formally guaranteed equal teaching in mathematics in primary and lower secondary education (Lundetræ, 2005). The socio-political constructed differences may have influenced women's and men's attitudes and skills in mathematics.

Studies indicate that when mathematics becomes voluntary, gender-differences in participation in this subject clearly appear but this tendency has in part been counteracted by increasing gender equalities. As for Norway, after equal status between genders seriously became a subject of public concern and a part of curricula and textbooks in the 1970s, the gender differences in the education statistics have diminished. Thus the female students' participation in mathematical subjects at university level has increased from 5% in 1978, to 24% in 1989, 29% in 1995 (Hag, 1996, 1998), and reached 32% in 2005 (OECD, 2008). However, in the ALL-countries, except for Italy, females are in minority in learning advanced mathematics in higher education (ibid.).

Several factors may account for these gender differences and trust in own capacities for handling mathematics may be one of them. Research has demonstrated gender differences in career choice involving mathematics, personal beliefs and attitudes towards mathematics (Fennema, 1996; Tatre & Fennema, 1995). Attitudes can also affect further participation when the subject becomes voluntary: *"One reason why gender differences in academic self-concept and self-efficacy are important is that these constructs are strongly related to academic achievement and a variety of motivational indicators"* (Skaalvik & Skaalvik, 2004, p. 241).

Self-concept, broadly defined as a person's perceptions of him- or herself (Marsh & Shavelson, 1985), is here regarded as a learned attitude towards the individual's own capacities and capabilities. The individual student's experiences with mathematics will most likely have a central impact on the self-concept, as might the influence from significant others like his/her parents. Also numeracy-skills, in ALL defined as *"the knowledge and skills required to effectively manage and respond to the mathematical demands of diverse situations"* (Gal, Groenestijn, Manly, Schmitt, & Tout, 2003, p. 4) may influence mathematical self-concept (and vice versa). Because of possible cultural differences with regard to e.g. equal status, gender role socialization and gender-stereotyping, mathematical self-concept might differ within and between the ALL-countries.

Literature review

During the last decade, cross-country surveys of students' achievement in mathematics have provided information about gender differences in mathematics performance and mathematical self-concept. In Trends in International Mathematics and Science Study (TIMSS) 2003, a survey of pupils in the 8^{th} grade in 50 countries, no significant gender differences in mathematics achievement were found regarding the international average. The tasks in TIMSS were derived from five mathematical areas and gender differences varied between these. TIMSS displayed significant gender differences in algebra in favour of the girls and in measurement in favour of the boys. Among the ALL-countries who participated in TIMSS, no gender differences were found in Norway and Ontario, Canada. Marginally significant gender differences in favour of the boys were found in Italy (6 points, SE 2.8), USA (6 points, SE 1.9) and Quebec, Canada (7 points, SE 3.3) on the 500-scale (Mullis, Martin, Gonzalez, & Chrostowski, 2004).

In Programme for International Student Assessment (PISA) 2003, where mathematical skills of 15-years olds were surveyed, significant gender-differences in favour of the boys were found on the international average and in all the ALL countries, except for Norway. In the US there were weakly significant gender differences (6 points on the 500 scale, SE 2.9). The gender-differences varied between the four mathematical areas in PISA, but where gender differences were found, they were in favour of the boys (OECD, 2004). The observed gender differences may reflect "true" differences, although they may also mirror effects of how the test is constructed (Kjærnsli, Lie, Olsen, Roe, & Turmoe, 2004). In PISA 2003, the largest gender differences were in "Space and shape". Cognitive gender differences in favour of the boys in some spatial tasks such as mental rotation, which *"involves the ability to look at a picture of an object and visualize what it might look like when rotated in three-dimensional space"*, are confirmed by Nuttall, Casey and Pezaris (2005, p. 122).

For the adult population (16-65 years), the ALL results displayed significant gender differences in numeracy skills in favour of males in all participating countries (Statistics Canada & OECD, 2005). Likewise, the International Adult Literacy Survey (IALS) also demonstrated significant gender differences in Quantitative Literacy in the same countries, except Canada (Educational Testing Service, 2008). In a survey of adult students' experiences with mathematics, their performance and feelings about mathematics, Evans (2000) found gender differences in favour of the males in school mathematics performance and practical maths performance among mature students (aged 21+ years). Data from the Norwegian Directorate for Education and Training (Utdanningsdirektoratet, 2006) show that in recent years, there have been no differences in marks of Norwegian girls and boys in the 10th grade school-leaving examination in mathematics. Lødding (2004) found a tendency for girls in the 10th grade to obtain higher average marks in mathematics than boys. The girls (n=4744) had 3.49 in final marks and the boys (n=4942) 3.43.

Still there are far more boys than girls continuing with the subject when it becomes optional after one year in upper secondary education and training in Norway (Lødding, 2004). This is also the case for pupils with good marks. Female students performed significantly worse than male students in the Norwegian Mathematics Council's investigation of basic skills in mathematics for students starting mathematics-demanding studies at university level courses (Rasch-Halvorsen & Johnsbråten, 2006). Men scored 52.8 percent, while women scored 41.3 percent. By then 63.1 percent of male students had mathematics for 3 years in upper secondary education and training, while this was the case for only 44.7 percent of female students. The latter can probably explain some of the gender differences in this test (ibid.). If girls were aware that mathematics will be relevant to their lives and useful in their future careers, they would be more likely to remain in mathematics courses (Hanna & Nyhof-Young, 1995).

Jones and Smart (1995, p. 223) suggested that "*Mathematical ability has long been seen as a yardstick for "braininess" and as such it is not seen as a socially acceptable ability to demonstrate in the school culture."* They referred to Jones and Jones' study (1989), where girls tell that "clever" was seen as "square" or "boring", and that they therefore, in contrast to the boys, had to hide such talents in upper secondary school. Results from PISA 2003 showed that Norwegian girls were less motivated towards learning mathematics than boys. The boys were more interested in mathematics, more motivated towards learning through competition, and had a higher instrumental motivation than the girls, who were more motivated towards learning through cooperation (Kjærnsli et al., 2004). Mathematics has traditionally been a school subject with high status and the subject that most strongly influences self-understanding (Linnanmäki, 2002, 2004). Negative experiences with mathematics are very common and Finnish pupils are more concerned about their achievement in mathematics than in any other school subject (Linnanmäki, 2004). In addition, girls in 8^{th} grade had a poorer self-concept in mathematics than the boys, even though they achieved a little better at assessment tests than the boys (Linnanmäki, 2002).

Self-concept can broadly be defined as a person's perceptions of him- or herself (Marsh & Shavelson, 1985) or *"the set of cognitions and feelings that each individual has about himself or herself"* (Gall, Gall, & Borg, 2007, p. 219) and is formed through experience with and interpretations of the environment. It is particularly influenced by evaluations by significant others, reinforcements, and attributions for one's behaviour (Shavelson, Hubner, & Stanton, 1976). The self-concept may be conceived as a hierarchical structure where the general beliefs about oneself is found on the upper levels, while more detailed and task-specific beliefs are found on lower levels (ibid.). As a lower-level belief, the individual's mathematical self-concept is a part of the academic self-concept and is to be understood as *"the general feeling of doing well or poorly in mathematics"* (Skaalvik & Skaalvik, 2004, p. 244).

In PISA 2003, the cross-country variation in mathematical self-concept was clearly evident (OECD, 2004). The index used had a range from -2.5 to 2.5, an average score of 0 and two-thirds scored between 1 and -1. The Norwegians (-.18, SE .02) reported the poorest mathematical self-concept among the ALL-countries, while the Americans reported the best (.25, SE .02). The gender differences in mathematical self-concept were significant in favour of the boys within all the countries, and largest within Switzerland (.72, SE .03) and Norway (.47, SE .04), and smallest within Italy (.14, SE .03). The average gender difference was .33 (SE .01). Knowing that the girls and boys performed approximately equally well in mathematics in Norway, with less than 10 percent of a standard deviation in favour of the boys, the gender difference in mathematical self-concept in PISA was considerable (Kjærnsli et al., 2004).

Lødding (2004) suggests that Norwegian girls have an incorrect picture of their own skills in scientific subjects. In a survey, all pupils in 10^{th} grade in seven Norwegian counties (n=9588) were asked whether they agreed or disagreed to the statement: "I have a good aptitude for mathematics". The girls had to achieve about a half mark better in the final assessment in 10^{th} grade than the boys in order to express confidence in their mathematical skills. The difference was less between girls and boys with the mark A than between girls and boys with marks B to E. The girls' belief in their own mathematical skills was therefore generally weaker than boys with the same marks. Lødding (2004) found opposite results for verbal educational topics. These different self-concepts may be outcomes of social and cultural attitudes as gender stereotyping and can not be explained by gender differences in self-confidence.

In a study of gender differences in mathematical and verbal self-concept, Skaalvik and Skaalvik (2004) found supporting results for the gender stereotype explanation of gender differences in self-concept in a sample of students in 6^{th} grade, 9^{th} grade, 11^{th} grade and adult students, stating: *"In mathematics, male students had better self-concept in all samples and higher performance expectations in the two oldest samples."* (p. 249). This could not be explained by grades. They also found that *"Older students had better verbal than mathematical self-concept regardless of gender"* (p. 241). Gender differences in mathematical self-concept were also found among Norwegian 16-65-years olds (Lundetræ, 2008). The Swedish GeMa-project (Gender and Mathematics) showed that most of the pupils perceived mathematics as gender neutral, even though some older pupils (from 11^{th} grade) of both genders stereotyped mathematics more as a male domain (Brandell, Nyström, & Sundquist, 2004).

Steele and Ambady (2006) performed three experiments containing "gender-priming". In the first study, female students saw word-flashes on the PC laptop, and were to identify whether it appeared on the right or left side of the screen. Half the females were primed with female words (aunt, lipstick, etc.), and half with male words (uncle, razor, etc.). They were then asked how pleasant they and other students would find different mathematical and arts-related academic activities. In the other studies half the females were reminded of their gender identity through a page-long set of questions about gender, co-ed or single-gender environment etc. The other half got comparable gender-neutral questions about their telephone service. Steele and Ambady found that gender stereotyping might be a result of gender priming on women's attitudes: *"women who were subtly reminded of the category female (…) or their gender identity (…) expressed more stereotype consistent attitudes towards the academic domains of mathematics and arts than participants in control conditions"* (p. 428). They also suggest that *"It seems possible that our culture creates a situation of repeated priming of stereotypes and their related identities, which eventually help to define a person's long-term attitude towards specific domains"* (p. 435). Gender stereotyping can impact mathematical self-concept, which together with mathematics anxiety might influence thinking and performance in mathematics in older students and adults (Evans, 2000).

The research questions motivating this study were threefold: 1a) What is the relationship between gender and mathematical self-concept? 1b) What is the relationship between gender and mathematical self-concept when controlled for numeracy skills? 2) To what extent do these same patterns of relationships appear across nations? The research questions are illuminated by analysing data of 16-24 years olds' achievements and self-concepts in mathematics across the ALL-countries (Canada, Italy, Norway, Switzerland and US). To our knowledge, this paper is the first that in a systematic way uses representative cross-country samples to explore the relationship between gender and a measure of mathematical self-concept between and within different nations.

Methods

To study whether 16-24 years olds' mathematical self-concept is dependent on gender, data from the Adult Literacy and Life Skills Survey (ALL) were used. ALL is a cross-sectional study, where the first part was carried out in 2003. It is a follow-up of IALS, and both studies were coordinated by Statistics Canada and supported by OECD. Development of the ALL methodology and definition of levels of difficulty are thoroughly described in the international reports *Learning a Living* (Statistics Canada & OECD, 2005) and *Measuring Adult Literacy and Life Skills* (Murray, Clermont, & Binkley, 2005).

Representative national samples aged 16 to 65 were assessed in the domains of Prose and Document Literacy, Problem Solving and Numeracy, and background information was gathered through an interview. Norway, Canada, Italy, Switzerland, USA and Bermuda participated, and data from the five first-mentioned countries were used in this study.

Every respondent was given one of 28 task booklets with tasks ranging from easy to difficult. Thereby, the respondents only worked with a selection of the assessment tasks, but still within all difficulty levels. The design of the study containing use of Item Response Theory (IRT) made it possible to range the assessment tasks according to degree of difficulty, securing correct findings on population level, and made it possible to compare the results between the participating countries (Murray et al., 2005).

Measurements

To examine what set of cognitions and feelings 16-24-olds have about them doing well or poorly in mathematics, different approaches could be used. Skaalvik and Skaalvik (2004) used a six-item scale based on a modified version of Marsh's (1990) "Self Description questionnaire", with items such as *I always do well in mathematics*. The Cronbach's alpha was .87, indicating that the responses to the six items were quite similar. PISA used a self-concept index that summarised four items including *I'm just not good at mathematics* (OECD, 2004). In TIMSS, a similar index of students' self-confidence in learning mathematics, including the item *I usually do well in mathematics,* was used (Mullis et al., 2004).

In this study, the item *I'm good with numbers and calculations,* with the response scale *strongly disagree*, *disagree*, *agree*, *strongly agree*, was used to provide a picture of mathematical self-concept. It was assumed that those who agreed with this claim also considered themselves good with mathematics, and that this item would catch the same cognitions and feelings about mathematics as the indexes mentioned. Four other items quite similar to the self-concept items in PISA and TIMSS were excluded, because in the Norwegian sample, they were answered only by respondents who had finished upper secondary school. Hence, they were not applicable in this study. The Cronbach alpha coefficient on the five self-concept items in ALL was .85 for the ALL-countries –including Norwegian respondents who had finished upper secondary school. This means that the results of the analyses would be very similar if all five items were used. Even though it would be an advantage to have more than one item, it was considered better to do the research with one item than using five items and thereby exclude the Norwegian sample.

Data collection

Respondents in the sample

The participating countries identified a representative sample of the civilian non-institutionalized population aged 16 to 65. The final sample met the set requirement of no more than five percent deviation from the target population in each of the participating countries (Statistics Canada & OECD, 2005).

Table 1. Distribution of the respondents (16-24 years) and gender in ALL.

	Norway	Canada	Italy	Switzerland	USA	Total
N (16-24 years)	996	3574	1147	458	641	6816
% women	49.9	50.9	51.2	45.0	53.0	50.6

Data collection

The data were collected during 2003. The ALL assessment was administered in respondents' homes, and started with a background questionnaire where the respondents were asked questions judged to yield information about the respondents' literacy and life skills. When the background questionnaire was completed, the participants were presented with a booklet containing six simple level 1 tasks from everyday life. If they failed, the interview was closed / terminated, because the tasks over level 1 in all probability would be too difficult. Respondents who passed the core tasks were given one of 28 task booklets. There were no time limits and the respondents could use a ruler and a calculator for the numeracy tasks. On the average approximately 2 hours were spent in each home (Statistics Canada & OECD, 2005).

Data analyses

ALL employed the same 0-500 scale as its predecessor, IALS. The statistical analyses were based on the Item Response Theory (Murray et al., 2005), which briefly means that the pilot study data were used to place each task on the 0 – 500 scale according to its difficulty level. The same scale was also used to rank individuals on the test dimensions. The scale was divided into five levels, where level 1 was the lowest. The score denoted the point where a person had 80 percent chance of successfully completing tasks associated with the same level of difficulty. The 80 percent criterion is a fixed point, based on agreement and tradition in the field, and is comparable to how the .05 significance level is based on agreement.

SPSS 15 for Windows was used for the analyses. Frequency distributions and crosstabs were analyzed for *I'm good with numbers and calculations.* Hierarchical multiple regression analyses were applied to assess the relative importance of *gender* on the self-concept when controlling for the possible modifying effects of *parents' level of education*, *years of schooling* and *numeracy skills*, as well as the isolated effects of these variables. Finally, the analyses also included *born in the country of interview* to control for possible confounding factors due to poorer mastery of the test language (Statistics Canada & OECD, 2005).

To make use of multiple regression analysis, the dependent variable must be continuous, while the independent variables may be continuous or dichotomous (Tabachnick & Fidell, 2007). In this case, multiple regression analysis was applied, even though the dependent variable was not continuous, but ordinal with the values 1-4. The sample was large (see table 1), and the dependent variable was approximately normally distributed (skewness = .55; kurtosis = -.21 and the variance = 0.64). We therefore presumed that the ordinal dependent variable was nearly metric and continuous and thereby behaved as if it was interval scales. Preliminary analyses were conducted to ensure that the assumptions of normality, linearity, multicollinearity and homoscedasticity not were violated. Also, the ANOVA indicated that the models as a whole were significant.

Missing values in the variables *Mother's highest schooling* and *Father's highest schooling* (.8 to 7.3 percent missing) were replaced by medians within each country.

Validity and reliability

The survey was implemented according to the standards provided in "*Standards and Guidelines for the Design and Implementation of the Adult Literacy and Life Skills Survey*" to ensure a minimum survey design (Statistics Canada & OECD, 2005). The proposed sample-design from each country was reviewed by Statistics Canada to make sure that guidelines and sample design standards were satisfied (ibid.). Statistics Canada and ETS checked all sections in the survey to make sure that the study was suited to draw conclusions on population level. The findings in ALL generally coincide well with the findings in IALS, which indicate that the survey is reliable. In Norway, the results correspond well with descriptive statistics from Statistics Norway regarding sample characteristics on background variables. Concerning Italy, the results diverge distinctly from other countries, and some uncertainty is therefore attached to the Italian results until they are retested (the Italian results from IALS were not published, and thus comparison data are lacking).

By using only one item, we cannot assume that the analyses give a complete picture of the respondents' mathematical self-concept. Still, the Cronbach's alpha value of .85 for the five items used on parts of the sample, suggest a very good internal consistency reliability for the scale, and indicate that the item used can represent one measure of mathematical self-concept, if not *the* measure.

Results

In the USA, Canada and Switzerland more than 80 percent of the population between 16 and 24 agreed or strongly agreed that they were "good with numbers and calculations" (figure 1). In Norway and Italy, which are the countries where fewest agreed that they were "good with numbers and calculations”, barely 70 percent agreed or strongly agreed. It is also clear that far more males than females found themselves “good with numbers and calculations”. The gender differences were largest in Norway and Switzerland, where they were twice as big as in Italy.

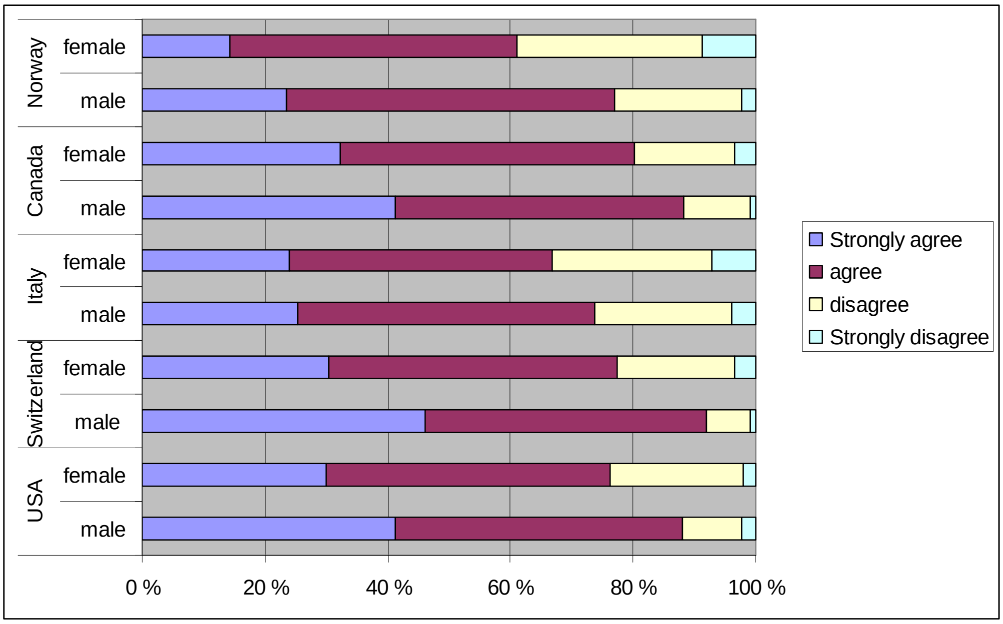

Figure 1. “I’m good with numbers and calculations” and gender, age group 16-24.

In Switzerland, Norway and Canada, there were far more females than males that strongly disagreed that they were good with mathematics. In Norway, the gender differences were significant at the .01-level within all response categories accept for “agree” (sig. at .05-level). Also in Canada the gender differences were significant at the .01-level in all response categories accept of “agree” (not sig.). In Italy there were only significant gender differences within the category “strongly disagree” (.05-level). In Switzerland and USA there were significant gender differences within the categories “strongly agree” and “disagree” (.01-level) on the statement *I’m good with numbers and calculations*.

Multiple hierarchical regression analysis was applied to identify the direct and the indirect effect of *gender* on mathematical self-concept (*I’m good with numbers and calculations*), see table 2. The hierarchical regression analysis had the following steps: 1: *gender (f=0)* ; 2: *born in country of interview*, *mother’s highest schooling*, *father’s highest schooling*; 3: *Canada*, *Italy*, *Switzerland*, *USA (reference country: Norway)*; 4: *years of schooling*; 5: *numeracy skills*. All the 16-24 years olds in the current countries was included.

The numeracy scores ranged from 84.0 to 448.6 (M = 269.46, SD = 48.96) and total years of schooling ranged from 0 to 22 (M = 12.2, SD = 3.53). Mother’s educational level was distributed with 28 percent on comprehensive school; 40 percent on high school or vocational training and 29 percent on college or university degree level. Father’s educational level was distributed with 28 percent on comprehensive school; 37 percent on high school or vocational training and 29 percent on college or university degree level. A total of 91 percent of the sample were born in country of interview.

Table 2. Summary of Hierarchical Regression Analysis for Variables Predicting Mathematical Self-concept. Dependent variable: "I'm good with numbers and calculations." Age group 16-24. Reference country: Norway.

	Step 1		Step 2		Step 3		Step 4		Step 5	
	B (SE)	Β	B (SE)	β	B (SE)	Β	B (SE)	β	B (SE)	β
Gender	.21 (.02)	.13 ***	.20 (.02)	.13 ***	.20 (.02)	.13 ***	.21 (.02)	.13 ***	.16 (.02)	.11 ***
Born in co			-.04 (.03)	-.02	.01 (.03)	.01	.02 (.03)	.01	-.06 (.03)	-.02
M's edu.			-.07 (.02)	-.07 ***	-.06 (.02)	-.06 ***	-.05 (.02)	-.05 **	.02 (.01)	.02 *
F's edu.			-.08 (.02)	-.08 ***	-.09 (.02)	-.09 ***	-.08 (.02)	-.08 ***	.00 (.01)	.00
Canada					-.39 (.03)	-.25 ***	-.38 (.03)	-.24 ***	-.44 (.03)	-.27 ***
Italy					-.19 (.03)	-.09 **	-.17 (.03)	-.08 **	-.30 (.03)	-.15 ***
Switzerl.					-.41 (.04)	-.13 ***	-.38 (.04)	-.12 ***	-.29 (.04)	-.09 ***
USA					-.35 (.04)	-.13 ***	-.33 (.04)	-.12 ***	-.43 (.04)	-.16 ***
Yrs school							-.02 (.00)	-.08 ***	-.00 (.00)	-.00
Numeracy									-.01 (.00)	-.37 ***

Note R^2 = .17. ΔR^2 = .02 for Step 1; ΔR^2 = .02 for Step 2; ΔR^2 = .03 for Step 3; ΔR^2 = .01 for step 4; ΔR^2 = .10 for Step 5. (N=6816) *p<.05, **p<.01, ***p<.001.

At the first step of the analysis of mathematical self-concept, gender explained only two percent of the variance (see table 2). The direct effect of gender was β=.13, meaning that males had some better mathematical self-concept. At next three steps, the gender effect remained the same and eight percent of the variance was explained. At the last step, where numeracy skills entered the model, sixteen percent of the variance was explained. The indirect effect of gender (β=.11) was also slightly less than the direct effect (β=.13), indicating some lower numeracy skills in females. Skills were the most decisive variable in this model. Gender meant less, but still had a clear effect beyond what skills could explain. The analysis also shows that Canadian and Swiss adolescents had the best mathematical self-concept, while the Norwegians had the lowest (reference-country). When controlling for skills, the Canadian and Americans had the relatively best mathematical self-concept.

In the following regression analyses, where the countries were analyzed one by one, gender had a separate effect after numeracy skills entered the analyses in all the countries. Still, gender meant far less than numeracy skills for whether one perceived oneself as good with numbers and calculations. Being a female was not only associated with lower mathematical self-concept, it was also associated with some lower numeracy skills in all the current countries except Italy. The steps in the analyses are 1: *gender*; 2: *born in country of interview*, *mother's highest schooling, father's highest schooling*; 3: *years of schooling*; 4: *numeracy skills*.

Norway

Gender (β=.20) predicted mathematical self-concept at the first step of the hierarchical regression and explained four percent of the variance (table 3). At the next step, another four percent of the variance was explained by *born in country of interview* and *parents' highest schooling*, while the gender effect remained nearly the same. *Total years of schooling* at the third step, was not significant. At the last step, numeracy skills and gender were the only significant IVs and altogether 25 percent of the variance was explained. The indirect effect of gender was β=.14, indicating that some of the gender effect went through skills.

Table 3. Summary of Hierarchical regression analysis for variables predicting mathematical self-concept. Dependent variable: "I'm good with numbers and calculations." Age group 16-24.

*p<.05, **p<.01, ***p<.001

		Step 1			Step 2			Step 3			Step 4		
		B (SE)	β		B (SE)	β		B (SE)	β		B (SE)	β	
Norway[1]	Gender	.31 (.05)	.20	***	.30 (.05)	.19	***	.30 (.05)	.19	***	.22 (.04)	.14	***
	Born in c of int.				.07 (.10)	.02		.07 (.10)	.02		-.05 (.09)	-.02	
	M's schooling				-.11 (.04)	-.10	**	-.11 (.04)	-.10	**	-.04 (.03)	-.04	
	F's schooling				-.14 (.04)	-.12	***	-.14 (.04)	-.12	***	-.02 (.04)	-.02	
	Years in school							-.00 (.01)	-.00		.01 (.01)	.05	
	Numeracy										-.01 (.00)	-.45	***
Canada[2]	Gender	.19 (.03)	.13	***	.19 (.03)	.13	***	.21 (.02)	.14	***	.15 (.02)	.10	***
	Born in c of int.				.01 (.04)	.01		.03 (.04)	.02		-.06 (.04)	-.03	
	M's schooling				-.06 (.02)	-.06	**	-.04 (.02)	-.04	*	.04 (.02)	.04	*
	F's schooling				-.08 (.02)	-.08	***	-.05 (.02)	-.05	**	.01 (.02)	.01	
	Years in school							-.05 (.01)	-.17	***	-.00 (.01)	-.01	
	Numeracy										-.01 (.00)	-.40	***
Italy[3]	Gender	.11 (.05)	.07	*	.11 (.05)	.07	*	.13 (.05)	.08	**	.12 (.05)	.07	*
	Born in c of int.				-.04 (.22)	-.01		-.04 (.22)	-.01		-.03 (.21)	-.00	
	M's schooling				.03 (.05)	.02		.03 (.05)	.03		.05 (.05)	.04	
	F's schooling				-.11 (.05)	-.09	*	-.09 (.05)	-.07		-.06 (.05)	-.05	
	Years in school							-.04 (.01)	-.13	***	-.03 (.01)	-.08	**
	Numeracy										-.00 (.00)	-.15	***
Switzerland[4]	Gender	.32 (.07)	.22	***	.31 (.07)	.21	***	.32 (.07)	.22	***	.26 (.07)	.18	***
	Born in c of int.				.08 (.10)	.03		.07 (.10)	.03		-.02 (.10)	-.01	
	M's schooling				.02 (.06)	.02		.02 (.06)	.02		.03 (.06)	.03	
	F's schooling				-.03 (.06)	-.03		-.03 (.06)	-.02		.05 (.06)	.04	
	Years in school							-.00 (.00)	-.05		-.00 (.00)	-.02	
	Numeracy										-.01 (.00)	-.30	***
USA[5]	Gender	.22 (.06)	.15	***	.22 (.06)	.14	***	.23 (.06)	.15	***	.15 (.06)	.10	*
	Born in c of int.				-.07 (.10)	-.03		-.05 (.10)	-.02		-.07 (.09)	-.03	
	M's schooling				-.06 (.05)	-.06		-.04 (.05)	-.03		.02 (.05)	.02	
	F's schooling				-.06 (.05)	-.05		-.02 (.05)	-.02		.09 (.05)	.08	
	Years in school							-.04 (.01)	-.12	**	.01 (.01)	.03	
	Numeracy										-.01 (.00)	-.40	***

Canada

Gender (β=.13) explained two percent of the variance in mathematical self-concept at the first step (table 3). The next step, *born in country of interview* and *parents' highest schooling* explained another two percent, while *total years of schooling* at the third step explained three percent of the variance. The gender effect remained nearly the same at these steps. At the last

[1] Note $R^2 = .25$. $\Delta R^2 = .04$ for Step 1; $\Delta R^2 = .04$ for Step 2; $\Delta R^2 = .00$ for Step 3; $\Delta R^2 = .17$ for step 4. (N=996).
[2] Note $R^2 = .17$. $\Delta R^2 = .02$ for Step 1; $\Delta R^2 = .02$ for Step 2; $\Delta R^2 = .03$ for Step 3; $\Delta R^2 = .11$ for step 4. (N=3574).
[3] Note $R^2 = .05$. $\Delta R^2 = .00$ for Step 1; $\Delta R^2 = .01$ for Step 2; $\Delta R^2 = .02$ for Step 3; $\Delta R^2 = .02$ for step 4. (N=1147).
[4] Note $R^2 = .13$. $\Delta R^2 = .05$ for Step 1; $\Delta R^2 = .00$ for Step 2; $\Delta R^2 = .00$ for Step 3; $\Delta R^2 = .08$ for step 4. (N=458).
[5] Note $R^2 = .14$. $\Delta R^2 = .02$ for Step 1; $\Delta R^2 = .01$ for Step 2; $\Delta R^2 = .01$ for Step 3; $\Delta R^2 = .10$ for step 4. (N=641).

step, when controlling for numeracy skills, gender (β=.10) was still significant, but the indirect effect was less than the direct effect. Altogether, the model explained seventeen percent of the variance.

Italy

Gender (β=.07) was significant on the first step in the analysis, but did explain less than .5 percent of the variance, and hardly predicted mathematical self-concept (table 3). B*orn in country of interview* and *parents' highest schooling* at the second step explained 1 percent of the variance, while *total years of schooling* added two percent variance explained in the analysis. At the last step, where numeracy skills entered, a total of five percent of the variance was explained, which is not much. The indirect effect of gender was the same as the direct effect, indicating that there were no gender differences in numeracy skills.

Switzerland

At the first step, gender (β=.22) predicted mathematical self-concept and explained five percent of the variance (table 3). The second and the third step in the analysis (*born in country of interview; parents' highest schooling* and *total years of schooling*), did not add any explanation. At the last step, where numeracy skills was added, total variance explained was thirteen percent. The indirect effect of gender (β=.18) was less than the direct effect, due to gender differences in numeracy skills.

USA

Gender (β=.15) predicted mathematical self-concept and explained two percent of the variance (table 3). *Born in country of interview* and *parents' highest schooling* added at the second step in the analyses were not significant, while *total years of schooling* at the third step explained another one percent of the variance. At the last step in the analysis, where numeracy skills was added, the indirect effect of gender (β=.10) was less than the direct effect because some of the gender effect went via skills. Totally fourteen percent of the variance was explained.

Discussion

The results suggest that females rate their mathematical skills lower than males in all participating countries. This even occurred when controlled for numeracy skills, and corresponds with Skaalvik and Skaalvik's findings (2004), where males had better mathematical self-concept in all samples, when controlled for grades. Gender was moderated by country, meaning that the gender differences in mathematical self-concept varied between countries. The gender differences in mathematical self-concept were largest within Norway and Switzerland, where they were twice as large as in Italy. This corresponds well with the findings in PISA 2003 (OECD, 2004). Mathematical self-concept increased with increasing numeracy skills, and indicates that the answers were based on a certain degree of self-insight.

The findings indicate that good mathematical skills give self-confidence and it is therefore a substantial challenge to make sure that as many as possible learn enough basic skills in mathematics to feel comfortable in common calculation situations. However before proceedings leading in further discussions of the findings, one should be aware that the effect of gender on mathamtical self-concept was moderate and was in some of the instances of limited practical importance. Skills strongly affect mathematical self-concept and it explains between two and five times as much variability in the dependent variable as does gender.

Compared to hierarchical regression analysis on gender and mathematical self-concept performed on Norwegian 16-65 years old in ALL (Lundetræ, 2008), gender means even more to

16-24 years olds' mathematical self-concept, even though there are smaller gender-differences in educational level and numeracy achievement in this group. It may look like the gender-differences in mathematical self-concept prevail even though the gender differences in numeracy skills in the youngest part of the population are smaller. However, it is encouraging that gender differences in mathematical self-concept have diminished in primary and secondary school the last years (Grønmo, Bergem, Kjærnsli, Lie, & Turmoe, 2004). It will be interesting to see whether this will emerge in the adult population in the future.

Over the last decades, there has been an effort to reach equality between the sexes. In the *Global Gender Gap Index 2007*, Norway was ranked as country number 2; Canada 18; USA 31; Switzerland 40 and Italy 84 (Hausmann, Tyson, & Zahidi, 2007). When it came to educational attainment, Norway was number 17; Canada 26, Italy 32, USA 76 and Switzerland 92 (ibid.). In Norway, where equality seems to have come far, there are still substantial gender differences in mathematical self-concept and it does not seem like gender stereotyping concerning mathematics is less in Norway than in the other ALL-countries. This may explain the fact that even though Norwegian females go to university for at least as many years as the males, they choose university subjects containing advanced mathematics to a lesser degree (OECD, 2008). Gender differences in interests could also provide an explanation as to why differences in mathematics still exist (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005). Women choose occupations involving working with people (medical doctor, teacher, nurse) to a greater degree, and seem in general to be less interested in occupations as engineer or electrician (Anker, 1998). Still, we can not discount that gender stereotypes also influence interests.

As a learned attitude, mathematical self-concept is also influenced by gender stereotypes and significant others. Furthermore, mathematical self-concept influences educational choices and pathways (Skaalvik & Skaalvik, 2004). To diminish the gender differences in mathematical self-concept, and thereby gender differences in educational choices and pathways, school should make the students aware of their own capabilities and capacities, their attitudes towards this, and what influences it. Gender stereotypes should also be discussed with both boys and girls to improve awareness, and to reduce its influence. For instance, Swedish analyses of books in mathematics in compulsory school showed that through names and pictures, books portrayed the world as if it consisted of twice as many men as women. At the same time, the teachers were not aware of the problem (Grevholm, 1995, 2004). Sweden has been one of the leading countries when it comes to equality between the sexes (Hausmann et al., 2007) and there is no reason to believe that the situation has been much different in other countries.

The fact that some women believe that they perform less well in mathematics than they actually do might make them avoid these situations, lose training, and as a consequence of that, obtain lower skills in the future. Mathematical self-concept should be discussed with adult learners to make them aware that gender stereotypes affect this. Women's self-concept can influence their children and make it even harder to close the gender gap. Some women may need to hear that it is "proved" that they probably perform better than they think. In the same way, we can tell males that they are probably better at English than they think. Even though the gender differences are smaller when we control for skills, there is still a pronounced difference between women's and men's mathematical self-concept.

It is arguable whether it is possible to measure mathematical self-concept by using one item measures, because this will increase the error of measurement. Still it is considered as better to do the analyses with the available items, accept possible errors of measurement and get new knowledge in this area, than not to. One item measures have been used by for instance Bay, Hellevik and Hellevik (2007) to examine personal faith and economic skepticism, and also by Beckie and Hayduk (1997).

It can also be debated whether it is possible to get a true picture of the population's proficiencies and attitudes towards mathematics in a survey where the respondents are interviewed and asked to solve pen and paper tasks, instead of acting in a "real life context". We must be aware that what a person answers about her/his cognitions and feelings in an interview may differ from what she/he actually feels in a real situation. The ALL was anonymous with voluntary respondents and we see no reason to believe that they did not answer to the best of their ability. The numeracy tasks are derived from real contexts and seem quite realistic within the limits that task booklets in a big, comparative survey can give. Also, self-reporting of cognitions and feelings and the use of multiple choices might elicit responses corresponding to social norms. On the other hand, it is hard to see another and more reliable way of gathering such an amount of data. When doing cross-country comparisons of mathematical self-concept, it is important to be aware that two persons in different countries who give the same answers can be influenced by cultural factors, even though skills are controlled for. Still it can provide knowledge of how these phenomena are distributed on gender in different countries.

Conclusion

It can be concluded that 16-24 years old males had some better mathematical self-concept in all the current countries. The gender differences in mathematical self-concept were of some practical interest in Switzerland and Norway, while the practical implications can be questioned for the other countries. Numeracy skills was the strongest predictor with accounting between two and five times as much variability as gender. The pattern of the gender effect corresponds with the findings in PISA 2003 (OECD, 2004). Also when controlled for numeracy skills, there were significant gender differences in mathematical self-concept in all the countries. The direct effect of gender on mathematical self-concept was however larger than the indirect effect due to gender differences in numeracy skills in all countries except from Italy. The findings in this study offer a new contribution to the existing knowledge in the theory about mathematical self-concept and gender.

One study (Grønmo et al., 2004) indicates that gender differences in mathematical self-concept diminish among fourth and eighth graders, however further research is needed to tell whether this is a stable tendency and whether it applies also to young adults. Also, more research is needed to provide knowledge about possible ongoing changes of gender differences in mathematical self-concept, and to identify possible elements in the educational systems that can explain varying gender differences in mathematical self-concept across countries.

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