Lower secondary school students' gendered conceptions about mathematics and related careers

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Sweden is considered as one of the leading countries regarding equity work, but at the same time a country with a highly segregated labour market. This is true for graduate education as well, especially in mathematics, but not at secondary level. Previous studies have concluded that mathematics is considered a male domain, but little is known about mathematics and related careers. Here, the focus is on lower secondary students, and an online questionnaire was used. The results show that little gender stereotyping was made by both groups, but there were some nuances in the replies. Boys more often thought that female teachers and mums would reply that it is more important for boys to study mathematics in order to get a good job. Regarding who has the best requisites to study mathematics, the main response was 'Both'. The qualitative replies signal a relatively advanced understanding of gender as a social construct.

Introduction

Sweden is a country recognised internationally for its gender equality work (Weiner, 2005) and usually score high on international measures of gender equality. For instance, in 2019, Sweden was ranked first in EU (eige.europa.eu). At the same time, national and international research indicate that stereotyping is still an issue:

> Negative stereotypes about girls' and women's abilities in mathematics and science persist despite girls' and women's considerable gains in participation and performance in these areas during the last few decades. Two stereotypes are prevalent: girls are not as good as boys in math, and scientific work is better suited to boys and men (Hill et al., 2010, p. 38).

This is, for instance, present in teaching when studying teachers' interaction with students in science class, male teachers tend to favour boys in their interaction (Eliasson et al., 2016). Also, Sweden has gender segregated occupation, one of the highest in EU (Keisu et al., 2021) and, segregated university education (Sumpter & Sumpter, 2021). At the same time, at secondary level only a few vocational programmes are gender segregated and most programmes including the Natural Science programme has a division within the 40/60 division (scb.se). It appears that there is a shift between secondary school level and further education, and Brandell (2008) has concluded that gender work in Sweden has stagnated regarding mathematics, a conclusion still valid given the gender-equality paradox found in STEM education (Stoet & Geary, 2018).

Continuing with gender stereotyping, recent studies show that views/ conceptions/attitudes can be complex allowing contradictory elements (e.g. Sumpter, 2012), where students can express a very developed understanding of gender (e.g. Frid et al., 2021) and teachers saying ‘gender is not an issue’ (Gannerud, 2009). There is a tension which has been concluded as an area of “limited consensus” (Forgasz, et al., 2014, p. 371). With respect to this tension, especially regarding the segregated labour market, the aim of the present study is to study lower secondary school students’ conceptions about who might have stereotypical views about girls, boys, and mathematics. The research questions are: (1) Which groups have, according to 15 year olds, stereotypical views about mathematics and professions?; (2) Which groups have stereotypical views about who has the best requisites to work in professions using mathematics?; and, (3) How and in what ways have this changed over time?

Background

Gender is here considered a social construction, more than just a consequence of a biological sex (Acker, 2012). This includes seeing gender as a pattern of social relations, and that definitions of women and men depend on the context and definitions can be changed (Connell, 2019). The patterns are under constant negotiations and gender is thereby a dynamic process (Acker, 2012). As a theoretical framing, gender is here divided into the four different aspects (Bjerrum Nielsen, 2003): structural, symbolic, personal, and interactional gender. Structural gender cover social structures alongside with other factors such as class and ethnicity. One example of such a study that falls under this aspect is Mozahem et al. (2021) looking at age and gender as factors to understand how self-efficacy is developed, and the findings are discussed using theories about social roles. The second aspect is symbolic gender which appears in the shape of symbols and discourses (Bjerrum Nielsen, 2003). These symbols are part of a norm, hence providing information about what is considered normal and what is deviant. Symbols are bidirectional: it can be that an object or an abstract concept that is considered male or female, such as the idea of mathematics as a male domain (e.g. Brandell & Staberg, 2008). It could also be about how men and women are perceived, such the idea of the ‘the hard working female’ and ‘the male genius (Leslie et al., 2015). Personal gender is how individuals perceive the structure with its symbols (Bjerrum Nielsen, 2003). The following quote illustrates the experience of not fitting into the created norm:

> An advantage of being male would be to have been more encouraged to pursue a career in mathematics/engineering/technology. I would also have fitted in at high school better than I did—my Years 9 and 10 were spent on an all-girls campus where it was supremely uncool to be good at maths and science (Leder, 2010, p. 453).

This quote illustrates how gender symbolism and personal gender can be inter-related and seen as an interchange (Bjerrum Nielsen, 2017). Symbols have been shown to be powerful: the symbols mentioned above, ‘the hard working female’ (e.g. Hermione Granger) and ‘the male genius’ (e.g. Sherlock Holmes), are considered the main reason for gender imbalance at university level, functioning as an explanation for success

(Leslie et al., 2015). Another study indicates that both boys and girls at the Natural Science programme in Sweden stereotype girls as being insecure in mathematics, but when asked from a personal view, this was not repeated where boys more often answered that they were not sure (Sumpter, 2012). The last aspect described by Bjerrum Nielsen (2003) is interactional gender. It covers the interactions between individuals within the structure and its symbols. Here, we are interested in how individuals perceive themselves in the structure (i.e. personal gender) and symbols including stereotyping (i.e. symbolic gender).

Looking closer at mathematics education in Sweden, at lower levels and secondary levels, there are small differences regarding participation and in grades (Brandell 2008; Brandell & Staberg, 2008). Regarding participation, the main differences appear to be at graduate level, and mathematics stands out together with IT compared to other subjects (Sumpter, 2012). There are only a few studies focusing on gender stereotyping and professions related to mathematics (e.g. Hill et al., 2010), and in a relatively recent one, where almost 800 000 individuals from nine different countries where asked "Who are more suited to be a scientists?', most countries, such as Canada, Israel, and Singapore, had over 50% of the respondents going for the option 'Same' (Forgasz et al., 2014). Only two countries, China and United Arab Emirates (UAE) had the main response 'Boys'. Such results do not support the conclusion of mathematics as a male domain (e.g. Brandell & Staberg, 2008).

Methods

The methods section contains a description of how the instrument was designed, using a questionnaire that was revised, and some theoretical underpinnings of this revision. Then, there is a short description on how data were generated and methods of analysis.

Design of the instrument

The data were collected using an instrument that builds upon a well-known questionnaire that was designed to study individual's attitudes about gender and mathematics (e.g. Gómez-Chacón et al., 2014). The first attempt on translating and piloting the questionnaire indicated several limitations although following "good practices" (Nortvedt & Sumpter, 2017). The results were about both intercultural and intracultural differences, including feedback such as "you can't ask question like this". The decision was to reconstruct the questionnaire so it could function in a Nordic context. As a step towards this revision, a literature review was made. It showed that most prior research treat gender as a cultural-neutral construct and do not consider cultural dimensions (Sumpter & Nortvedt, 2018). This meant, for instance, that the respondents very seldom were able to demonstrate knowledge about gender beyond the classic male –female dichotomy or express any nuances or an awareness about gender stereotyping, which falls under gender symbolism (e.g. Bjerrum Nielsen, 2003). As a theoretical tool for the revision, the choice was to apply Clarke (2013)'s seven dilemmas: (1) Cultural-specificity of cross-cultural codes; (2) Inclusive vs Distinctive; (3) Evaluative Criteria; (4) Form vs Function; (5) Linguistic Preclusion; (6) Omission;

and, (7) Disconnection. It resulted in several revisions, where one solution was to use vignettes (Nortvedt & Sumpter, 2018). For Question 2a, the vignette was: “Traditionally, one has said that it is important to study mathematics to get a ‘good’ job. What a ‘good’ job is has not been defined and there can be many different conceptions what it is”. By adding such a vignette, the context enables the respondent to express perceived gender stereotyping from others whilst expressing a personal attitude that might differ. The question posed to the respondents were: What do you think the different groups would answer to the question “For whom is it most important to study mathematics to get a ‘good’ job, girls or boys?’. The response alternatives consisted of a matrix where one dimension had the alternatives Most important for girls/Most important for boys/Equally important for both groups/It is not about gender/I’m not sure, and the other dimension had the groups Girls in grade 9/Boys in grade 9/Dads/Mums/Male teachers/Female teachers/Girls in general/Boys in general/You. This would allow the respondents to answer both from a personal view but also signal that other groups might think differently (e.g. Sumpter & Sumpter, 2021). Question 2b was a follow up question asking if this has changed over time allowing the respondents to write a comment if they wanted to. Question 3 had the same set up, but with the focus on who has the best requisites about professions where one uses mathematics. The pilot study indicated that the questionnaire did allow respondents to demonstrate their awareness of a range of culturally rooted differences in attitudes towards boys’ and girls’ abilities to learn mathematics (Nortvedt & Sumpter, 2017). The results from question 1a and 1 b, then focusing on the attributed symbols regarding who is considered best in mathematics, have been presented in an earlier paper (Frid et al., 2021).

Data collection and methods of analysis

The data were generated by asking lower secondary school students (grade 9; age 15; *n*=241) from seven schools in different locations in Sweden (north/south; rural/town/city). Since we followed the Ethics rules provided by the Swedish Research Council, meant that students who had not turned 15 before December 2019 could not participate. According to Statistics Sweden, it should be around 6% of the population which is equivalent to two students per class. The questionnaire was made in Survey tool provided by Stockholm University which included both safe treatment of data and anonymous replies. Given that online surveys have less response rate (Fan & Yan, 2010), the second author used personal contacts to find participating schools. The quantitative data were analysed using statistical analysis, chi-squared test, of the replies used stated gender (boy/girl) as a factor (*n*=222) with the aim to see where girls’ replies differ from boys’. The descriptive statistics were generated through the Survey tool. Reliability measured by Cronbach’s Alpha coefficient for this scale was .909. The qualitative responses were analysed using inductive thematic analysis (e.g. Braun & Clarke, 2006), and then compared to previous research as a second step. Thematic analysis, in short, meant that we searched for similarities and differences in the written replies, gathering similar statements using a coding scheme. One example of code could be “symbols has changed” and the overarching theme was called “change over time”. The themes were then compared to make sure that they were not overlapping.

Results

The results are presented with first looking at the results about symbols about for whom it is most important to study mathematics, and how in what ways this might have changed over time. Then, the focus is on related professions to mathematics and which groups might have stereotypical views about this. Note that each category might have small variations in the number of respondents with the results that percentages could differs slightly. The main responses in each category are presented in bold.

		Most important for girls	Most important for boys	Equally important	Not about gender	I'm unsure	*p*
Girls in grade 9	Girls	24(21.6)	5(4.5)	**60(54.1)**	18(16.2)	4(3.6)	>0.05
	Boys	13(11.9)	8(7.3)	**56(51.4)**	21(19.3)	11(10.1)	
Boys in grade 9	Girls	13(12.1)	19(17.8)	**51(47.7)**	18(16.8)	6(5.6)	>0.05
	Boys	9(8.4)	19(17.8)	**50(46.7)**	20(18.7)	9(8.4)	
Dads	Girls	7(6.5)	15(13.9)	**63(58.3)**	20(18.5)	3(2.8)	>0.05
	Boys	5(4.8)	18(17.1)	**54(51.4)**	18(17.1)	10(9.5)	
Mums	Girls	8(7.4)	2(1.9)	**68(63.0)**	26(24.1)	4(3.7)	<0.05
	Boys	6(5.7)	13(12.4)	**54(51.4)**	23(21.0)	9(8.6)	
Male teachers	Girls	7(6.6)	7(6.6)	**60(56.6)**	29(27.4)	3(2.8)	>0.05
	Boys	4(3.8)	11(10.5)	**59(56.2)**	22(21.0)	9(8.6)	
Female teachers	Girls	9(8.6)	2(1.9)	**61(58.1)**	31(20.5)	2(1.9)	<0.05
	Boys	7(6.6)	9(8.5)	**59(55.7)**	23(21.7)	8(7.5)	
Girls in general	Girls	24(22.4)	3(2.8)	**51(47.7)**	24(22.4)	5(4.7)	>0.05
	Boys	16(15.1)	11(10.4)	**47(44.3)**	21(19.8)	11(10.4)	
Boys in general	Girls	12(11.2)	16(15.0)	**52(48.6)**	19(17.8)	8(7.5)	>0.05
	Boys	8(7.5)	24(22.6)	**43(40.6)**	21(19.3)	10(9.4)	
You	Girls	16(14.8)	2(1.9)	**58(53.7)**	30(27.8)	2(1.9)	<0.05
	Boys	3(2.9)	8(7.6)	**55(52.4)**	28(26.7)	11(10.5)	

Table 1. Responses to “For whom is it most important to study mathematics to get a ‘good’ job, girls or boys?, *n*(%).

As we can see in Table 1, most students opt for the response ‘Equally important’ for all groups including ‘You’. The analysis showed that girls’ and boys’ responses differ statistically significantly regarding three groups. The first two groups, mums and female teachers, can be seen as stereotyping, and it is boys that state that these groups to a larger extent say it is more important for boys. Girls, on the other hand, respond that female teachers would say that this is not about gender. When looking at responses related to the aspect ’personal gender’, you, the main difference is that girls more often say it is more important for girls to study mathematics in order to get a ‘good’ job. The next step was to study if this has changed over time (see Table 2):

	Yes	No	I’m unsure	*p*
Girls	**85(75.9)**	9(8.0)	18(16.1)	<0.05
Boys	**56(50.9)**	22(20.0)	32(29.1)	

Table 2. Responses to “Has this changed over time?, n(%).

Table 2 shows that the responses are statistically significantly different: girls more often reply that this has changed over time. Looking at the qualitative replies, two main themes were identified. The first one is about the process of gender symbols and gender structure has changed:

Girl [3]: Before, professions were more divided into what was considered female and male, but now it is not as much of that.

Boy [3]: Since technology has developed, more jobs are opened up that both boys and girls want to have.

The other theme is about gender structures and how it can have consequences, resulting in a segregated labour market:

Girl [4]: I think it is more important for girls since in general, it is more difficult for them to get a good job since girls on average get less in salary than boys.

Here, the reply signals that if one is working towards a change, it is more important for girls to study mathematics. There is no implication that girls or boys are better or worse at the subject, it is about the structure (less salary) and what that entails (difficulty getting a certain profession). Neither of these themes explain why girls’ and boys’ replies differ.

The next results are about how the students perceive if and how different groups might have stereotypical views about who has the best requisites to work in professions using mathematics, see Table 3:

		Girls	Boys	Equally good requisites	Not about gender	I'm unsure	*p*
Girls in grade 9	Girls Boys	15(13.4) 17(15.6)	23(20.5) 29(26.6)	**41(36.6)** **37(33.9)**	23(20.5) 19(17.4)	10(8.9) 7(6.4)	>0.05
Boys in grade 9	Girls Boys	11(10.2) 8(7.5)	31(28.7) **40(37.4)**	**44(40.7)** 31(29.0)	14(13.0) 19(17.8)	8(7.4) 9(8.4)	>0.05
Dads	Girls Boys	7(6.5) 7(6.6)	31(28.7) 33(31.1)	**48(44.4)** **37(34.0)**	12(11.1) 23(21.7)	10(9.3) 6(5.7)	>0.05
Mums	Girls Boys	8(7.4) 12(11.3)	13(12.1) 19(17.9)	**55(51.4)** **41(38.7)**	22(20.6) 28(26.4)	9(8.4) 6(5.7)	>0.05
Male teachers	Girls Boys	6(5.6) 6(5.8)	18(16.3) 18(17.5)	**55(51.4)** **52(50.5)**	21(19.6) 21(20.4)	7(6.5) 6(5.8)	>0.05
Female teachers	Girls Boys	5(4.6) 9(8.6)	12(11.1) 13(12.4)	**62(57.4)** **52(49.5)**	22(20.4) 25(23.8)	7(6.5) 6(5.7)	>0.05
Girls in general	Girls Boys	15(14.2) 20(19.0)	21(19.3) 26(24.8)	**37(34.0)** **29(27.6)**	23(21.7) 19(18.1)	10(9.4) 11(10.5)	>0.05
Boys in general	Girls Boys	7(6.6) 12(11.4)	30(28.3) **37(35.2)**	**40(37.7)** 28(26.7)	19(17.9) 19(18.1)	10(9.4) 9(8.6)	>0.05
You	Girls Boys	4(3.7) 7(6.8)	19(17.8) 21(20.4)	**42(39.3)** **33(32.0)**	31(29.0) 29(28.2)	11(10.3) 13(12.6)	>0.05

Table 3. Responses to "Who has the best requisites to work in professions using mathematics, girls or boys?, *n*(%).

Table 3 shows that none of the categories have responses that are statistically significantly different. But there are some patterns within the responses. One that is worth lifting is that only 3.7% of the girls say that girls have the best requisites compared to 20.4% of the boys about boys having the best conditions. Also, the stereotyping made by boys towards the groups Boys in grade 9 and Boys in general, is not repeated when replying as 'You'. When asked if this has changed over time, the majority replied 'Yes':

	Yes	No	I'm unsure	*p*
Girls Boys	**51(47.2)** **48(44.4)**	18(16.7) 23(21.3)	39(36.1) 37(34.3)	>0.05

Table 4. Responses to "Has this changed over time?, *n*(%).

As we can see in Table 4, the responses are not statistically significantly different. The qualitative replies were gathered into two themes: those who have witnessed a change and those who argue that there has been no change:

Girl [5]: It is more common with women working in those professions, and because of that the conditions for girls/ women who wants to work in those types of business have been better.

Boy [5]: Before, boys had the norm on their side to get more advanced professions but now, this has stabilised.

Girl [6]: I don't think this has changed over time since the norm is that guys should work with such professions and then, they automatically get better prerequisites since they are right for the job.

These replies illustrate an awareness of gender structures with including norms and the dynamic process of gender. The motivation given by Girl [6] show how symbolism inter-relates with other aspects of gender. Combined, there is an awareness that some things have changed but still gender inequality exists in our society.

Discussion

This study focused on lower secondary school students' conceptions about mathematics and in particular how they perceived how different groups would stereotype mathematics and related professions. The main result is that the majority of girls and boys reply that they think that most groups (e.g. parents, teachers) do not hold stereotypical views regarding who have the best requisites to work professions using mathematics. This result does not support the traditional view that mathematics is a male domain (e.g. Brandell & Staberg, 2008). Regarding who are most suited to work in a profession, the most common response was that both groups were equally suited. This is a similar result as Forsgasz et al. (2014), and the explanation of the segregated higher education and labour market (Keisu et al., 2021; Sumpter & Sumpter, 2021) lays elsewhere. If we want to understand why girls do not continue with mathematics, we need to look beyond compulsory schooling. This is a suggestion for further research.

There are some micro-level results. One is the perceived difference between boys and girls regarding stereotyping whether it is more important for one gender to study mathematics. The qualitative analysis generated two themes that neither fully explain why there is a difference. When trying to understand the themes using the theoretical underpinnings of gender (e.g. Acker, 2012; Connell, 2019; Bjerrum Nielssen, 2003), one notices how aware the students appear to be of gender as a social construct. The students talk about dynamic processes, using norms and example of gender structure as a base for their motivations. In that sense, gender work has not stagnated (c.f. Brandell, 2008). When comparing their awareness with the teachers in Gannerud's (2009) study, an interesting implication arrives: either the students are more informed than teachers, or teachers do involve gender in their teaching. Such a study, comparing two different groups, would be an appropriate second step of research. Also, when teaching about gender issues in school, students might have a more advanced view of gender compared to their teachers. This is something that should be acknowledged in teacher education.

Another result is that boys sometimes tend to stereotype boys as a group which could be seen as an indication of 'mathematics as a male domain', which is not replicated when asked from an individual perspective, as personal gender. This could be seen as an example of intra-cultural tensions (e.g. Clarke, 2013; Frid et al., 2021; Nortvedt & Sumpter, 2018). This is a more refined description compared to “limited consensus” (Forgasz, et al., 2014, p. 371). One possible explanation is that the updated instrument does allow different views to be expressed, including nuances, compared to earlier studies (e.g. Brandell & Staberg, 2008; Forgasz, et al., 2014). We therefore suggest a second study on upper secondary school students from different programmes to see if the idea of mathematics as a male domain is (still) present.

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