FOUR FEMALE MATHEMATICIANS' COLLECTIVE NARRATIVE: REASONS TO LEAVE ACADEMIA

Lovisa Sumpter

Dalarna University, Sweden

lsm @ du.se

In this paper, I explore four Swedish female mathematicians arguments for why they decided not to work in academia after finishing their PhD. These stories were merged into one narrative, the fictive voice of Sarah. Her story describes life as a female PhD student in a mathematics department as a positive experience. The two main reasons to why she decided not to stay at the university were (1) the difficulty of getting a job, and (2) her wanting to work with applications and problem solving instead of working with the development of theories.

Keywords: Conceptions, female mathematicians, gender, higher education, post-PhD

INTRODUCTION

In United Nations Convention on the Elimination of Discrimination Against Women, the principle of equal rights for women and men is established including the stating of equal opportunities. Still, many work situations show old patterns of inequality. In Sweden, a country with a reputation of being ahead in terms of gender equality (Weiner, 2005), the issue of gender segregation in labour market has been noted and reported (e.g. Bergström, 2007). A relevant question posed by Watt (2008) some years ago is "Why do men and women frequently end up in different kinds of careers" (Watt, 2008, p. 3). This question addresses some important issues especially looking at the lack of women in mathematics departments. Watt (2008) concluded that women are both less likely to enter mathematics and more likely to leave. Women seem to 'disappear' through the grades and following academic professions. Sweden has a 50-50 division at the most mathematical intense upper secondary school programme, but at undergraduate level, one third of all students in mathematics or other mathematics intensive courses including engineer and teacher education are female (Brandell, 2008). This is similar to the situation in many western countries e.g. USA (Herzig, 2004) and the UK (Burton, 2004). Moving up in the career ladder, the number of women lectures or professors decreases even more. In USA, a postdoc is a strong factor for the possibility to get a tenure track and the number of women doing a postdoc is far less the number of graduate students (Nerad

& Cerny, 1999). Looking at the UK, only 2 % of the professors in mathematics in 2002 were women (Burton, 2004). In 2007, the number of female post-docs in mathematics in Sweden was 6 %, senior lecturers 21%, and professors 7% (Lindberg, Riis & Silander, 2011), and there is a difference in which area these professors worked in. In 2008, the distribution of 13 female professors in mathematics was the following (Wedege, 2011): mathematical statistics (n=5), mathematics education (n=3), applied mathematics (n=2), pure mathematics (n=2) and numerical analysis (n=1). At the same time, there were 138 male professors and 67 of them worked in pure mathematics. This means that some areas are more male than others. Hence, even within a subject (here mathematical sciences), men and women end up in different kinds of careers and this in a country described as a "society in which gender equity is highly valued at societal and political levels" (Brandell, 2008, p. 659). So even though gender equality is a component in the Swedish self-image (Liinasson, 2010), it is not visible in a Swedish mathematics department.

In general, women are in majority at undergraduate level not only in Sweden but also in many other countries (UNESCO, 2007). However, higher education has a strong gender structure and the number of women is reduced when you move up the hierarchy. In EU, on average, 45 % of all PhD graduates were women in 2006 (European Commission, 2009). About one third of the world's researchers are women, but the number of professors is lower (UNESCO, 2007) and the proportion of women is the smallest (18%) when we look at grade A academic staff in EU (European Commission, 2009). Focusing on Sweden, the Glass Ceiling Index (GCI) is higher compared to the average of the EU (European Commission, 2009) implying that 'glass ceiling' is lower. The main problem seems to be number of women disappearing especially between PhD and further careers. Why do women leave? According to Connell (2006) gender division of labour is not just a question of glass ceilings but more a question about gendered institutions including relations of power and symbolism. This paper aim to explore female mathematicians' expressed conceptions about their decisions. The research question posed is "What reasons do female mathematicians give for leaving mathematics as an academic profession?"

BACKGROUND

In this paper I use two main concepts, gender and conceptions. I will here discuss these two concepts.

Gender

In this paper, I follow Connell (2006) and gender is understood as:

> "a pattern of social relations in which the positions of women and men are defined, the cultural meanings of being a man and a woman are negotiated, and their trajectories through life are mapped out." (Connell, 2006, p. 839).

Therefore, gender is a social construction more than a consequence of a biological sex (West & Zimmerman, 1987). It refers to what is thought of

> “as socially constructed differences between men and women and the beliefs and identities that support difference and inequality” (Acker, 2006, p. 444).

One conclusion provided by Damarin and Erchick (2010) is that gender is best described or viewed as a dynamic process meaning that the attributions, beliefs, identities etc. are not static. An example of such a process is that thought of femininity and masculinity in the school discussion in Sweden in the 1970s were understood as sex roles or sex-value roles (Hedlin, 2013), terms that have a more narrow view compared to the definitions presented above.

The concept gender can be divided into different aspects or dimensions. Connell (2006) uses four dimensions when describing gender as social relations: gender division of labour, gender relations of power, emotion and human relations, and gender culture and symbolism. This model works well analysing for instance an organisation’s gender regime. Another way of viewing gender is the four different aspects presented by Bjerrum Nielsen (2003). These are structural, symbolic, personal, and interactional gender. Structural gender refers to gender as part of a social structure alongside with other factors e.g. ethnicity and class. The number of female PhD students in mathematics in Sweden in relation to male students or the percentage that gets an academic profession is an example of structural gender. Symbolic gender stems from these structures such as that symbols and discourses are attributed to a specific gender creating norms and trajectories that tell us what is normal and what is deviant, e.g. the idea of mathematics as a male domain (Brandell, Leder & Nyström, 2007) or what girls and boys are thought of as mathematics students (Walkerdine, 1998). The third aspect is personal gender. It focuses on for instance how the individual perceive the structure with its symbols, e.g. girls’ different views of themselves as students in mathematics (Mendick, 2002) or female professional mathematicians description what it is like to work in a mathematics department (Burton, 2004). It can also be about how a person develops gender within a structure (e.g. Walls, 2010). Personal gender and symbolic gender do not have to overlap and can even contradict each other, e.g. girls are considered insecure in mathematics but don’t feel insecure themselves (Sumpter, 2012).

The structure and its symbols can influence in a constant on-going process. Solomon (2012) studied women undergraduate students in mathematics and she concluded that they were forced to work with their identity, their self-concept as ‘a woman in mathematics’, including how they talk about themselves and their situation. It is about adapting your view of yourself into the norms you are supposed to fit in. When gender norms are not met it can create confusion, a situation described by Connell (1996) as ‘gender vertigo’.

The fourth aspect is interactional gender. This is when we see gender through social interaction: how people interact with each other or how the structure is created e.g. studies that focus on situated learning. Compared to personal gender, which could describe gender as something we “are”, interactional gender is something we “do” (Wedege, 2011). These four aspects on gender are not separate components, but more an analytical tool used to highlight different sides of the same phenomena. An example how these aspects are inter-related is in how stereotype threats work in salary negotiations, leaving women with less salary then men (Tellhed & Björklund, 2010). Stereotype threats falls under symbolic gender, affecting personal gender (how you see yourself) and interactional gender (negotiation of salary) resulting in women getting paid less than men for the same job (structural gender). Another example is the case of homosociality (Lipman-Blumen, 1976), a pattern where primarily men construct and choose situations dominated by men. An example of this would be male professors choosing male PhD students similar to themselves, and male students opting for mathematics since it is a ‘good’ environment. The symbols, self-concept and interactions shape the structure and the structure produces norms. Connell (2006) calls this overall pattern of gender relations within an organisation for gender regime, and it “provides the context for particular events, relationships, and individual practices.” (Connell, 2006, p. 839).

In organisations, gender together with class and race create the base for inequality (Acker, 2006). For a long time, gender and class were often integrated in many organisations but this has changed. Gender is still a main factor for women participation at work. When studying Swedish bank worker, Acker (1994) saw that men ‘aspiranters’ (those aspiring to a career in the bank world) were trained for managerial work whereas the women were given tasks such as answering the phone or work as tellers. Thereby a filter for further careers was created, similar to the chance to have a post doc position and the probability to get a tenure track (Nerad & Cerny, 1999). In this way, gender structures are created. Other factors that are related to the structure are norm-controlled self-selections and internal and external factors such as how research grants and other funding are distributed (Lindberg, Riis & Silander, 2011). Husu (2005) concluded that in higher education, female professors and female colleagues were important sources for support for female researchers. Similar ideas have been expressed by female mathematicians (Henrion, 1997). You need help if you want to move on. This seems to be true for undergraduate studies too. Undergraduate students in mathematics at English universities point out how important the relationship is with the tutors (Solomon, Lawson & Croft, 2011). Tutors could be ‘good’ but also be described as having power and authority and thereby working as a gate. If to look at obstacles, the lack of support and discrimination (both explicit or hidden) are two main factors behind women struggle to advance in their careers especially when the work situation often are uncertain (Husu, 2005; Husu, 2013). This has also been noticed in mathematics (Henrion, 1997) and in other STEM subjects (Heilbronner, 2013). Women in STEM subjects reported to have less research support and less opportunity to advance in their career but also found it hard to freely express their ideas (Xu, 2008). The idea of support was raised by Leder (1995) in a review looking at elements contributing to successful graduate studies. Women graduate students were then more likely to feel overlooked, neglected and receiving of less support. It appears that if a woman is less integrated in her department and in scientific networks, she will have more problems in pursuing a career in research. Women in male-dominated professions don't seem to benefit of the 'glass escalator' as men in female-dominated professions (Budig, 2002; Williams, 1992). Instead they hit the glass ceiling (Hultin, 2003). Budig (2002) summarised the theory of gendered organisations developed by Acker/ Williams as

> "women are not disadvantaged simply because they lack work experience, seniority, or other human capital. Instead, or in addition, women are disadvantaged because the typical woman does not fit the disembodied category of the ideal worker: (Budig, 2002, p. 261)"

Applying this theory to female in mathematics and with mathematics as a male domain, women are not and cannot be mathematicians just by default.

Conceptions

This paper studies female mathematicians' conception. Conception is here defined as "a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences" (Philipp, 2007, p.259). This would imply that conceptions may have both affective and cognitive dimensions. As parts of conceptions you have beliefs such as beliefs about yourself (Schoenfeld, 1992) and self-identity (or self-concept). Self-identity can be viewed as "a person's perceptions of him- or herself" (Marsh & Shavelson, 1985, p. 107) including dimensions as your capacity or your role in different situations (Devos & Banaji, 2003). Conceptions should be viewed, just as gender, as a dynamic concept that is developed and changed through interactions and experiences.

METHOD

A written questionnaire was sent out to nine female mathematicians from six different Swedish universities (different sizes; north to south) that finished their PhD in mathematics during the years 2002-2012. Mathematics is here interpreted as mathematical sciences such as pure and applied mathematics, mathematical statistics, computational mathematics and optimization but excluding mathematics history and mathematics education. The author knows four of the women and the other five were found through a mutual contact or the Swedish network 'Women and mathematics', a sub-organisation of IOWME. Since the answers to the questionnaire were kept anonymous, and the respondents were aware of this, the assumption is that the difference connections did not affect the objectivity or the quality of the replies. The respondents were instructed that they could write as much or as little as they wanted. Four main questions were posed: (1) Why did you become a mathematician/ Why mathematics?; (2) Why did you do a PhD in mathematics?; (3) How was your experience as a (female) PhD student in mathematics?; and, (4) You have a career outside the university. How did that come about? To each of theses four questions, several optional sub-questions were listed. The respondents were also encouraged to write something about their background. The answers were sent back within two weeks. A first analysis of the data showed that four of them had similar answers describing a slightly more positive experience whereas the remaining five shared a more negative view. In this paper, I will focus on the first four. They come from three different universities. These replies constitute the base of for the story presented as Sarah's. In another paper (Sumpter, 2014) I have performed a similar analysis on the other five responses.

The method of analysis used in this paper collective narrative meaning that one story is created by interweaving the (written) answers from several respondents. It is a tool to emphasize meaning of responses (patterns) in a collective context rather than to show individual's replies (Mendick, 2002). Here, the collective narrative analysis shares similar goal as content analysis with the aim to identify traits of the material (Smith, 2000). In this paper, the traits are told by a fictive voice creating sharing 'her' story. This also helps to keep the respondents anonymous especially in a small community such as female mathematicians in Sweden. Mendick (2002) argues that collective analysis also can have a theoretical point when the focus is on identity "and the mode of data analysis should be motivated by this understanding" (Mendick, 2002, p. 3). It is about how individuals identify themselves relative to mathematics but instead of presenting data isolated, individual by individual, collective narrative analysis reports the results as an interview and thereby allow for the context to come through but still presenting patterns. As common in narrative analysis, my own voice is part of the story (Smith, 2000) although I've tried to minimize it as much as possible by using the respondents' own formulations. In some cases, the formulations have been joined together to one sentence and when needed I've changed the context (e.g. seminars have become lessons) to make sure that the specific person/ situation can't be identified. In both these cases, the meaning of the replies remains the same.

This is a qualitative study that aims to describe some female mathematicians' voices with no aim to generalise or trying to grasp over all their conceptions including their self-concept. Since self-concept can have both descriptive and evaluative dimensions, e.g. I am angry or I am bad at mathematics (Marsh & Shavelson, 1985), the respondent's answers can have both these characteristics. These expressions can differ from other evaluative constructs e.g. grades. It falls under the personal aspect of gender focusing on women's own expressed conceptions in the role of 'female non-academic mathematician'.

RESULTS

The story of Sarah is the result of the analysis of four female mathematicians replies. In this story, their conceptions have been combined into one trait.

Sarah

Sarah was born and grew up in a middle size town in Sweden. (She can also have been born in another country and immigrated to Sweden as a young adult.) She studied the most mathematical intensive program at upper secondary school (age 16-19), the natural Science Programme. Sarah's parents have always supported her, but they didn't work in mathematics themselves. When she was 25-30 years old, she started her PhD almost right after her undergraduate studies (which was in mathematics/applied mathematics/mathematics statistics combined with engineering/ physics/ statistics; 4-5 years). During her PhD, she had no children and therefore did not experience what it was like to be on parental leave. Sarah finished her PhD when she was around the age of 30-35. This is now 1-10 years ago. She had both female and male supervisors (where the most common situation was only male supervisors).

Sarah is now working as a mathematician/ researcher in a private corporation or at a council/governmental institute. Why did Sarah choose mathematics in the first place?

> I have always liked math already from an early age. When I succeeded in school, the subject became more fun. It worked liked a positive spiral. After graduating from upper secondary school, I didn't know what to choose so I went for subjects that I liked: math and physics. With time, my interest for physics decreased and my interest for math increased especially for applied mathematics/mathematics statistics. It surprised me how versatile the subject is! You can work in so many different areas. And I like the logic behind it.

The step to do a PhD was pretty straightforward but there were also people who expressed negative opinions:

> When you study, there are so few students so you get both good contacts with the other students and with the teachers, but also a look into the world of academia. So, with some encouragement from my male supervisor that I had when I wrote my final essay, I applied for a PhD and I got a position. There were some individuals that thought that I wasn't clever enough, but it didn't effect me.

Sarah got a PhD position at the same department where she had done her undergraduate studies. Her main topic was applied mathematics/mathematics statistics. How was it then to be a (female) PhD student in a mathematics department?

> I enjoyed being a PhD student. It was mainly a positive experience. There were several female PhD students when I started (in my group) so there were no hinders [left] because of that. I learnt a lot from my supervisors, not just science. And I worked closely to other groups both outside mathematics and the university, which meant that I got valuable insights in how things can work in different places in and outside academia. Even if women and men were treated differently at the department, I didn't notice/experience anything. My supervisors treated me with the greatest respect. I sat in decision-making boards at the department as a PhD student and I always felt they listened to what I said. But later I've heard what have happened to others. I didn't have any children while I was a PhD student. During the first years, it wasn't on the agenda, and later I found it hard to be on parental leave.

Sarah had a positive experience from the mathematics department. However, staying in academia was not really an alternative. She explains:

> I didn't want to stay in academia and I had no plan to stay. I wanted to apply my knowledge. I like my work a lot. I get so solve problems, which is the most fun part of research, but I do not have to pursue my own research project. I find this work much more meaningful – to apply – than to do theoretical work.

It is the application of mathematics and the problem solving Sarah emphasizes. But there are things Sarah misses from the academia.

> What I can miss from the university is the freedom: the freedom to choose your work and the flexible work situation such as working hours. My job now is more based on commissions. But overall it felt so unsafe with employments at the university. It is so hard to get a permanent position [at the university]. Also, you had to go abroad and do a post doc and that didn't work for me since I wanted to start a family and have children. And you have to apply for grants, which you are most likely not to get.

Sarah also talks about the view of mathematics as a closed subject:

> In Sweden, for some reason, there is little interest in that researchers changing between the university world and outside academia. There are not many mathematicians that decide to work with other subjects (such as biology and medicine). Instead, you meet researchers [in other subjects] struggling with models they don't fully understand. As I see it, you should encourage researchers in mathematics that like applications to work in other subjects, to collaborate with other people.

Summary

Sarah gives two main reasons for why she is working outside academia. The first reason is the lack of full-time, long-term jobs in academia. The jobs available are short-term contracts with little security. The other reason is the nature of the work. Sarah is interested in the applications of mathematics and to use mathematics to solve problems. She thinks that mathematics (in a mathematics department) is a closed world and it would be better if mathematicians open up their eyes for other subjects.

DISCUSSION

This paper started by presenting the data on the decreasing numbers of female participation in mathematics when moving upwards in the career ladder. The aim of the study is to give a voice to the women who 'disappear', here between PhD and further academic research and teaching professions. In another paper, I addressed a more negative story (see Sumpter, 2014). For Sarah, even though she enjoyed being a PhD student in a mathematics department, staying in academia was not part of her plan. The first explanation Sarah gives for not working in a mathematics department is the difficulty of getting a permanent position. This is related to structural gender. The types of job, the uncertainty of getting them and short-term contracts seems to create a filter that has been noticed before for women scientist (Husu, 2005). Women who like to pursue a career at the same time having and/or providing for a family find it hard to take such work contracts. No one mentions the size of the salary, but it is the knowing that you have a salary (at all) that matters. Sarah continues describing this filter by saying that a post-doc abroad was not an alternative since she wanted to stay in Sweden. One reason for this was the wish to start a family. Post doc seems to be a filter for further career not only in USA (Nerad & Cerny, 1999) but also in Sweden and thereby working as a norm-controlled self-selection in the structure (Lindberg, Riis & Silander, 2011). Those who are not willing to take such work contracts or want to stay time abroad have no future in mathematics as an academic. Other factors are the application for grants, which is a time consuming business. If you then add that you are most likely not to get these grants, you might ask why you should be part of such a system. This is a structural problem similar to what was reported as a general problem for women in STEM subjects (Xu, 2008). If you want to pursue research in academia you need research grants, and to get research grants you need support. Also, Sarah is not interested in applying and managing her own research project. Therefore, life in academia was not an option.

The second explanation is based in the nature of the work and the subject itself (as it is created). Sarah wanted to apply her knowledge, to use her skill, in other contexts. She was never interested in theoretical work for its own sake. She describes mathematics as slim in scope or perhaps a bit narrow when done in isolation. As a result, she experiences that other researchers are struggling with the mathematics. Sarah would rather see more cooperation between mathematics and other subjects. She emphasises the collaboration with other subjects and outside academia partners both during her PhD and now in her profession as a positive thing. What she describes is conceptions about mathematics as a subject (see Schoenfeld, 1992 for a longer discussion about what beliefs about mathematics as a subject might encompass). Sarah is more interested in applications, and according to her, you have a better chance to do this outside the university.

The common trait for all the female mathematicians that responded this questionnaire was the joy and love towards the subject (see also Sumpter, 2014). Sarah says that she has always liked mathematics from an early age and that she was successful in it. Her (self-)conceptions include the idea that this is a subject for her, a conception that would go against the main view saying that mathematics is a male domain (Brandell, Leder & Nyström, 2007). The positive experiences continue when she moves on to a PhD. Sarah mentions that there were already several women in her group when she started. As several researches already have concluded (eg. Henrion, 1997; Husu, 2005) female colleagues are important when it comes to support, and support is important for advancing in a career (Heilbronner, 2013; Leder, 1995; Xu, 2008). Sarah describes this support such as that some obstacles were gone. It shows an awareness of that the situation has been different, or that other mathematical subjects/departments may have another climate. It could also be an indication that

Sarah was not in an environment affected by homosocial segregation (Lipman-Blumen, 1976), an environment that was open for different norms (Connell, 1996). If there is space for several norms, or a wider norm, the chance is greater that the individual feel that she (or he) 'fits' in. This could be seen in a general level such as 'female in mathematics' but also on group-level such as particular research groups in a university. Following this idea, it is interesting to note that the four women that create Sarah's story all work in mathematical sciences focusing on applications. Do certain areas in mathematics have a better working environment for women? This question has not been addressed in this paper, but it is plausible to think that different micro-climates are created in different mathematical subjects and/or in different universities. Such a question is relevant for further research since it would help us to explore what is a successful working climate for female mathematicians compared to those women who leave mathematics without positive experiences such as Sarah's.

NOTE

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