

ADA LOVELACE DAY: ARE WOMEN IN BRITAIN AFFRAID OF MATHEMATICS?

I think the honest answer to this is that certainly too many women are afraid of mathematics (and I suspect also quite a few men!). There are plenty of known statistics about this and they all tend to show lower numbers of women, sometimes much lower, engaging with mathematics and science both at school and university.

So, why does this happen? There are two main factors that affect all our likings, choices and abilities. They are usually summarized as a competition between nature and nurture. If we consider the nature side then there is certainly no evidence that women are less able to understand mathematics or science (even if this was a view held for many centuries, including at the time of Ada Lovelace). There may be people out there that still hold this view but I suspect none of them is here (at least, I hope so). The decisive factor here must then be “nurture”. This comprises lots of things, essentially everything that is independent of our genes but which shapes the kind of people we become and, in particular, whether or not as women, we feel confident learning maths. From my own experience I think that there are three main factors, which could be included under the “nurture” headline: family, the wider society and school. So how do these three different (but interconnected) things affect the way women learn mathematics? Well, it is of course complex, but let me tell you some of my thoughts:

Let’s talk about the family: family, especially when we are children, shapes our opinions and behaviours. It often determines what we think is normal or acceptable and what we think abnormal or unacceptable. The family plays a crucial role in passing on attitudes to learning:

- 1) by recognizing the empowering value of knowledge, beyond material gain or immediate usefulness
- 2) by demonstrating the value of knowledge through its practical use
- 3) by showing that there is no field of human knowledge that is beyond anyone’s grasp, whether you are a boy or a girl, provided you work hard
- 4) by at least expressing the belief that every subject can be creative, stimulating and interesting and if possible by providing appropriate learning tools

These attitudes may seem ambitious and you may doubt whether or not some of them can really be passed on to small children. I am convinced that children do really copy their environment and in this context parents’ attitudes to learning can have a huge influence, as they indeed had for me. I also want to say that I don’t think the attitudes above should be the preserve of highly educated parents. There is a huge difference between valuing knowledge and having knowledge. It is my firm belief that valuing knowledge and making this known to your children is more powerful than actually being highly educated and perhaps overwhelming them.

Sadly, I believe these attitudes are not present in some families. And this is not entirely their fault but is part of a wider societal issue. An attitude which I particularly resent, is that in our society the appreciation and admiration of those that have knowledge has given way to appreciation and admiration of those that have money (and often not that much knowledge). In this context, the idea seems to have taken root that studying anyway is pretty useless as you may do better by exploiting other perhaps innate or unique skills. Implicit within that reasoning is often the idea that knowing and understanding stuff is no use if it doesn’t have an immediate practical use (such as getting you a job). Of course, earning enough to survive is very important, but it would be healthy to remind ourselves that knowing and understanding things can actually change you as a person, it can open your eyes to the world, it can give you opportunities, it will allow you to understand your surroundings, it may stop others from exploiting you and it is a pathway to improving yourself which is open to you all your life. I believe that if you really believe this then your children will instinctively feel it very soon.

Since I have already said something about society, let me proceed to describe how I think society is negatively influencing girls and women choices. In choosing to study Mathematics and Science girls

and women are often exposed to three negative stereotypes: 1) the stereotypes about what is appropriate (or not) for a woman to do (that is sexism) 2) stereotypes about what science and scientists are like 3) stereotypes about specifically what women scientists are like.

Sexism is still present in many aspects of women's lives in active and passive ways, even in western advanced societies. It can start incredibly early. A week ago my colleague Andreas was telling me how when trying to get a present for his 8 year old niece and having visited a high-street shop he found himself confronted by a section for girls and a section for boys. The girl's section consisted mainly of pink stuff, with dolls and toy kitchen appliances centre stage. On the other hand the boys section contained what we would think of as "intelligent" toys: constructions sets, science games... I am sure it also had cars and other "boy games". Apparently Andreas' niece now has told her parents that she only ever wants to have boy toys.

Every time I go to Spain I despair at seeing my fourteen-year-old niece spend hours watching the Disney channel. This is a channel for children, which runs 24/7. It screens some particularly perverse series targeted at teenage girls. These series often describe life in an American high school and you don't have to watch very long to get the message: hot, desirable girls are generally not studious, they all want to be cheerleaders for the school team, spend their free time buying nice cloths and putting on makeup and they get the hot guys (which of course play in the aforementioned team). Studious girls on the other hand wear glasses, are understood to be ugly and tragically never get anyone to go to the Prom.

Examples of sexism are easy to find, but a classical undercurrent of sexism is that women should not engage with intellectual stuff, particularly not with science or Maths and that if they do, they somehow are less feminine.

What about stereotypes about scientists? Well, they are also aplenty. If you read the press or watch TV series then it will not take you long to find out that YOU are weird. We are geeks and nerds. We are socially inept weirdoes that are incredibly competent on a small number of highly specialized areas, we are people that understand stuff that no one else can (or should try to) understand. A Guardian interview with an Engineer 2 weeks ago included the question: In which ways are you a geek or a nerd? What happened to 18th century Enlightenment? When did Britain decide that science is not for everyone?

Even the BBC will from time to time show us news readers going into a fit of giggles when they have to report on anything scientific, curiously not so much if it is medicine or climate (these are somehow more normal areas), but definitely a lot if they are talking about Physics. There seems to be an entrenched belief in this country that science, and very particularly Physics, is the preserve of Albert Einstein, Isaac Newton and Stephen Hawking, that the rest of us mortals cannot engage with it. A similar attitude actually exists towards mathematics, especially among women, perhaps reinforced by the sexist messages I mentioned earlier. Science needs to be demystified!

I am now tired of counting how many times I have met women of various professions whom upon knowing what I do have immediately tell me how rubbish they are in Maths. As Shirley has highlighted I am sure there may be a whole lot of good reasons why they are bad, but what I find slightly irritating by now is how ready and comfortable women feel about admitting their incompetence in Maths. When they tell me this I feel they are also telling me implicitly: "You see, I'm normal, I'm like everyone else, I'm not a nerd, I'm rubbish in Maths". It is this acceptance attitude that bothers me. This has an impact on the family issues I discussed earlier. What will these women tell their kids when they say they find Maths hard? Will they say, yes, of course dear, I was also rubbish? Maybe yes, maybe not. Let me put it a different way. If I today went to a restaurant and told the waiter: could you please read the menu for me? I was always rubbish in reading? Would that be acceptable? No, I don't think so. I'm sure there are many people that have literacy problems in this

country. But they don't tell because they don't feel this is socially acceptable. However, being rubbish at Maths is socially acceptable. This leads to a sense of complacency and affects girls' choices and attitudes. We need as a society to internalize the fact that both literacy and numeracy skills are the two pillars of education and that both are equally vital.

Finally, I have spoken about stereotyping of women scientists. I think this is essentially a fusion of sexism and prejudice about science. If science is hard and women are not supposed to do intellectually hard things then it follows that those that do must be weird. Weird usually means not feminine (by some definition). It is the same kind of women stereotyping that is encountered in any profession where women are underrepresented. Although not always the case, women scientists are often portrayed like this. Sadly, the scientific community itself will on occasion buy its own stereotype and judge women that are deemed to take too much care of their appearance as not serious or as incompetent.

I should now say a bit about what is the third big influence in our lives (at least as young people). That is school. Inspirational teachers play a crucial role as role models and motivators and if they are female then even more so in the context we are discussing. However, as Shirley has highlighted in her work, perhaps science and Maths is not being taught in the best possible way to many girls and that is contributing to their failure to engage. About a year ago I watch a programme conducted by Prof Alice Roberts. She was visiting schools trying to encourage young girls to choose Maths and Science for their A-levels. She met a group of 20 or so girls and asked them whether or not and why they were planning to study Maths or Science. The immense majority of them said no, but what I found shocking is that the most common reason they gave for this was that they wanted to study something creative. It had never occurred to me before that Maths could be a non-creative subject, or indeed that any subject could be non-creative. This made me think. Perhaps this country's unique obsession with exams and lead tables is making us teach Maths in such a way that it has become no more than a series of boring recipes to solve certain types of problems. Perhaps if high-school teachers spent less time making their students learn past A-level Maths papers by heart and doing 100 variations of exactly the same type of Maths problem, they would have more time to make their subject creative and to teach their students to think for themselves. In addition all those exams and lead tables do not seem to be working very well. A striking headline last week in The Economist was the following: "Britain jobless youths are the most illiterate in the EU".

Now that I have told you some of my opinions, I would like to tell you something about myself. Why did I become a Physicist? Why did I think it was fine to be good in Maths? Why am I academically minded? Of course, I was born with a certain amount of intelligence and lots of people have had an influence in my career. I had excellent school teachers (most of them women), I had supportive colleagues and supervisors (most of them men). Some of them are even here today. But the person that actually made me believe that I could do anything I wanted and that whatever I chose would be of value was my mother. Her name was Amparo Alvaredo Osorio and she passed away almost 2 years ago. Let me tell you a few things about her.



My mum around 1953

My mum was born in 1928 in a remote, rural area of northern Spain. She married in the early 50s, had my two brothers and then 20 years later, at the age of almost 47 she had me.

My mum's parents were small-scale farmers as were all of their neighbours. They had 10 children of which my mum was the third. My mum went to her rural school in the 30s and 40s. She started school at a time when the newly democratically elected Republican Government had ambitious plans to educate the rural population of Spain (much of which was illiterate) and finished school after the Spanish civil war had replaced that government by a Fascist National-Catholic Dictatorship who made sure many school teachers were eliminated,

transformed schools into indoctrination institutions and defined women as first daughters, then wives and finally mothers.

It wasn't the best start in life. Very early in her life my mum developed very strong, instinctive ideas about the world, which never left her and which often were controversial within her immediate environment. One of those ideas was that studying was a way to improve and empower yourself and therefore was important. Although this may seem obvious to us, it is not entirely obvious why by the age of 12 she already thought like this, living in an isolated, conservative, largely uneducated community. But she did think like this. My mum always loved school, she did everything possible to go to school, which wasn't easy at that time, as she also had to take care of younger siblings and spend innumerable hours washing clothes, tending to cattle or working at the loom. No matter how tired she was, she made sure she would go to school every day. Not common at the time, it seems her teacher was very good and I know that in part because I actually have my mum's school notebooks from the late 30s and early 40s. They studied all sorts of stuff, including Maths but they also started every school day by copying a text on a number of exciting topics such as: why is Spain the country chosen by God? or the life and miracles of St XYZ. At the age of 12, she ended school with good numeracy and literacy skills and her teacher was so impressed with her that he attempted to convince her parents to let her study further. Her parents refused alleging that they couldn't afford it and that anyway it was not appropriate for a woman "to go alone into the world". The teacher insisted to no avail. Frustrated and saddened he delivered her school-leaving certificate and wrote a quotation on it. It is a quotation by the Spanish Saint Teresa of Avila, which translates as follows:

"Uncultivated ground will produce weeds even if fertile; the same applies to man's intellect"

"La tierra que no es labrada llevará abrojos y espinas aunque sea fértil; así es el entendimiento del hombre"

Unfortunately my grandparents didn't catch the message and so my mum as all her brothers and sisters did not study beyond primary school and she was destined for a life of hard toil as a farmer. Except that she never really forgot her school leaving experience. Ever since I have any memory of my mother I can remember her telling this story I just told you. I am pretty sure she told me this story at least 100 times. And every time she told us this story she cried as if she was still 12 and finishing school. Rather than forgetting it, it seemed to become bigger and bigger as time passed. She revisited it almost obsessively and felt very strongly that her life would have been very different and better if her parents have made a different decision. As time passed she often attributed to this event all her disappointments and unfulfilled dreams. If only she could have studied. She also pointed out every time that her teacher had been wrong. That although she was made of "uncultivated ground" she had not produced "weeds" that she still was an intelligent woman, which had achieved worthwhile things in life. That was obviously true but she also needed to tell it to us and to herself.

It is therefore not surprising that from a tender age it became completely obvious to me that learning stuff was extremely important and that finishing school was very sad. Even though she was a simple farmer and housewife, my mum was always fascinated by those that knew things and were eloquent about them. She would listen to a good radio programme and say "look what you can achieve if you study, see how well he/she speaks". Despite being fully committed to a life where money was often short, she made it clear that intellectual achievements were far more important than material possessions. An often-repeated say in our house was "knowledge takes no room" meaning that there is no limit to how much you can learn and that it can never do you any harm.

Despite her disappointment my mum made sure to put to good use the few things that she had learnt at school, especially her numeracy skills. She often said that "at least she had learn her four rules" meaning addition, multiplication, subtraction and division. She had in fact learned them much better than my father who had had a much worse teacher. A particularly proud episode of her life was the time when in the 60s my parents decided to have a new home built. Money was short and the works had to stop for long periods so that it took them about 10 years to complete it. Over this long period

my mother singlehandedly did all the accountancy relating to the construction. She had a booklet where she noted workers salaries, debts that were incurred, money that was due, interests that were to be paid, hours each worker had worked, price of materials etc. Apparently she never made any mistakes and she was very proud until the end of her life to be able to do calculations in her head very fast. For my mother that had on many occasions lead a hand-to-mouth existence, mathematics was a life saving skill. She had to use it all her life, when selling her cattle, when buying her groceries while in her head calculating how much she could spend. It never occurred to her that this shouldn't be a subject for women.

I was born in 1975 and enjoyed countless more opportunities than my parents generation had. I was encouraged to study but never pushed. I was provided with tools to widen my horizons. My brothers, by then in their 20s made sure I got lots of books to read and of course I went to a much better school than either them or my parents. Still, like them, I grew up in the countryside on an isolated corner of northern Spain, on a Hamlet consisting of 3 houses with a population of 11 people at the time of my birth. As you can imagine I spent a lot of time alone and had much opportunity to think. During my childhood many things had changed. I didn't have to help in the farm. For my mum doing homework was number one priority and in the meantime mechanization had come to the countryside and my parents were in a much better financial position. We had a TV but it essentially had a single channel which of course stopped at night and which only had kids programmes at certain times of the day. I did watch enough TV but it seems to me now that much of what I saw was really innocent compared to what kids see now and much less sexist. Ironically, having access to less information, made me have less fears and prejudices about what I could do or become. I find this actually quite interesting and also a bit sad. My parents had little idea of what becoming a Scientist or a Mathematician really meant and so they also lacked any kind of preconception as to whether this was a man's or a woman's job. In some unintentional way, their lack of prejudice and appreciation of knowledge enabled me to become what I am now.

So, let me conclude. What do we need to change to improve things?

We first need a society that instinctively values knowledge as a tool for empowerment and self-improvement. We need a society that fully recognizes that good numeracy and literacy skills are at the basis of this. We need good, motivated, well-paid schoolteachers that feel their profession is valued and that they have the freedom and opportunity to inspire kids. Finally, we need plenty of positive female role models at all levels of society and in all professions where women are still underrepresented. This doesn't mean just having women at the top. Their influence is often overestimated. Women that reach the top of their careers in an environment dominated by men often have the same innate biases against other women than men have because that is what they know.

I feel that my female colleagues at City and I in our small way are each day changing society a little bit. By delivering our lectures to classes sometimes dominated by male students in an environment where many of our colleagues are men we are demonstrating in a practical way that we have a right to be here and that this is normal and unquestionable. And just by doing this we are perhaps changing innate biases our students and others may have. Hopefully they will go on to be unsurprised by having female bosses or colleagues. This is at least what I hope.

We should aim to have a society where women and girls feel there is nothing they cannot do, including Maths.