

Presenter: Professor Kate Smith-Miles - 2017

Title: Myth-busting Mathematics - (17:16)

<i>Time</i>	<i>Dialogue</i>
00:11	My name's Kate [Prof Kate Smith-Miles] and I'm a Mathematician. Now whenever I reveal that to people their reactions are usually very interesting. It's either a complete conversation stopper where they say something quite polite like, "Oh that's interesting" and then slowly back away and go and get another drink, or if they want to engage in conversation about it then I typically hear at least one of the following responses; 1 – "You must be really smart?", closely followed by 2 – "I always hated maths at school" and that usually ends the conversation as well because there is usually some deep childhood trauma associated with mathematics that they don't want to discuss.
00:47	But some people will think about it a little bit longer and they will come back with, "So what do you do all day ... just add up numbers? Don't we already have computers for that?" Yes we do and no I don't. Why would I want to add up numbers all day? Sometimes other people will seem quite surprised that I'm a mathematician and they will say; "Hmm are there many female mathematicians?" and when I tell them that I do research into new mathematics some people will say, "What's left to invent? Don't we already know everything about numbers?"
01:19	So these comments are quite revealing of the kind of misconceptions and popular myths that exist around mathematics. What I'd like to do today is go on a bit of a myth busting session where I will also tell you about my personal journey of why I chose to become a mathematician. What it is I actually do all day, which is not adding up numbers and why 'mathematician' consistently ranks as one of the top jobs in the world. But first let us think about why we might have these misunderstandings?
01:48	I suppose it's not surprising when you think that most people really believe that they understand what mathematics is because you have been studying it from a very young age and for many years. At least a decade usually. So most people really think that they understand what maths is. It's a lot of arithmetic, a little bit of geometry, a bit of algebra. Maybe some calculus ... but what they don't appreciate is that they are just a few small branches of what is the whole tree of mathematics.
02:16	A very rich tree and in school you don't explore very much of those branches either and they are not the particularly interesting branches. People don't seem to appreciate that the kind of mathematics you do at school is foundational. It's like grammar is to literature or scales are to musical pieces. It's preparation for something beautiful and more profound but it is not the end goal. It's really unfortunate that most people never get to see the real beauty that is mathematics and its power and importance.
02:48	I guess another reason that there might be these misunderstandings could be because of the 'Hollywood' stereo type. So if you believe Hollywood, I'm not meant to be a mathematician. A mathematician is a male, genius, 'loner type', socially awkward who sits alone in a room trying to solve an impossibly hard maths problem for about a decade until they slowly lose their mind. It's not a very attractive aspirational goal for most people.
03:19	And it's true to say that these characters in Hollywood, there based on real people who exist but they are exceptional individuals. That's why they chose to make a movie about them. This is not me and mathematicians that I know. So I think we can debunk this myth with my own counter example. I am a woman obviously. I'm an intelligent woman but I'm no genius. I enjoy the company of people. I'm a mother with a social life and outside interests and my mental health is just fine in case you are wondering.

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03:51	It's really important to realise that this stereo type is just that. I sometimes wonder if when I was seventeen and I was trying to decide what my future would be, if I had seen a beautiful mind or some of these movies if that would had put me off studying mathematics. If that image of a mathematician would have somehow clashed with how I viewed myself? But I was lucky, I hadn't seen these movies. In fact I was completely oblivious to any of these myths about mathematics. All I knew was I was really good at mathematics and I really enjoyed it.
04:20	I enjoyed being able to get the right answer. Being able to find creative ways to reach the answer. Maybe different from the ways my teacher was showing us. I enjoyed when I got the answer being able to prove it was right. I liked that. I didn't think that you had to be a genius to be a mathematician but then again I didn't know any geniuses. I sometime feel like if I had known someone like Terry Tao (Terence Tao) then I might have been put off from studying mathematics. It's quite intimidating when you meet a real genius.
04:51	You see Terry is the 'real deal'. He is an Australian born mathematician. When he was in Adelaide he represented Australia in the International Maths Olympiad and won several gold medals by the age of thirteen. Became a full professor at the age of UCLA at the age of 24. Won the Fields Medal in Mathematics at the age of 30. That's like the Nobel Prize in mathematics. So he is a real genius. But it's a myth to believe that you have to be like Terry to be a successful mathematician.
05:17	I'm President of the Australian Maths Society and when I was in High School I hadn't even heard of the International Maths Olympiad, let alone represented my country. There are many ways to be good at Mathematics and that is my main point and this style of mathematics is just one. What I worry about is that young people might be discouraged from continuing with their mathematics studies unless someone has tapped them on the shoulder and said you're a mathematical genius. This is what you are meant to be doing. Right.
05:41	Maths is for everybody and it's really important because there is a huge skills shortage in mathematics. If you have to be a genius to be a mathematician ... I worry because that's like saying to any young child, 'Unless you are a Mozart like genius you are not allowed to study music'. Right. I think everyone would agree that would be detrimental to the individual or the personal qualities that develop when you learn an instrument or study mathematics. We wouldn't have enough musicians to fill orchestras or we wouldn't have appreciative audiences that understand music and the art form would just die out and it's the same with mathematics.
06:15	Right. We need more people to engage with mathematics. So let's bust that myth as well. You do not need to be a genius to have a successful career as a mathematician. So I'm lucky that I didn't know any geniuses to put me off studying mathematics but one thing that I had heard about that could have put me off but didn't because I didn't believe it was this myth and you may have heard this myth as well. Some people say that girls' brains are not hard wired for mathematics like boys' brains are. Well I just thought that was rubbish really. I had a high school mathematics teacher who felt the need to tell me this.
06:50	Very encouraging and he said girls can't do maths because our brains don't let us visualise in 3D. Well I found that really bizarre because I live in 3D. I manage to walk around just fine without bumping into things so what does he mean I can't visualise in 3D or I can't read maps? You know it's just rubbish and research supports me on this. Amongst all of the studies that have been done probably the most comprehensive was one in 2010. It was a meta study; a study of many studies. They looked at 242 studies that had been done on this subject involving 1.2 million people and the conclusion was 'There is no overall difference in performance in mathematics based on gender'.
07:32	Sometimes girls feel that they are as not as good at maths as boys. They feel that they can't do it but that is not the same as not being able to do it. That's about confidence and that's a lot to do with the way that mathematics is taught but of course that's a whole conversation for another day. Ok so we will bust that myth as well. So back to my story. I was lucky in high school that I had another maths teacher, Ms Kerr. No longer with us but she was such an inspiration to me.

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08:00	And she managed to show me from amongst a fair dull high school maths curriculum I must say back in the 1980's. She managed to show me a little glimpse of the real potential of mathematics. Its power and that it was creative and elegant and beautiful. Now when mathematician speak like that a lot of people do start to think that we are crazy so I better try to explain what I mean.
08:22	When we speak of elegance what we really mean is surprising simplicity. It's that moment when you have a really hard problem and you don't know how to begin and then you apply a trick or you think of something creative that you can do that turns your problem into something easier and the solution just falls into place and you think, 'that arh elegant'. It's like when you are trying to solve a Sudoku puzzle and you are staring at it and you don't know how to begin and then you see that one number that you can place that creates an avalanche of other numbers that flow and then you have cracked it. Right. Elegant.
08:56	So what I love about maths is that it is a means of taking the impossible and making it become possible if you have got enough creativity. I'm going to show you a simple example, just from high school so that we can all share together that feeling of elegance. So suppose we have this polynomial $x^6 - 9x^3 + 8 = 0$ and we are trying to find the values of x that make that true. Now some of you will have already guessed some values of x that make that true. But let's suppose that we don't want to guess and we don't want to give up. Mathematicians don't like doing either of those things. Let's try to solve them.
09:37	So I can rewrite $(x^3)^2 - 9(x^3) + 8 = 0$ I should say that if the highest power there was x^2 then everybody knows how to do that. That's the quadratic equation, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ but x^6 there is no formula for that. No one teaches you a formula for x^6 but if I replace x^6 with $(x^3)^2$ then I've got an x^3 term and another x^3 term so what if I do this change of variable trick. Let me just change variables and instead of dealing with the x^3 I'm going to call that y.
10:09	So if I let $y=x^3$ then I now can just rewrite this as a quadratic in y [i.e. $y^2 - 9y + 8 = 0$] and we know how to do that. We have taken a problem where we didn't know what to do, that was hard and we have turned it into problem where we now know how to solve that problem. We can solve it for y. We can just 'plug in' the formula or we can factorise and we can solve that and we can find the two solutions for y are 1 and 8.
10:33	I don't care about y. I needed to solve for x. But we have. I created a bridge from my hard problem to my easy problem and I can get back again ... right? I know the answer for the y and now I can come back to get the answer for x because y is = to x^3 . So x is the cube root of y. Just take the bridge back and all of a sudden I now have a solution to my hard problem and wasn't that elegant. That's what I'm talking about. There is a very simple example of what I'm talking about.
11:00	So maths is about building bridges between hard problems and easy problems. Building upon facts. Following logic to enable problems to be solved that we don't know how to solve yet. It's not about adding up numbers really fast. It's not about mental speed and agility necessarily. A lot of people believe that mathematicians have some brilliant 6 th sense and numbers just pop into your head and you can multiply massive numbers together. That's not what being a mathematician is about for me but it is perpetuated even in primary school.
11:32	Do you remember in primary school you were encouraged to know your times tables as fast as possible and sometimes mathematics is treated like a competitive sport? That's very off putting for a lot of people. A lot of people don't enjoy the competitive sport aspects of maths but that's not what maths is for me. My mental arithmetic is actually really shocking because I just don't use it. So I think we can bust that myth as well. Maths is not about adding up numbers really fast.

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11:56	Maths is about finding patterns. It's about following logical paths, following creative diversions to draw evidence based conclusions. Undeniable facts that you can prove that are true. It's about making the impossible become possible. Finding those tricks that enable you to solve really hard problems which you couldn't at first glance see the solution to. And when it happens it's elegant and surprising simplicity.
12:25	So I was lucky that I saw all this in high school. Really grateful for that. Fantastic high school teacher. I saw the elegance and the power of mathematics and of course it's not about solving order 6 polynomials. Nobody cares about that really. For me mathematics is a language that's used to model everything we see. I can use mathematics to model how something is right now. I can model how we would like it to be in the future. How we can improve what it is and then figure out what we need to do to achieve that. So you need to realise that I'm an idealist.
13:02	I like to use my mathematics to improve the world and I'm really impatient to have an impact. There are two types of mathematicians depending on their patience level. There are pure mathematicians who have infinite patience and they ask the questions about what mathematics is possible. Just curiosity driven. They find solutions to equations that they don't even know what those equations are describing yet but they are interested in whether solutions exist.
13:28	And history has born this out. Many many times, 200 years later after a mathematician presented some mathematics result someone used that for the development of some technology like CAT [CT] scans or the Internet or understanding DNA better. So it is really important that we give pure mathematicians the time and space to investigate what mathematics might be possible. But I'm not a pure mathematician. I'm an applied mathematician because I'm really impatient to have an impact in my lifetime. I don't want to wait.
13:57	And there are so many challenges that need the attention of mathematicians. So for instance, climate modelling where mathematicians try to understand the complex interplay of dynamics in the oceans, the atmosphere and on land to try to predict what is happening to our climate. I have worked with meteorologists and atmospheric scientists in predicting extreme weather events. Disease modelling where I have worked with epidemiologists to try to detect at the earliest possible time when we might be experiencing an outbreak of an epidemic so we can take preventative action...
14:28	or thinking about how people interact with each other in a social network of who knows who or bumps into who in a typical day and how a disease might spread through a community and how things like vaccinations or shutting schools for the day could prevent that disease from spreading so fast. I work with Stem cell researchers in trying to understand the pressures that exist on a Stem cell. How that Stem cell decides what it is going to be when it grows up. Is it going to become a bone cell or a blood cell because if we can understand that mathematically we can control that process and we can make that stem cell become what we need it to be with therapeutic medicine?
15:03	So many applications in food security trying to protect our food supplies from invasive species and crops modelling the spread of invasive species. Working with neuroscientist trying to understand the difference in brain structure between control patients and those with epilepsy, schizophrenia or Parkinson's and trying to clean up the mess we humans keep making on this earth as we have cities busting at the seams. How are we going to have a sustainable collection of cities when we have traffic management issues?
15:34	These are just a few of the examples of the kinds of critical problems that our society faces where mathematics can really make a difference. So I think I can debunk the myth of what I frequently hear people say especially a lot of young people where you hear people say "why do I need to know this? How is any of this maths I'm learning relevant to the real world?" I hope these examples have helped to debunk that myth that the mathematics you are learning is foundational and vitally important for so many problems that we face as a society.

<i>Time</i>	<i>Dialogue</i>
16:04	So that is what mathematics means to me. I love the diversity of my work. The impact that it is having and I'm living proof that none of those myths are true. There is a reason that 'mathematician' consistently ranks as one of the tops jobs in the world. You know every year there is a survey of professions and they ask people about their income, their stress levels, their work environment, their job prospects and they rank all the jobs. Now the worst job in the world is lumberjack. The best job in the world is mathematician. It's always at the top of the list year after year.
16:38	We mathematicians love our work and it's because we are not sitting by ourselves in a room trying to solve an impossible problem until we go crazy and we are not adding up numbers super-fast. We are using the power of mathematics. It's logic, it's elegance to find solutions to some of the world's most pressing problems. It's creative. It's collaborative. It's fun and it's a really rewarding journey helping to improve the world one equation at a time. Thank-you for listening.
17:16	