

Numberphile Podcast Transcript

Episode: The Math Storyteller - with Simon Singh

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Author and campaigner Simon Singh talks about his fascinating career, a famous legal case, and his attempts to change the way mathematics is taught in UK schools.

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[gentle piano music]

Brady Haran [BH]: Hi there, I'm Brady Haran. Welcome back to the Numberphile podcast where today's guest is Simon Singh. [music continues] Some of you may know Simon from our Numberphile videos, usually as the guy talking about mathematics in the Simpsons TV Show. He's written a whole book on the topic. [music continues] But Simon's equally well known for best selling books about Fermat's Last Theorem, codebreaking, the Big Bang. He's been a

filmmaker for the BBC, where he made what I reckon is the definitive documentary about Andrew Wiles proof of Fermat's Last Theorem. [music continues] And if that's not enough Simon's also worked as a physicist at CERN and he found himself sued for defamation in a court case that changed the legal landscape in Britain. [music continues] These days, much of Simon's focus is on mathematics education. He wants to shake up the way it's taught in British schools and we'll be talking about that later on, but first, let's talk about money.

[music fades out]

BH: So Simon when I told people I was coming to meet you today, lots of people know who you are, mathematical people, but people who didn't know who you were, the thing I tell them that impress them most was that he's on this committee that's gonna decide whose face is gonna be on the new British fifty pound note. How did you end up on that committee? That sounds amazing.

Simon Singh [SS]: I've no idea. No idea at all. And I must admit I'm pretty excited about it too. So every so often we change our money and I think there's a big push at the moment for plastic money in order to increase security and I guess with the fifty pound note you want a really secure fifty pound note and so... they decided it's gonna be a sciency type person and there're a few of us who have been brought together. I'm hugely honored to be part of that committee and it's gonna be fun and interesting and I think we've have a record number of suggestions from the public of scientists from the past right up to people who have recently passed away like Stephen Hawking.

BH: Mhm.

SS: To be on the fifty pound note, you need to be deceased and you need to be a real person.

BH: Yes.

SS: And a scientist.

BH: Yes.

SS: Doctor Who does not count.

BH: I know I saw the governor of the Bank of England had to specifically rule out Doctor Who.

SS: That's right.

BH: [laughs]

SS: But yeah we've had, I think the people have nominated everyone from Margaret Thatcher...

BH: Yeah?

SS: Who was a chemist.

BH: Yeah.

SS: And may or may not have invented the Mr. Whippy Ice Cream.

BH: [laughs]

SS: Going back to yeah, all sorts of incredible people. So it's gonna be great fun. We sit down next month to go through the list and to come up with a short list and then we'll argue about that and then I think ultimately Mark Carney, the governor of the Bank of England, will choose but hopefully he'll go with whoever we think is the best person.

BH: I've seen in like, you know, the publicity and the articles about it, there are three or four people that seem to be emerging as like, you know, the bookmakers' favorites. As someone who's on the committee that will then decide, do you feel swayed by that or do you feel like this resistance? Oh no, let's choose unexpected, let's surprise the public, or do you feel no let's go with what the public wants or like... how does that work? What's like your instinct?

SS: [laughs] It's really frustrating 'cause I can't say anything. 'Cause if I say to you, you know what? I've heard some of the names and they were on my list too.

BH: Yeah.

SS: Or if I said to you, well actually I've got completely really different names.

BH: Yeah.

SS: We can't really voice an opinion until we've come out with our final... person.

BH: Okay.

SS: So, I just find it wonderful. Names have come up who I haven't thought of, and there are other names that are obviously much more familiar. And there are, you know, people like Newton has already been on the one pound note, I think.

BH: Right.

SS: And is also commemorated on the pound coin, because he was... Secretary of the Royal Mint.

BH: Yeah he ran the Mint.

SS: He ran the Mint, yeah. And so I think he may have been the person who came up with the idea of milling around coins so you couldn't chip away at them. So he's been commemorated, Darwin's been there, there are been engineers like Watt and Bolton I think. Faraday of course, fantastic to see him there, standing in front of the bench at that Royal Institution. So there have been many great scientists and we just need one more for the new fifty pound note.

BH: Have you been getting like emails or phone-calls of people wanting to give you their two cents worth or have you been like... have people been like leaving you alone and realizing that you're like quarantined from being influenced?

SS: No, no, I've had a few suggestions. My own son came along with me to the... when it was all announced at the Science Museum,

BH: Yeah?

SS: I took him along as well. So he's had a good think about it and he's got... a definite strong suggestion which I will not reveal either. [laughs]

BH: Oh, no. [laughs]

SS: But I've also encouraged teachers, you know, get the classrooms talking about this. Get them to figure out who they think should be on the fifty pound note and run your own poll and let us know as well. Because we'll take all of those into consideration.

BH: Okay. We made a video on one of my Youtube channels where we made some suggestions, so I'll send you the video as well and you can see what you think.

SS: Oh, excellent. Great.

BH: Alright then. Starting properly then... I was reading up and I didn't realize that you are from Somerset which is where I live.

SS: Yeah. Yeah, the West Country, yeah Somerset.

BH: Right, you were born there?

SS: I was born in Wellington. Which is a very small town not very far from Thomas Young was born.

BH: Right?

SS: Thomas Young was born in Milverton, just down the road from where I was born. And he went to Emmanuel College, and I went to Emmanuel College. And he's a great brilliant scientist and I'm not.

BH: [laughs]

SS: [laughs] That's where the similarities end.

BH: The paths had to diverge at some point.

SS: So, yeah, no, very very proud and my family for some very odd reason, they're from the Punjab originally and for some very odd reason back in the 1930s, so they were among the very first wave of immigrants.

BH: Yeah.

SS: From India. Settled in the West Country. So... when I was growing up in

the Sixties and Seventies, everybody west of Bristol who was brown was from my village. So if you go to a place like South Molton and Tiverton and Barnstaple and Taunton and Exeter, anybody there who was Indian was related to me or was a next-door neighbor back in the home village. And I remember the first person I ever met who wasn't from our village who was sort of of Indian descent when Idi Amin expelled the Asians from Uganda, we had a family settle in our town. But yeah, so... I had very happy childhood. Loved being in the West Country and still very very fond of Somerset and always enjoy going back.

BH: Did you ever find out why your parents chose, like, a village in the West Country as opposed to London or the other places or...?

SS: I think if you go back to 1938, you know the late Thirties, there was kind of no obvious place to go. There wasn't an Indian community in places like Gravesend or Southhall or Birmingham or Wolverhampton like there is now. So there was no obvious place to go and I think there had been some people from our village who'd gone to the West Country and sold sort of door to door and that was sort of what are family did as well. They would sell things to local farmhouses. You know, whether it's some boots, overalls, actually I remember my grandfather passed away. I wrote a little story for the local newspaper and got letters from people who'd remembered him. 'Cause you know you'd remember a big brown guy turns up to your door in 1940s by that stage.

BH: [laughs]

SS: You'd remember him.

BH: Yeah.

SS: And so I remember a woman who said she just distinctly remembers getting a pair of socks when she was about five or six, 'cause getting a new pair of socks was a big deal and it was my grandfather who kind of knocked on their

door and sold them. So...

BH: [laughs]

SS: So yeah there'd been sort of tinkers selling from door to door just prior to my family's arrival.

BH: Yeah.

SS: And they just said well okay, that's where will go. It was fairly random to be honest I think.

BH: What were you like as a boy? For a start where you like, where you a science and math geeky kid or were you like into sports or what was... would I have guessed you were going to be who you became?

SS: I loved football. You know, I used to collect all the cards and kind of name all the players in the first division at the time.

BH: What was your team?

SS: Derby County.

BH: Oh.

SS: Very local to Somerset [laughs].

BH: Yeah I was going how did you end up with them?

SS: I've cousins who lived in Derby so that was the reason for that. And it was good time to be a Derby fan because they won the league a couple of times and... it was through the Brian Clough era and...

BH: Yeah.

SS: And many other great things. So... So I loved football and I loved television. I used to watch television... at any point TV was on, I'd be watching it.

BH: Like wholesome good TV or just like fluff and...?

SS: Oh just anything, you know, when I was a bit older I used to love watching Tiswas. Do you remember Tiswas? Today is Saturday, Watch and See. It was kind of an anarchic TV show where people like Chris Terrance started off on Tiswas. And then when the video recorder came in... I would just watch even more television. So I loved TV, I loved junk TV, I loved football...

BH: Were you good at football?

SS: Yeah, I was. I was pretty good, yeah, yeah.

BH: Yeah?

SS: I'd play football late into the evening until the sunset and then I'd get home eventually. But I also loved science. So science was the thing I did at school and I loved maths and, you know, people were landing on the moon. I can't quite remember the first man on the moon landing. But I can remember a lot of what followed in the early Seventies and so yeah that was who I was. I kind of just knew that physics is what I loved. I grew up watching Tomorrow's World and people like Patrick Moore and James Burke and Magnus Pyke and in one of my books I've sort of dedicated to all those heroes that I grew up watching on television.

BH: Yeah.

SS: Physics, the universe, Einstein, where did it all come from, it was just a thing that was always what I was gonna do. It just seemed like the most fascinating in the world. I had fantastic maths teachers. I had a great physics teacher and then I went to university and did physics and that was it.

BH: Just still while you're young, one last thing I have to ask, 'cause of your Indian background. You said you're really into football, were you into cricket?

SS: A little bit, yeah. I mean being in Somerset, Joel Garner, Viv Richards, you know occasionally go down to Taunton and watch Somerset play. So enjoyed cricket as well, but football was my real passion.

BH: It sounds like compared to a lot of people who I speak to who have become scientists and mathematicians. You sound like you were quite well rounded. You weren't just like this total math nerd, you know, you were liking your sport and popular culture, and it sounds like you were like pretty normal.

SS: I mean I'm slightly different to the some of the other people you've spoken to because in the... I'm more of a journalist now than a mathematician or scientist. Never ever was a mathematician really. Though scientist I'm gonna say, well I'm maybe not typical to your usual interviewee because I do something different to your usual interviewee. But actually what I'm gonna say is that... I also interview mathematicians a lot, and have worked with physicists and others and I tend to find that they're hugely well rounded. So when I was at CERN, you know, physicists would run the local marathon, they go skiing, they do extreme sports, they'd be very accomplished musicians. So I tend to find that mathematicians are passionate many many things. They're curious about anything and everything. That's my impression, whereas if I tend to meet an artist... they tend to be scared of science whereas scientists I think aren't scared of very much.

BH: I agree with you... when it comes to adult scientists and mathematicians. But when I hear them describe their childhood, I mean they could be just like, you know, being humble, but they always describe themselves as quite nerdy as a kid. They grow up to become quite well rounded people I agree with you, but they always say, oh yeah I was always the nerdy kid at school.

SS: They're still the nerdy person now.

BH: Yeah.

SS: But they're nerdy surrounded by all the other nerds. So... I don't think they've changed really. It's just that they've become part of a bigger community [laughs] of concentrated nerdity.

BH: Coming back to your story then. You... were you being influenced by your parents, did they say, yeah you should be a physicist, that's a good path for you? Or were they saying, no, no, you should be a doctor?

SS: No. So my mother never went to school. So she can't read or write and my dad can sort of read a newspaper but that sort of... you know, he struggles as well. So when they came to this country, they're both very bright, but they're not educated. So they just worked incredibly hard to build a security for themselves and also obviously for their children. So, you know, when my mom left India she never saw her parents again. She never even spoke to them again, because even a phone call would be impossible. So, I think for my siblings and myself, the goal was to continue that security. To go into business, or to become a doctor would have been a dream scenario for my parents. But that was it, you know, the things that they were comfortable with, the things that they were familiar with, the things that they knew would bring security to all of our lives. My two brothers and sister went into business as well, as well as my parents. But because I was the youngest and I was the youngest by quite a long way. My sister's about eight, nine years older than me. I think I was cut a bit of slack, and they always thought

oh eventually he'll come into the family business and he'll work and do something sensible.

BH: [laughs] Yeah.

SS: But I kinda just did what I did. And I still think my parents don't quite understand what physicist is and probably don't even quite remember that that was the degree I did. So I kinda just did that. I just knew it was the right thing for me and I just knew it's what I loved. And I think what clicked. So I did a degree in physics. I did a PhD in physics, they were probably even more confused about what that was all about. And then I went to work for the BBC... and I got a job on Tomorrow's World and that was the point at which they think, oh okay, he makes programs about science for TV. Okay, we can understand what that's all about it. So, that was a point at which they could explain to their relatives [chuckles] our relatives, what I actually did for a living. Which was to make science programs on television.

BH: Like me using the fifty pound note to describe who you are. [laughs]

SS: Yeah! Exactly, so... and they could see that I was happy doing what I was doing and they could see that I was successful and they could see that I had a secure future. I could pay my own way and so on. So at that point, there was no need to try and entice me back into the family business. You know, when I was a kid I used to work in the markets, again we used to sell at places like Glastonbury Market, I remember when there was incredible England comeback again Australia.

BH: [groans]

SS: With Botham and Willis and... I was in...

BH: How have you wedged that into a Numberphile podcast? [laughs]

SS: [laughs] My lasting memory of markets is getting up on freezing cold days and building these little... stalls with big heavy iron pipes and pulling the canvas over it. You know, getting up at five in the morning, all of that a misery, but that sunny summer's day in Glastonbury when England were coming back was amazing.

BH: [laughs]

SS: So... so I used to work in the shops and I'd run summer stalls in Weston-super-Mare, so I did all of those things and when we got our first computer to run the business I remember trying to program that and getting that working and doing stock takes. So I did all of those things and I even remember when we're at decimalization, could do the translations between shillings, pounds and pence, to new money. And I could help the customers do that and so on. So... that was kind of one of the first times I actually found math useful. [laughs]

BH: Yeah?

SS: So, you know, I did my time in the family business, I learnt a huge amount I'm sure, but ultimately that's not what I was gonna do. I mean you can tell from my dress sense, right? [laughs]

BH: [laughs]

SS: I don't know anything about fashion from that business, which was women fashion. Clothing, retail. So, yeah.

BH: Right. [chuckles] What was your PhD?

SS: It was in particle physics.

BH: Okay.

SS: So again, you know, that's the kind of physics I loved, it's what I wanted to do. We have the Large Hadron Collider today. It's a super massive ring that accelerates higher hadrons, yeah, beams of protons against beams of protons, that's what it does.

BH: Yeah, right.

SS: One of its feeder... rings. One of the rings that accelerates stuff before it gets injected into the Large Hadron Collider, is called a Super Proton Synchrotron, the SPS. And that's what I worked on when I was doing my PhD. I worked... it had two experiments. UA1 and UA2. Underground Area 1 and Underground Area 2. And prior to my arrival they'd won the Nobel Prize for discovering the W and the Zed boson. Which are these large particles responsible for the weak nuclear force. And so when I joined the experiment UA2 we were probing the W and the Zed in more detail but we were... the little group I was working on was trying to find the top quark. The five other quarks had been discovered, there wasn't a seventh and eighth one, there wasn't a fourth generation so they say. So to speak. But there was a third generation and the other half of that generation the top quark was missing. We looked for it, we couldn't find it. Ultimately our... accelerator wasn't powerful enough to create that top quark. So my PhD was all about saying the top quark must be heavier than a certain mass otherwise we'd have seen it. So, you can put constraints on what the top quark can do. And that was sort of the bulk of my PhD was, I'd built a bit of the detector as well. Essentially that's kind of what you do, you build a bit of the detector. You do some physics and you write up what you learned. And I loved it, I loved every minute of it. It's what I wanted to do, it's what I always dreamed of doing, it's an incredibly exhilarating exciting place. It's fantastic and I loved every minute of it, but by the time I was writing up I could just see other people... who were better than me. Much better than me. Quicker, brighter and that they were the people who would go on to make great

discoveries. You know, some of the people in my group have gone off to become Director General of CERN and do other incredible things. And so then I thought, in those final six months I'd actually applied for a couple of postdocs, so I was in the process of saying well, from here I go on and carry on doing more physics. But I just had this realization that, you know, what else could I do? What else should I do? What else am I good at? And then that's what took me back to television. [laughs] I'm thinking I loved television when I was a kid... I love science... I love teaching and talking about science. Just before my PhD, before I started I spent some time teaching in India. So teaching, talking about science, watching science on television, why don't I try and become a TV producer or TV director? So that was the next step. I was lucky enough to get a... a traineeship at the BBC for just six months.

BH: You say that so casually but I mean... lots of people dream of working in TV and like...

SS: Yeah.

BH: And think, oh I'd be good at TV but not many people get to do it.

SS: Yeah.

BH: And you sound like you just said, hmm, think I'll try TV now.

SS: [laughs]

BH: Like what did you have that they saw or how did you get in?

SS: So I remember applying for a job in radio for a start. And I turned up for the interview and they said, so... tell us about what radio you've listened to this morning? [pause] And I hadn't listened to much radio 'cause I didn't really love radio with the same passion that I loved television. And so that was the end of

that interview. But when it came to the TV interview and it was with the science department, you know, I knew TV inside out. I knew the history of science television, broadcasting, I could critique programs. I had a PhD in physics which made me... I think that meant they said, we've got to interview him at least, because this is interesting and a bit different. You see, the difference now... is that if somebody applies for a job in television, they better have a portfolio. They better have edited stuff at home on their PC. They better have their own podcast. You know, they've got to... there is no reason today for anybody not to have done the ground work themselves before they start going to their interviews and so on. Back then you couldn't really do that, so I had to kind of cook-up as much as I possibly could in terms of anything media related I had ever done at university. I edited... I started a physics newsletter. I'd contributed to university magazines, I'd made a couple of videos for the student union. I'd done a bit of studio radio at Cambridge but in a way that was only done because I knew I wanted to apply to the BBC. Tried to make my CV look as good as possible. Had this PhD in my back pocket to say look, you've at least got to interview me. Got on well with the people who were there at Tomorrow's World who interviewed me. And then it's a case of you've got six months to prove yourself and if you can do it, great, if not, goodbye. And then turnover is huge. Even when you get a job it's only a one... it used to be only a one year contract. And if you didn't deliver then you were out. So it was a pretty tough environment. But I could do it, I could make film, I could find... again people say, how'd I become a good filmmaker? But first you've gotta find the stories, and that's really tough. It's the same with writing a book. First you've gotta find what you're gonna write about. Then you've gotta convince somebody else that this is worth writing about or making a film about and then you've actually go away and make it. And that's only the final stage and if you can find great stories... turning them into great films is pretty easy. Especially if just let people do their jobs. [laughs] So I would just say to the cameraman, make this look good. [laughs] And say to the sound person look, you know just make sure I'm not doing anything stupid here and if you work with good people and give them the opportunity to make you look good as director then you end up making interesting films. And I loved my time

at Tomorrow's World. I made dozens and dozens of films about all sorts of subjects from, you know, debunking miracles to the environment to anti-snoring surgery to going back to CERN and making films. Making films about Artificial Intelligence, I got to interview Gary Kasparov. Time-travel, got to interview Stephen Hawking. Just extraordinary opportunity to go out there and play and I did find what I'm supposed to do. You know I loved physics and couldn't have gone through my life without doing my PhD... but ultimately that sort of media side of science is where I've thrived I think.

BH: I imagine also having the PhD and the... the street credibility in science helps when you're approaching those scientists and saying I want to make a book or I want to make a film, you know, you're like I'm one of you. It must help at least at the start?

SS: It works two ways. So there was someone people in the BBC Science Department who have virtually no scientific background. They can quite rightly argue when that when they go into see a story, they're seeing it from the perspective of the non-scientist and that's fine. When I go into a story I can build those relationships, I know about peer review, I know how research works, I know about the frustrations of research, I can perhaps win people over and I would say that's all the advantages of when I tell a story. But I think ultimately you just have to be a good storyteller. That's the main thing. Whether you're a non-scientist or a scientist you go into it and you just find those stories, get on with people well and then tell those stories.

[gentle chimes]

BH: When you finally became an actual practicing physicist, you know working at an amazing place like CERN, how did that compare to what you imagined being a physicist would be like when you were like a school boy, you said this is what I want to do I wanna be a physicist? When you actually did the real thing and met the reality of funding and the grind and the ups and downs of

it, was it very different to what you had dreamt or was exactly what you dreamt?

SS: It was pretty much how I'd expected. [laughs] You know, CERN's a pretty glamorous place and yeah you're... you know I was living in France, I was crossing the border, Lake Geneva was just down the road, it's this huge facility with, you know, shiny metal stuff everywhere, famous physicists wandering around, it was brilliant, you know, incredible seminars by people visiting from all over the world, Nobel Laureates speaking, you know, maybe I'm looking back on it in rose tinted glasses but I do remember the first three months being terrifying because... it depends when you join the experiment but I joined the experiment at a sort of critical phase where we needed to start building this detector and get on with it quickly. So I just got sent straight out to CERN. I didn't know much particle physics that was gonna be relevant. I didn't know much about the technology that I was going to be using to build this bit of the detector and I felt really lonely. So those first three months were super super tough. Getting through that was hard. But... I survived it and I think literally I just about survived it and you know, it was probably one of those phases where you probably throw the towel in or... what doesn't kill you makes you stronger. And then I got back to Cambridge after Christmas, managed to kinda take a bit of a breather, consolidate some of my understanding of particle physics, build on my knowledge of the technology we were trying to build, take a deep breath and begin to really enjoy my PhD, which is what I did for the rest of the two and half years.

BH: You talk about this realization that you weren't as good as some of the others. You weren't gonna be like the super star and thinking maybe I need to be doing something else, like I don't often hear people say that. It sounds like a... was it a difficult decision? Was it forced up you? Was it just... was it easy? Was it courageous?

SS: I think, well the people you talk to [laughs] in general are successful mathematicians.

BH: [laughs]

SS: And so they've got to be professor of Whatsit at University of Doodah and to get from age ten to professor at wherever, you pretty flawlessly gotta leap every hurdle, I would imagine, I mean I'm trivializing here because it's clearly... a struggle all the way through and unless you really strive and work hard, you don't get to those places. And there will have been moments of self doubt for all of those people, but clearly they got to where they needed to be and where they deserved to be. So for me it was just a case of thinking, you know, what else can I do? What else should I do? What else will make me happy, what else... when I talk to Sixth Formers, I also say what makes you different and special? What can you do that other people can't do? I remember somebody once said you know when you're looking for a good job for the rest of your life what can you do? What do you enjoy doing? And what will somebody pay you to do? So you might be good at lying on the beach, you might like lying on the beach but you might not get paid for it. And there are various other combinations. So I just had to find something that I really would be good and which, you know, some... if... I could have taken a postdoc position at the University of Toronto, I think that's one of the places I was applying to, and that would have been fine. I think I would have got the position maybe and carried on quite happily. But so could ten other people have done that job. So also... what makes you different? What would you do that nobody else would do? And find that maybe odd combination of skills that you have. So there are lots of other people who were good at physics and there were lots of people who were better at physics than me. But they didn't love junk TV. And they didn't necessarily enjoy teaching. And they didn't necessarily enjoy talking about their work as much as I do. So all of those skills are what makes me a bit different from those people. And then I think it's... there's maybe a pattern here that when I was at the BBC and I was there for sort of six or seven years, and I think I did really well, I think I made some great films and then I just left. I just said, right, that's it, I've kind of made enough films, I could make more films but I'm not sure how life would different,

so I'm gonna go off and write a book. In fact I actually said I'm gonna leave and then a few months later I thought, oh hang on I should write a book. I haven't written a book now since 2013, so it's been five years, and that's it, I can't imagine writing another book, because I want to do something different. So there's this kind of a pattern there of leaving something behind and moving on but then using all those skills that you've picked up from a previous... so there reason I write books in a certain way is because of the way I used to make television. The way I make television has been hugely informed by the fact I've done a PhD in particle physics, so even though you abandon things and move on there are science related and all those experiences and skills feed into whatever you do next.

BH: Are you someone who has always had the next step secure and safe before you let go of the branch? It sounds like a couple of these times you take the plunge. You just let go.

SS: Yeah. You know, I suppose... I still had my postdoc application in the pipeline while I was applying to the BBC, but I definitely left the BBC before I knew what I was gonna do next. I just said right, that's it, when this project's over I'm off. And I had no idea really where I was gonna go.

BH: Something we'll come to... shortly we're gonna talk about like 'cause... some of the things you're working on now, but now I very much think of you as someone who... is like bit of like a campaigner and someone who wants to make a difference and change the world for the better like you know in a kind of crusadey type way but were you like that when you were at the BBC? Were you thinking, these films are gonna make the difference and make the world a better place or where you just like, you know, this is my job and I'm a storyteller and I like TV? Or was that sort of streak already through you, that I must make this film because the people must know and the world must be made a better place, like? [chuckles]

SS: [laughs] I think there are a lot of people who join the BBC Science Department with that mentality. And I was one of them as well and I think it's a great thing, that you... you are passionate about science and you want other people to see that passion, that passionate side of science. You want to inspire that next generation, and I think that's true for whether you make political films or you know, films about history, you want to bring on that next generation. You want to excite them, you want to tell those great stories. So... I wouldn't say it's campaigning I would say it's just trying to share the joy of science. Yeah, in a very kind of obvious way that I think many people who go into television want to do.

BH: So when you left the BBC you went through the book phase, then of writing a series of very successful books. How does one decide, okay this is a good idea and this a good newspaper article? This is book-worthy this one. This one's a book?

SS: So Fermat's Last Theorem I'd made a film about it for the BBC and... the idea there was that... the film had been hugely successful and it just, you know, as soon as you hear the story you realize it's a terrific story.

BH: This is the story of course of Andrew Wiles proof.

SS: Yes Professor Andrew Wiles and Pierre de Fermat and this three hundred and fifty year old problem, it's just full of wonderful little stories a long the way and it's a sort of terrific beginning and an even better end.

BH: So you made this film which was still a great film that people love watching, but then a book. Is it because you felt like the film hadn't told the story or...?

SS: Yeah. So I had left the BBC and... or was in the process of leaving the BBC and then you realized that a fifty minute documentary, which is what that

Horizon documentary was, is about six thousand words. Okay? Now a picture's worth a one thousand words and all of those things and I wouldn't change anything about that film. I'm hugely proud of it. But in six thousand words you cannot go through all of the history of Fermat's Last Theorem. The mathematicians in that film were so eloquent that all the history really went out the window. Because you wanted to hear about the mathematicians alive today. So why not write a book that's got all that history in it? Television is not a great medium for explaining for maths. So we got some of the core concepts in but not much beyond that. So let's explain more of the maths in the book as well. So that's where the book came from. Let's tell the full story of Fermat's Last Theorem. And then... in that book there was a little bit about Alan Turing, a little bit about Bletchley Park and Colossus in computing, that's sort of where the Code Book came from. I probably had a much bigger section about Alan Turing and Enigma, which inevitably got squeezed right down. So it then got blown up again into a huge book called the Code Book. And when I was at Tomorrow's World, I had a whole file of stories about cryptography because it was a really fascinating area of technology but not very televisual, so I never ever made a film about it with the BBC, but I had all these stories and I knew it was very relevant today. I knew there was a great history and I knew there was the story of Alan Turing and the Enigma. So that's where the Code Book came from. Nobody had really written about cryptography since the late 1960s. There's a great book by David Chaum which is about fifteen hundred pages long. It's huge! But it hadn't been updated and it wasn't the book that I wanted to write, even though it is a great great book. And then I was on plane once talking to somebody about CERN and particle physics and the Big Bang and it was quite clear that this perfectly pleasant person had no idea really what the Big Bang Theory was or how much evidence we had for it, or where it came from. And I thought well this is extraordinary, we're part of unique generation, we're the first generation really to have a theory of the universe and it's evolution and it's origins. So... everybody should know this story and that's where Big Bang came from. And I think I wrote the proposal for that book on the plane.

BH: Right?

SS: And faxed it back to my agent, and said look this is it. And it's... I've got the scraps somewhere, of barely fifty words and by the time I got back to England about a week later, that was it, the contract was signed and that was Big Bang ready to write.

BH: It helps when you've already had two pretty successful books, though.
[laughs]

SS: That's true, that's true, yeah. Then I was gonna write the Simpsons book, and that's just a great... that's just a fantastic idea. When you realize that there's maths in the Simpsons. You know, great stories are very few and far between. They're very hard to find, especially if its a book story or a book idea that's gotta last hundreds of pages and it's gonna take up years of your life. It's gotta be a really compelling idea for a book. And the Simpsons is just absolutely a gift of an idea. And so once I'd realized it was there, that was a very obvious book to write. But then... I got annoyed and angry about alternative medicine and I thought that was a more important book to write and this is where the campaigning side I think maybe starts is the Simpsons book was set to one side and I wrote a book with Professor Edzard Ernst all about alternative medicine, called Trick or Treatment. Our back is very critical of alternative medicine but I think it's also very very fair. It's based entirely on the facts and the evidence. Where an alternative therapy works, we say it works. And then I got sued for libel, and that's where more campaigning stuff happens. [chuckles]

BH: Yeah.

SS: And then eventually when that case ended... I got back to writing the Simpsons book. Yeah that's where those five book ideas have come from.

BH: I have to ask you about the libel stuff, seeing you brought it up, 'cause it's

so fascinating to me as a journalist as well. For people who don't know this story, 'cause outside the UK it's obviously probably not quite as well known, can you give them an executive summary of what happened?

SS: Sure. So I'd...

BH: It wasn't the book that got you sued?

SS: No, no. So when you write a book, you write articles to promote the book. And I had written an article for the Guardian about chiropractic... when I started writing the book with Edzard, I didn't know much about chiropractic, I thought they were just sort of physios that focused on your back. Turns out... chiropractors have a very very odd history. There are some good chiropractors who will just focus on your back and they will do some [sighs] perhaps good things. But it's all a little bit questionable and some of its very very questionable. Manipulating babies that are just a day or two old, giving very dodgy advice about... vaccines. Just really some disturbing things happening in chiropractic in general around the world. And so I had written this article saying if you want to see a chiropractor about you back, yeah fair enough, not for me, but you may want to do it. When it comes to other conditions don't go near a chiropractor was my advice.

BH: 'Cause you'd already written a book.

SS: Yeah.

BH: When you wrote this article, were you... did you feel that you were stepping on a landmine...

SS: No, no.

BH: Or it just felt like grist to mill sort of?

SS: No, it was just... it was a... I'd written it. I probably said to Edzard, Edzard do you want to have a look at this, any thoughts before I submit it? The editor at the Guardian would have read it. They may have run it past their legal team if... I don't think they did 'cause there was nothing really contentious there as far as anybody could see. But a month later a letter arrives... through the door and I still remember being sat there on the steps... reading this letter, feeling nauseous immediately, because it's a letter from a firm of solicitors saying that the British Chiropractic Association is threatening to sue me for defamation.

BH: The paper, or you?

SS: Just me!

BH: You think they'd go for the paper with all their money?

SS: You would think so. Never really thought about that before. [laughs]

BH: [laughs]

SS: Yeah... why would they just go for me? There are a couple of sentences in the article where I talk about... they happily promote bogus therapies and there is a reading of that, there is an interpretation of that, which says... you know my interpretation was... they're promoting stuff that just doesn't work, kind of blithely doing it. Their interpretation was that they are deliberately fraudsters who know their therapies don't work and yet they do it anyway in order to get money out of the public. Now there are things in my article that I think make it clear that's not the case. Where I'm saying... that I called them fundamentalists. If you're a fundamentalist, you're not defrauding anybody, you have a deeply honest belief but you may be wrong.

BH: Hmm.

SS: So I thought that was a very different spin on it, they disagreed... they threatened to sue me. The Guardian just said, look we can't be involved because English Libel Law is so expensive and it's so one sided. English Libel Law used to be horrendously anti-free speech, anti-journalist. And the Guardian said we're gonna lose this case. You know, people just lose libel cases all the time because the law is stacked against the writer. And I quite accept that the Guardian couldn't stand by me because if they'd have lost it would have cost them say a quarter of a million pounds, and they would probably have to lose two journalists. So, it's not right for them to put the journalists' necks on the line for one little article by me. So I went to speak to a lawyer and he told me the same thing, he said, oh just settle, you know, just write a nice apology, pay them a small amount of damages, everything will go away. And I just couldn't... it just didn't make sense to me. It just... how on earth could this be the right thing to do? How on earth can anybody in the future who... you know, if they look at my wiki-page, how could they ever trust my writing again? You know, Simon Singh who was found guilty of libel and sort of... so... that wasn't gonna happen. And so I just said, look, we'll just rebuttal the claims, you know, and we'll see what they do. And I just assumed they would back down, but they didn't.

BH: It became a right old mess, didn't it?

SS: Yeah, and then we... then you have something called a preliminary hearing where you say right before we go to court, let's agree what these words mean. Do they really mean that I'm calling you a fraud or do they just mean I don't think what you do works? And the judge at the time Justice Eady sided with the chiropractors and said it was plain as a pikestaff that I was defaming them, that I was calling them fraudulent. And at that point it looked like we'd lost, you know, there was no point carrying on. And what I did at every stage was I just kinda did a cost benefit analysis. That by that stage I think it had already cost me sort of fifty, sixty, seventy thousand pounds. And I said look if I lose now, that's... it's goodbye to that money. Now I was lucky 'cause you know,

as you said, I had, you know, three or four successful books by that stage and so I could afford to take that loss. It would have been painful but you know my wife is a journalist as well so she was standing right by me, I had her support, I had a bit of financial cushion that I could rely on and when I looked at the cost benefit analysis it was a case of, if I spend another twenty thousand, let's take this to appeal. I could lose another twenty thousand pounds but I could hopefully save a lot of money, save my reputation, and prove that I'm in the right. We were refused the permission to appeal. We appealed again for permission to appeal. Eventually they allowed us to go to the Court of Appeal, which was a really big deal because by this stage and this was two years later, the Court of Appeal had the Master of the Rolls and the Lord Chief Justice on it. So they brought out some of their really big guns to sit on this... because by this stage lots of people were writing about it.

BH: It has become a bit of a cause celebre hadn't it for an issue like...

SS: Yeah. I was getting support from Norway and America and Australian because there was this other problem that our libel laws were so one sided that it encouraged libel tourism.

BH: Yeah.

SS: People would come to London to sue because this is where you'd win. Russian Oligarchs would sue in London. Ukrainian newspapers would end up getting sued in London. And so that's why I think the Court of Appeal was so powerful in its members and luckily, well, luckily? Whatever it was. They could see the sense of it. And they said look, when discussing scientific, medical, health issues. Issues that are seriously in the public interest, we must allow journalist to be able to speak up reasonably and fairly. Not maliciously and not recklessly, but we have to allow people to speak their minds and not to have treading on eggshells in fear of libel threats. There was this thing called the Libel Chill which is that you didn't even write certain things because you were scared of what the

repercussions might be. So they had to remove that. So that was the end of my case, but then lots of other people, as I say, not just in the UK but also from around the world, human rights groups, charities, all banded together, a lot of skeptics, a lot of rationalists, a lot of scientists, a lot of bloggers, you know, a huge community on the internet who'd been threatened with libel. They all came forward and we worked together on trying to change the libel law, the defamation law. And that resulted in the Defamation Act of 2013, which now means we have a much fairer libel law in this country and the experience over the last five years... [pauses] suggests that we've not had those high profile scary cases where people say, how ridiculous is that? How could that possibly happen? Academic Journals have a huge amount of protection now. Scientists have much more protection. The law is still there, if somebody says something nasty about you, then you should be able to defend your reputation as an individual. That's really important. Nobody wants to get rid of libel. But the big powerful body should not be able to use libel to bully journalists. That's where that change has happened. And there are people like David Allen Green who now... quite a well known blogger on legal issues and he was one of those people right there at very beginning who started blogging about my case and helping me with my case and beginning to build this campaign. Organizations like Sense about Science that people may know about, absolutely at the heart of this campaign. Index on Censorship, English PEN, Global Witness, large numbers of people worked on this, and yeah... so now we're in a much better position.

BH: How close did you come to... packing it in? Taking the loss, you know? Did you... were you ever teetering right on the edge or...?

SS: [sighs] It was always a consideration. It was always a case of, right... you know, on the one side this is what could happen, on the other side this is what could happen. So it was always a consideration.

BH: But there was never a day when like a pen was hovering over the page and thinking, ahh, I'll just write this off.

SS: The day when we lost the preliminary hearing was disastrous. We just... I remember my... Robert Dougans from Bryant Cave was my solicitor and we just sat across the table from each other and just said... what do we do? [chuckles] There's no where to go here. The judge has just told me that I've accused them of fraud. That's not what I meant and that's not a statement I can defend. How do we go? You know, where do we go from here? So there was a point there where it was a case of now how do we write the apology letters? How do we get out of this as quickly as possible?

BH: Are you glad you wrote the article? Like, because of the good that came... if you could go back in time...

SS: Yeah!

BH: Would you rewrite the article and keep yourself out of trouble or...?

SS: No! No, no. It's just... it's a great number of... you know, the libel reform came out of that article. Also Ben Goldacre was sued at the same time. David Colquhoun was being sued. It was a great thing and again it probably, you know, the first time I'd ever gotten to see my MP... I'd never done that before and I think other people who were involved in the campaign went to see their MPs. And so I learnt about how you can begin to change things. About how Parliament works. One of the things we wanted to do early on, we wanted to get this on the Parliamentary Agenda, so we had to... one of the ways to do that is to have an early day motion. So I think any MP can put something down in a book and if other MPs support it and it gets enough support than the government has to consider it as something that they need to take onboard. And so we said great we'll get an early day motion. Who's our MP? Who's gonna put this forward? And then we said well no we can't do that because what will happen is it will encourage everybody to write to their MPs, their MPs will look at this early day motion, they won't know what to do, they'll go and see their party officer. The

party officer will say, we don't know anything about this don't bother signing it and once an MP said they're not gonna sign it, they're reluctant to change their mind. Instead of doing that way round, first we need to spend three months lobbying all the MPs first, informing them, bringing them up to speed, then we put down the early day motion, then we get people to write their MPs, then the MPs know what to do and they will back it. And it was the biggest early day motion of that Parliamentary session. So learning about the levers of government and how you make change, how you work with the party conferences to bring the parties on board, how you sometimes play one party off against another, all of those things were for a kid who was doing a PhD at CERN, you know...

BH: [chuckles]

SS: And was only interested in quarks and so on, this was a whole new world and... very happy to have published that article and... happy to have survived it. [laughs]

BH: Did you end up seriously out of pocket or did you end up like, you know... you weren't on the bread line.

SS: I'm trying to think what the costs were in the end. The costs in the end... my costs... I'm thinking about two hundred thousand pounds. So I was presented with a legal bill at the end of two hundred thousand pounds.

BH: From your lawyers and people who'd helped you and all that sort of stuff?

SS: Yeah.

BH: Yeah.

SS: So all the people that I was responsible for paying for.

BH: Yeah.

SS: And they had a legal bill... probably of about... let's call it two hundred thousand pounds as well. Possibly...

BH: The other side this is?

SS: The other side as well, yeah. So had I lost... I would have to pay the whole lot.

BH: Right.

SS: So that's why it was... it was terrifying amounts of money.

BH: Yeah.

SS: Now, because they lost, they had to pay their own bills... that's the end of that.

BH: But you still had to pay yours?

SS: No, no, I can claim my money back from them.

BH: Right.

SS: But... they will argue every single line. So they will say, hang on, you had a meeting here with your senior barrister, why didn't you only have a meeting with the junior barrister? Look you had two meetings here in three days, why couldn't that have been consolidated into one meeting?

BH: Okay.

SS: They will argue about every single point. And so you only get back about two-thirds of your money.

BH: Right.

SS: So I was still seventy thousand pounds out of pocket and the Guardian... these numbers are not quite right.

BH: okay.

SS: But at the end of the day whatever the short for was the Guardian was very very helpful in bridging that and...

BH: Okay.

SS: You know, I absolutely understand why they weren't there at the beginning but I'm very grateful that they were there at the end. And also I mean the other cost was that during those two years I wasn't writing a book, I wasn't really traveling or lecturing, so you're not doing any work either.

BH: How has Simon Singh not written up the definitive libel book?

SS: [laughs]

BH: This sounds like an amazing story.

SS: Yeah.

BH: You talk about meeting Andrew Wiles and the compelling human story of that. You sitting on the steps feeling sick with that letter sounds like a great opening to a book.

SS: Yeah... yeah, maybe. Maybe... it'd be interesting listening back to this because I know one of the things I don't like doing is talking about how I feel.
[laughs]

BH: Right. [chuckles]

SS: And so, I can tell you facts. I can tell you... there was this libel case and there was that libel case and there was David Allen Green and there was... facts I can tell you. And I can probably even do quite a good job of... this is how they felt, and this is how they felt and so on.

BH: [chuckles]

SS: But it turns out how I feel about things I tend not to be very good at. So... and I'm thinking if you're gonna write that, that sort of book you need to be very open with how you felt.

BH: I can imagine the family conversations over the breakfast table during that period would have been compelling.

SS: Yeah. Yeah... it was... but you know we... so my first son was born... my wife was pregnant actually during the final Court of Appeal... and I think she was trying to catch the judge's eyes to try and gain some sympathy.

BH: [laughs]

SS: But the bulk of it happened when it was... you know, we didn't have children and this sort of... dominated our lives and as I said my wife's a journalist so she was absolutely there every step of the way. And all those people out there, you know, all the people that are listening to this and who followed that campaign and who wrote to their MPs or who tweeted about it or who

blogged about it or who mentioned it to their mates in the pub. You know, all of those people saying that I wasn't the crazy one, that the law was crazy, that made a huge difference, absolutely had I just been left high and dry, I would have then just thrown in the towel but had I been high and dry I wouldn't have need a towel. So there we go.

BH: For all the successful things you do, television, books and other things you're doing now that will talk about in a moment, how much do you think the libel thing will be like one of your real legacies? I mean that's how I first heard of you, was oh Simon Singh he's the libel guy. Oh yeah, I know that story it's amazing like... but I mean maybe that just... you know...

SS: No, no... I mean...

BH: Does it still follow you around?

SS: Like occasionally yeah it does. It... I met somebody in a cafe the other day and said, oh I'm teaching you today in our journalism class. And it was a very odd to think that your case is being discussed with journalists to help them understand the pitfalls of libel. So that's great and... absolutely so exciting to know that legacy is still there. And that many others, you know, I said, Ben Goldacre in particular and many others, you know fought for that change. But it also just goes back to my PhD is utterly forgettable, you know...

BH: [laughs]

SS: Whatever was in there has been superseded within six months by many other people. So... had I got on and stayed in physics... I don't think I'd of done a great deal that would have been very memorable but the libel law, you know, I'm very proud of that and very proud that people still remember it and still teach it in lecture theaters.

BH: All it took was a couple of loose sentences in a Guardian article. [laughs]

SS: They weren't loose! They weren't loose! [laughs]

BH: [laughs]

SS: There was nothing wrong with those sentences.

BH: Not at all. Obviously the court decided... so quickly on some of the books then. I'll ask you a quick couple of quick things about books. One is, it seems like over the course of these five books, this is where you're turning from Simon Singh the physics guy into Simon Singh the math guy. 'Cause you seem to start like... three of the five certainly I would describe as math books rather than science or physics books.

SS: Yeah, so when I was on Tomorrow's World, you just look for any story. You look for any good story. I couldn't have had a career at the BBC just doing physics.

BH: But I would've thought math'd be the last place you'd look for the stories. [chuckles]

SS: Well, Fermat's Last Theorem was there from the get go. So that was the first story. So you have a maths head-start when your first book is Fermat's Last Theorem, and then the Code Book is a maths book, I agree, but it's also a book about history and technology and many other things, and linguistics and so on. So... it's not a physics book, I agree. But it's only a little bit of a maths book. Big Bang is physics, through and through. Trick or Treatment's completely outside of my area of expertise and could have only written that book having co-authored it with Edzard Ernst. And the Simpsons Book, I was absolutely probably deliberately avoiding writing any maths books, so the Riemann Hypothesis... the Poincaré Conjecture, people send you ideas for maths books all the time. It was

just deliberately not gonna write about any of those things. But the Simpsons maths book was just, you know, just irresistible.

BH: The Simpsons math book seems like the... the odd man out in that collection to me, though. It seems more frivolous than the other ones.

SS: It is. It is and I think when I started writing it, I wrote it in a different way. I had 6 big chapters. 'Cause all of my books kind of have six or seven big chapters. And... when I was flying over to meet the writers for the first time, yeah... for the first time I rewrote the whole book. Between London and Los Angeles. And I smashed it up into seventeen little chapters. So each little chapter is just you kind of come in, you learn a bit of maths, you learn about that Simpsons episode. The math begins to get a bit difficult and bang we're out into a new chapter, a new idea, a new writer, and so on. So it's a much more bite sized book, you know, I think the flow of it and the pace of it and lightness of it is more akin to Simpsons or Futurama, so it is different in that respect, absolutely. But I would also just say the maths in it is, you know, in Fermat's Last Theorem we talk about, infinity, but in the Simpsons, Futurama math book we talk about... uncountable infinity and different scales of infinity. So there is some... pretty heavy maths in there as well. It's not a trivial maths book, but it's a little bit lighter.

BH: What are you doing at the moment? How do we even start with what... you've left books behind, I actually was secretly hoping you were gonna reveal to me today the new book you're working on.

SS: [laughs]

BH: But you've left books behind, that's it?

SS: I'm not sure. One, I don't have any ideas. I have not had an idea for a book since... 2006... have I not had an idea for a book for twelve years?

BH: Is that true? I would have thought like surely aren't you someone who just walks down the high street and think and everywhere you look you see a book idea? Is a book idea that different to another idea?

SS: So the Simpsons is the most recent book, but I had that idea a long long time ago. And the last book I had was for Trick or Treatment. That came out in 2008. So I would have that idea in 2006, 2007. So I haven't had an idea... a new idea for a book for ten, eleven, twelve years. So if I had an idea I might write a book. I probably wouldn't, because I'm not sure that I'm ready at the moment to spend two or three years working on a book that people may not necessarily read. You know, I think the book market is receding. There are amazing things on the internet, there are amazing long-form articles, clever blogs, short blogs, podcasts, funny videos, interesting videos, challenging videos... I have no problem with people reading fewer maths books as long as they're getting their maths in many many other ways and I think that's just as enriching. The Numberphile videos you make are every bit as informative and entertaining as any other chapter from any other book. So I have no problem with the book market declining but it just means it's not what I'm then gonna do next. Especially if I don't have any ideas. So instead what I'm really really interested in is education, maths education in particular. Because I think if you don't get the maths right, you can't do the physics, you can't do the engineering, you can't do any of those other great things.

BH: So your interest in the math education that we're about to talk about now doesn't mean you've like turned your back on physics, it's almost to help the physics.

SS: Oh yeah, absolutely. I mean I think physics A level is not really a good preparation for doing physics at university. And that's because they've taken the maths out of it. That's why I'm interested in maths. There are many areas that people could look at in terms of maths education. You've got kids who are

struggling with their basic numeracy, you've got other kids who are okay but who could do much better. There are many many different areas and age groups and people you could focus on. The one that I think gets ignored and the one that I'm really passionate about are kids who are good at maths but who never become excellent. I think in the non-selective state school system it's almost impossible to become excellent at maths. Because... GCSE maths is kind of a walk in the park. If you're great at maths. If you're not good, it's a bit of a struggle and if you've got your grade nine you've really earned it. But if you're good at maths... grade nine's not so hard and so we need to get these kids, preferably when they're quite young and if they've mastered everything at primary we need to stretch them and stretch them and show them interesting fascinating maths. And prepare them for what they could do later in life. So I've been interested in how do you do that. How do you... in a non-selective state school environment how do you encourage good students to become excellent? And I'm only interested in ideas that are cost effective and scalable. There's no point taken... I don't think there's much point taking kids away for a week long gifted and talented summer school... when in September they'll go back to their old classroom and the mundanity of their classroom maths is there for the rest of the year. So I'm interested in something that happens day after day after day, within a school environment. And so the idea that I've developed is something called Top Top Set Maths, okay? Horrible name... but just bear with it. Top Top Set Maths.

BH: Okay.

SS: And the argument I've got there is that if you're in a top set in maths, you're in the top twenty-five percent, the ability range in the top twenty-five percent is very broad. You know, if you take twenty-five percent of the population they are not all good good mathematicians, some of them are bit better than average, some of them are brilliant. And you tend to have to go at the pace of the weakest students in that top set. So the good top set students just twiddle their thumbs.

BH: So they're still being held back even though they're supposed to be in the elite group?

SS: They're in the top set, exactly. So and schools often have two top sets. You know, the schools very large so you'll have two top sets, so I'm saying... refocus it so you've got 1 top top set, and then a second top set below it. And then with that cohort of students that are quite narrowly ranged in their ability, but all confident and they've mastered primary school maths. In year 7 when they're eleven or twelve years old start pushing up. Start pushing them along in this top top set environment. And keep that top top set going right through to GSCE. So those kids don't just get a grade 9, they go beyond grade 9. Their maths is so strong at that stage. And, we're running it now in thirteen schools. We've only got data from the previous two years when we only had about four schools, but the results are quite staggering. There's something called the Junior Math Challenge, which kids do when they're in year 7, year 8. Our four schools doubled the number of certificates they're getting in the Junior Math Challenge. So they're getting twice as many kids being excellent at maths. And so I think we're making a step change. And this year we'll have a lot more data and then the next stage is to say right, let's not just have it in thirteen schools, let's have it in a hundred schools or five hundred schools or a thousand schools. So that wherever you are in the country, if maths is your thing, you can get into a top top set and you can continue to build on those skills.

BH: Isn't this just like divvying up the cake even more though? Just more slices, like it doesn't sound like a paradigm changing idea to say let's break them up even more, into more specialized groups.

SS: It's not a very a radical... idea... it's quite an old fashioned idea. It's not a new curriculum. It's not a new way of teaching maths. It's not math mastery. It's just saying, if kids are good, let's progress them really as far as they can go. Let's stretch them.

BH: Don't you need another class? And another teacher? You were talking about cost effective and isn't this just like creating more work at school?

SS: Yeah, yeah. Oh, yeah you do need an extra class 'cause, you know, this is an additional set effectively.

BH: Hmm.

SS: And so you do need an extra person to be teaching it as well. I still think pound for pound this is the best way to teach excellence. I've seen lots of other ideas over the years. I've spoken to five, six hundred school groups over the years, I've been to hundreds of schools. I've heard lots of ideas. This is the one where I'm seeing concrete results and... financially if you wanna make this change, this seems to be the best way to do it. But in a year from now I'll have more data, maybe I'll be wrong, but... at the moment it seems to be more effective. The other thing I would say is that it kinda maybe sounds elitist, you know, you're focusing on the good kids and so on. But what I'm seeing is that at the moment if you want to be excellent at maths, mum needs to be an engineer or dad's a math teacher or there's somebody there who kind of mentors you along. Because the schools struggle to do it. So what I'm hoping is that this will allow far more children from a far wider range of backgrounds to become excellent at math. You don't have to had to go to private school or had to go to a grammar school. It's less divisive than a grammar school. It's... you know... everyone's in the same school. Kids can move in to the top top set or out of the top top set. So one of our schools is Plashet School in Newham, all girl school, from a huge variety of backgrounds, large Muslim community there. And I remember sitting in the back of the class when the project started and these girls are all very bright, you know, they're in the top top set already. So... if we did nothing at all they would all go on and probably do maths A level. But in our set, I think they're gonna go on and do further maths. And go beyond further maths. And become computer scientists or they're gonna become aeronautical engineers or they're

gonna do something incredible. So I think we're giving those kids a huge opportunity to become brilliant at maths which is otherwise very hard to achieve.

BH: You said you're piloting this in a number of schools at the moment, does that mean you've brought money to the table for them to be able to do it?

SS: Yeah. So I... so for the first year I said I'll pay for it. 'Cause I don't want anybody else interfering with it. So for example somebody might say well... we're gonna fund this project but only if it's developed in such a way that more girls do maths A level. We're not gonna get more girls doing maths A level. As I was saying earlier, the girls that I was talking about are already gonna do maths A level. But they will do much much better. They will become incredible role models, so, it's not about getting more girls to do maths A level, it's about getting those that are doing it to excel even further. But I didn't want that tinkering or tweaking from other people. So the first year I funded it, the second year I funded it but as you can imagine the year 7s become year 8s and there's a new year 7 cohort, and I didn't have any more for that. But all four schools said, we don't care we're gonna carry on doing it because we see the benefits. In the third year, I'm still putting in some money but I'm also getting funding from John Lyon's charity, which is kind of the philanthropic arm of Harrow's School. They've been tremendously supportive. Emmanuel College, Cambridge have put in some money. The London Mathematical Society have been fantastic and the Winton Foundation. Winton Philanthropy have also been very supportive. So we're beginning to having show the proof of concept, I can then go out and say, we need some money to support this and people have come forward and that's been great. The next step is to get the data, show that it works, or not. If it does work get bigger money in and expand it across the country.

BH: I mean it sounds like if your dream was to come true and this was to become standard across the country, it'd be enormously expensive though. It'd be a whole new bunch of maths classes.

SS: The cost would be about five million, a year. Five to ten million a year.

BH: What, for the whole country?

SS: Yeah. Okay. I find that quite a lot of money but... [laughs]

BH: Well on the national education scale of things that doesn't seem that much.

SS: Yeah, you've worked it out more quickly than me actually.

BH: Alright [laughs]

SS: So, yeah, you're absolutely right. It's one teacher per school. Because you've got a top top set in year 7, year 8, year 9, year 10 and 11. That's five classes. One teacher could teach all those classes. In practice you would... you'd share it around a bit. But you need one extra math teacher per school. Now math teachers are like gold dust. So that could be a limiting factor in how it grows.

BH: Right.

SS: But, if I was retiring as a math teacher, I'd be quite happy to come in part-time and teach one of these groups. If I was a school that ran a top top set maths project I think I'd find it easier to recruit math teachers to my school. So I think there are ways of making it work and, you know, if teachers are the limit then we'll find out soon enough, but at the moment there's... we could definitely have a hundred, two hundred, three hundred. And then that means that's a thousand, fifteen hundred extra very strong mathematically minded people coming through the system every year.

BH: I know you travel around Simon, and sort of evangelize for this idea and

I've seen you talk about it myself. Obviously a lot of people are gonna like what you're saying. When you get criticism or when people say hang on you haven't thought about this, can you think of any criticism you've heard so far that you've thought, actually that's a good point, I hadn't thought of that, like the one that came to my head, you've already addressed which was sort of the elitism of it and just like you know, the good get better and that but, you say you can come in and out of the set, so... but what's a criticism of it? Like, help me criticize it... [chuckles] 'cause I think it's a good idea.

SS: The weird things are things like... there are problems with it which you don't see until you actually get to the coalface, like time tabling.

BH: Right?

SS: In schools this is really boring. This is the most tedious thing in the world.

BH: [laughs]

SS: But it takes them a lot of effort. Some schools are so big they have a band 1 and a band 2.

BH: Right.

SS: For anybody who can't see this I'm doing jazz hands at that moment.

BH: Yeah. [laughs]

SS: You've got band 1 and band 2. And it's purely so that we don't have enough science labs. So when this band is doing physics, the other band's doing history. When they do physics the other band's doing history.

BH: Yeah.

SS: So that means that your top top set has gotta sit in one of these two bands.

BH: Right.

SS: Now that...

BH: You can't have band 1 top top set and band 2 top top set.

SS: Well then you double to costs of the project.

BH: Yeah, yeah.

SS: So then how do you select students and how do you allow for migration between bands and how do you... so those things are the nitty gritty of how do you actually make it work? Then some schools, they do maths across both bands, it's not a problem. In some schools they only have one band, so they make it work that way. They're more logistical problems than this project is fundamentally flawed or is ethically wrong or something... you know, every school I've come across has said, we want to do the best for all of our students. If this student's musically gifted we want that student to excel. If this student's struggling with their science, we want them to become scientifically more confident. But if this kid's got a maths bug, we want to stretch it as far as it'll go. So they want to do the best for every student and they very much see this as being one of those ways of succeeding.

BH: Do we not need English top top sets and history top top sets? And...

SS: No.

BH: No?

SS: No. No.

BH: Just math?

SS: Just maths, yeah.

BH: Yeah?

SS: I can explain that.

BH: Yeah?

SS: The reason is, my feeling is that if you're interested in history, I think a lot of families can support that. There are families can, you know, they'll go to Warwick Castle or the Tower of London. You can watch Horrible Histories. You can watch more serious documentaries. History's very accessible. If English is your thing, you know, I remember our English teacher's used to say oh you know, look, you know, you're good at English, you know here's a Dickens book, I want you to read this one over the Easter because I know you'll cope with it. And you can just be stretched while you're at school. Maths is different. Maths needs mentoring. It needs that guidance. You know, you and I can read the same Shakespeare book and a load of it will go over my head and you may appreciate in a much deeper more meaningful way but we can look at that same book and read it at the same rate. If we look at a calculus book then that's not gonna work, you know, for some people it just means absolutely nothing at all, for others its meat and drink to them and they'll speed through it. So I think maths needs that mentoring and that careful approach. The data suggests, the international data suggests that our students, are average students are pretty average compared to the rest of the world. And we've a lot of average students. What we don't have, thankfully, is very much at the bottom tail, but we certainly don't have very much at the top tail either. So that's where we're failing as far as I can see.

BH: An argument I've heard that I'm imagining you're gonna disagree with quite strongly but I wonder what you think about it, is the argument that maybe we place too much importance on math education now in schools and maybe the times have changed and while there is a place for mathematics we should be pushing more towards computer science and programming and coding and we should be turning the math dial a little bit?

SS: When I think about maths, I think math is really just about developing thinking skills and it's just developing problem solving skills. So those skills can be applied to anything and everything. So if you wanted to say let's throw out this loads of maths and instead put in this coding bit in the maths curriculum, very happy with that if that coding skill is all about maths... is about problem solving and so on. It's about giving children problems that they can't necessarily do and showing them how to tackle the problems, approach those problems, develop tenacity, this whole thing about growth mindset? Have you come across all these things? Oh, you've not come across growth mindset, oh... right okay. So I hadn't come across it either, but it's very big in education at the moment and some people say it's a little bit of twaddle and other people say it's... it's revolutionary. But the idea is that in the past... when I was at school, oh Simon, he's good at maths. That's it and Fred's rubbish. And Fred's always gonna be rubbish and Simon's always gonna be quite good, because he's just somehow he's got the math gene or whatever. And that's a really unhealthy approach, because it means that Fred's just gonna give up 'cause he just hasn't got that maths thing. And Simon's... it's not good for him either 'cause if he's just good at maths, he's not gonna try that hard. And also when I reach a point where there's a problem I can't do, that's kind of catastrophic 'cause I'm supposed to be good at maths and here's something I can't understand and it just destroys kind of your view of who you are. And that's fixed mindset. Growth mindset is the opposite. Growth mindset says that whether you're good or bad, by working harder you can always get better. And in fact people who are good have typically been working quite hard previously to get to be good. And so it's not about you've failed, it's about you haven't succeeded yet. And so you always praise the

effort and the work rather than the achievement and regardless of the achievement you know you can always do better, and so... that's... you know... kids in our top top set should be struggling. 'Cause struggling is part of becoming a good mathematician. Whereas if they're in a normal top set, they're just good at maths. Gosh look it's just so easy. And it makes them complacent and lazy and it just doesn't develop the skills they need. There was an experiment done a few years ago which I think illustrates some of these points. Which was that, you know, same kids put their hands up to answer certain questions. So... you have lollipop sticks with all the names on and you pick them out at random. So you have a much broader array of kids answering questions. Being picked on to answer a question and everybody has to be alert 'cause they may get picked on next. When they moved to this model, some kids started playing truant and just not turning up. And the kids who are not turning up... were the ones who were thought to be very very bright. Because previously when they put their hand up they always got it right. Now there was a chance that they may get picked on for a question that they didn't know the answer to and then they'd be shown up as not being as bright as everyone thought they were and that just destroyed their vision of who they were. So that's part of top top set, is about developing those skills to apply in engineering or coding or anywhere else. Physics in particular.

BH: I could imagine not wanting to go into the top top set for that very reason though.

SS: [laughs]

BH: Like thinking, oh, if I go up there I'm gonna get beaten up every day and...

SS: Yeah.

BH: If I stay here in the, just in the top set, it's alright, I'll have a happy life.

SS: No, our experience is that it's a leap from primary and I think when they move from primary to secondary kids kind of are open to anything. And that's one of the advantages. I know some schools do this sort of top top set approach in the year before GCSE. You know, these kids are gonna do A level, well we better start working them a bit harder because they're gonna be the A level math. That's too late. You gotta start them when they're eleven or twelve, when their attitudes can change and their ambitions can change and they realize they can solve maths problems that look apparently impossible to them.

BH: I can't remember what it's like to be that age. It was so long ago, but is it a situation where being put in the top top set is like... prestigious or is it like being put in the nerd club when you wanna be cool with all the cool kids?

SS: I think some schools don't make a big deal of it. They just say look we have... we've always had a top set and now we've also got a top set but the old top set is now just gone down... you know it's just the same system as before. Top top set's tend to be a little bit smaller. They tend to be more like twenty rather than thirty. So I think in general the students know that maths is now their thing. Like being on the school football team or the school orchestra, they're sort of in the school maths team and...

BH: So it's more prestigious.

SS: I think it's a bit more prestigious and they take it a bit more seriously. And they do extra work. Again, you know, one argument well you said, well they're good at maths, why do they need to do extra work? And my argument is well if they're gonna build their future on maths then they do need to do it. If they're gonna compete with the grammar school kids. If they're gonna compete with the kids in the private schools, they're actually still catching up. And so one of the things we've done in addition to just having the Top Top Set project, is something called Parallel. So Parallel is a weekly maths sheet, comes out on a Thursday at

three o'clock. It's all free, anyone can sign up.

BH: It's like an email list, isn't it, you can sign-up to it?

SS: Yeah that's it and you just go onto the Parallel website. We've designed though for our top top set students. So they have an extra twenty minutes of maths to do over the weekend. But as I say, anybody can sign up, it's... we've got a year 7 sheet, a year 8 sheet, a year 9 sheet. Teacher's can sign up their classes. Parent's can sign up their kids. The maths is interesting, some of times there's even a Numberphile video there.

BH: Oh... excellent. Excellent.

SS: [laughs]

BH: I need to get on more of them.

SS: No, they're brilliant, because you know some of them are pitched at just that age group and they're challenging and interesting and then there are film clips, TV clips, sometimes a video about philosophy. Sometimes something about physics.

BH: So these weekly... are you still calling them Parallelograms? [laughs]

SS: That's right. Yeah.

BH: These weekly missives designed for the students who are in top top sets, but you let everyone else in the world sign on for them too. If they just wanna do them for fun or...

SS: That's right.

BH: ...have some use for them.

SS: We've got about three or four thousand do them every week.

BH: Yeah?

SS: Largely in Britain but also around the world and if, you know, if you teach in a school that doesn't have a top top set but you've obviously got kids who are strong and you want to stretch them then this is a really easy way to do it. They can just sign up. They can do it. They get a solution sheet when they complete it and I think it's challenging but it's also fun. If you're a teacher or a parent or just a kid and you wanna sign up to this just, yeah, parallel.org.uk.

BH: And I'll put a link in the notes as well for people.

SS: Great.

BH: Yeah.

SS: Yeah.

BH: You said that you don't think television is a good medium for teaching mathematics... [pauses] why is that?

SS: Television is a good medium for inspiring people. Television's a good medium for telling stories and so on but if you want to teach somebody some maths. You know, if I'm watching a Numberphile video, you know I know the videos are not... there to teach you maths. But you can learn a huge amount of maths from them. People do learn a huge amount of maths from them. And I watch it and I pause it and I'll go back and I'll watch it again. Hang on, didn't quite follow that. Oh, I might pause it again, do some calculations, oh yeah, now I see what they mean. So... you can't really do that with television. You know,

television really is just a flow and yeah... [gentle music fades in] in a book again you can read a book and you can stop and you can pause and re-read it and do some calculations and stuff... so... you know, books and Youtube are far better at teaching maths... than television.

[music gets louder]

BH: If you'd like to find out more about all the stuff we've been discussing today from court cases to Parallelograms, I'll include some useful links in the show notes. I'll also include something about Simon's books which are well worth a look. [music continues] My thanks go to the Mathematical Sciences Research Institute for its support of Numberphile and our episode sponsor today Meyer Sound, an amazing audio engineering company based in Berkeley, California. Thanks so much for listening and we'll be back very soon with another interview.

[music fades out]