

Numberphile Podcast Transcript

Episode: Why Study Mathematics - with Vicky Neale

Episode Released December 8 2020

Dr Vicky Neale's latest book is about why people should study mathematics - but why did SHE study mathematics?

[Dr Neale's website - with links to her work and books and craft](#)

[Why Study Mathematics - book on Amazon](#)

[Vicky's author page on Amazon](#)

[Vicky's craft, including the prime bracelets](#)

Support Numberphile [on Patreon](#) like [these people do](#)

With thanks to

[MSRI](#)

Direct Download: <https://www.numberphile.com/podcast/vicky-neale>

Listen on Numberphile2: <https://youtu.be/rh7zVQy4XD0>

[gentle chime music]

Brady Haran [BH]: Today's guest is Vicky Neale a mathematician at the University of Oxford. She's just written a book about why people should study mathematics at university. So of course, I wanted to find out why Vicky studied mathematics at university.

[gentle piano music]

BH: So... the beginning is always a good place to start, where are you from? Where were you born?

Vicky Neal [VN]: [laughs] I was born in a place that we moved away from

when I was six months old, so I was born in Worcester but I know nothing about Worcester. I grew up just outside Winchester in the south of England. So a little village near a small city.

BH: So when you go to Worcester or Worcester comes up in conversation, do you feel any warmth or attachment to it because you were born there or is it just like complete coldness?

VN: It's mostly coldness. I have been to Worcester a couple of times to go and do maths with young people and...

BH: Yeah?

VN: I was curious to go and see having being born but... I know nothing about the place. [chuckles] I'm sure it's a lovely place I've just not spend very much time there.

BH: Did you like go and track down the hospital you were born in or anything like that?

VN: I spent sometime trying to work out whether the university building that I was working in was somehow... or they bulldozed the hospital and replaced it, I never really got to the bottom of that. I wasn't so excited to be honest to know exactly where I was born.

BH: Oh.

VN: I was more interested in finding somewhere nice to have lunch.

BH: [laughs]

VN: Seemed like more of a priority.

BH: Tell me then what you were like as a youngster. Would I have seen little girl Vicky and said, well she's gonna be a mathematician?

VN: I don't think you would have been surprised [laughs] that I now do maths. I think my friends from secondary school are not surprised that I'm now doing maths because I really liked maths when I was at school but I certainly had no idea that... I might go on to do the kind of things that I've done professionally that wasn't remotely on my radar. I don't think I understood when I was at secondary school that people had jobs as university lecturers. I think, if I stopped and thought about it I'd have worked out that somebody must do the teaching in universities but I didn't really stop and think about it. So I definitely didn't imagine that I would find myself doing this kind of thing. I had no... kind of concrete ideas of what I wanted to do beyond maths was fun.

BH: What did you wanna do when you grew up then? What would the answer have been when the adults said, and what do you want to be when you grow up, Vicky?

VN: [laughs] I'm still waiting to grow up.

BH: [laughs]

VN: I think growing up might be overrated. I still don't know what I want to do when I grow up. My answer as a secondary school student was, I don't know maybe something to do with maths. And then people would say, oh do you mean like a maths teacher in school? As though that was the only thing... that you might do if you studied maths further. I don't know. And being a maths teacher is a terrific thing to do but it didn't seem like the thing that I wanted to do. It didn't feel like the right fit for me, so I was rather vague about the whole thing. I think I just sort of hoped that something would turn up. That maths was a sufficiently useful thing to study that I would find an interesting job somehow.

BH: Well what were your other hobbies and interests when you were a girl? Were they sort of maths adjacent or were there other things you were into?

VN: No, I spent a lot of time playing music. I learned the piano...

BH: Hmm.

VN: ...and the oboe when I was at school and I spent quite a lot of my secondary school time playing in orchestras. I loved playing in orchestras. So, I didn't do that much maths outside of school. I had a few opportunities come up through Royal Institution Masterclasses when I was thirteen or fourteen and then UK Maths Trust things starting when I was about sixteen, which was fantastic, but I also spent a lot of time sitting in the middle of an orchestra playing an oboe.

BH: What about sort of family and friends, parents and things like that? Were you surrounded by mathematics and mathematical people or like what did your parents do for example?

VN: My parents are both mathematical but wouldn't necessarily describe themselves as mathematicians, I guess. My mum was a secondary school teacher and taught various things including maths for a while, but would be modest about her mathematical capabilities, probably overly modest given that she was a secondary school maths teacher. My dad's background is in electronic engineering, so he did lots of maths as part of that but very much maths as an engineer rather than maths as maths so I think the conversations when I was growing up maths was part of the conversation but it wasn't let's discuss maths over the dinner table per se it was more just an everyday part of life that these things might be interesting to discuss along with physics and IT and embroidery and you know, all sorts of other things.

BH: When you look back at your maths education at school like, the people I

speak to I get such mixed responses about how they look back at it. Some people, it was just a wonderful warm experience at school, other people, it was like this dreadful terribly taught thing that they kind of persevered despite it. How would you describe your school mathematical education?

VN: I think I was lucky in the teachers that I had who were always very supportive. I enjoyed the maths that I did at school. I think I was probably the annoying kid who kept wanting to be fed more. I [chuckles] sort of might finish some problems and can I have some more maths to do or can I have something more challenging to think about? I'm not very good when I get bored. I like having interesting things to think about and some of the maths in school was great 'cause I found it really stimulating and sometimes it seemed a bit... I don't know, I've done some questions like this I know how to do this I don't really want to do lots more, so feeding me enough maths to do was sometimes a challenge for my teacher. I was probably a nuisance to them. I discovered some books in the local library on maths. Sort of Ian Stewart books and those kinds of things, which I found really helpful for showing me where maths could go beyond what we were doing at school. So I guess the work at school was inevitably very focused on the school curriculum and GCSEs and A levels and so on and that was great, I enjoyed that, but it was also really exciting to see where else the subject could go and blow my mind a bit with trying to understand concepts that I really didn't understand.

BH: Were you then taking those concepts back to the classroom and bamboozling your teachers or...?

VN: I hope not 'cause I think I might have been quite annoying if I did. I don't remember doing that too much.

BH: [laughs]

VN: But maybe a bit.

BH: You sound as though you were very self motivated?

VN: Yes I suppose so. I don't... nobody has ever said, Vicky you have to sit down and do this maths now. I've always been very happy to get on with it and I guess it's one of the things I like about my job now is that I have quite a lot of flexibility to do things that I find interesting and just get on and do them. I don't have somebody saying oh the next job you have to do is this or those kind of things. So, yeah, I guess that fits with being the kind of teenager who was happy to get on with doing the work and also do whatever else needed to be doing.

BH: Besides music and mathematics what might I have found you doing? Would it be kind of the nerdy stuff like Rubik's cube and puzzles and games or would I have found you playing hockey or watching TV? What else were you into?

VN: [laughs] You would definitely not have found me playing hockey, possibly even when that's what I was supposed to have been doing at school. [laughs] I was never deeply into hockey. I used to go swimming, sometimes that was quite good for clearing the head and lots of craft things. I like doing craft things and still like doing craft things.

BH: So as high school started drawing to a close and you had to like start making actual decisions about university, what was the thinking and what were the decisions that were made?

VN: Yeah it was never a very difficult decision. I remember having a difficult decision when I was about fifteen and applying for Sixth Form College, 'cause I went to my local comprehensive school and in Winchester they stop at age sixteen, they don't have a Sixth Form, so I had to go to Sixth Form College for my A levels and I remember it being completely clear that I wanted to do maths and further maths and I figured I should do physics 'cause it seemed like that what

you should do and what I kind of wanted to do was French and German but I sort of had this idea that maths and further maths and physics and chemistry was a thing. I'd somehow got that impression and I remember having a conversation with my maths teacher who was very wise and very helpful and said if you want to do French and German, do those. So I loved doing the languages alongside that but... and I joined the physics A level but there was really never any doubt at all in my mind I think that I would be applying to do maths at university. I didn't know where, but... for me it was a very easy decision. I know some people find it hard to choose and there are lots of things that they're interested in, oh I didn't find it a difficult decision.

BH: At that point, at kind of Sixth Form, this is, you know the very end of high school, you're choosing to do mathematics at university, is this because you've just got this insatiable love of mathematics or at this point are you starting to see a career path?

VN: Yeah honestly it was just that I loved doing maths. That was the only rationale. [laughs] I really enjoyed the problem solving aspect and I really enjoyed that I didn't get bored thinking about maths, that they were concepts I grappled with, it wasn't that I found it all easy. I sought out challenges to think about and the UK Maths Trust Olympiad questions for example, I spent quite a bit of time as Sixth Former falling to solve Olympiad problems and...

BH: Right.

VN: ...I guess I solved just enough of them to keep me motivated to want to keep solving them but I also spent quite a lot of time not solving them. And I really enjoyed that challenge and the idea of doing more that sort of not lots of routine questions but questions that get you thinking and you have to find creative solutions and how might I go about doing this and so on. I was really keen for that kind of thing. I had no career plans at all. I just sort of got the impression that maths degrees opened lots of doors and I sort of figured I'd

worry about it later on. I was told that I should go and get some careers advice but the careers advice was... limited. [laughs] And I just...

BH: Okay?

VN: ...I think everybody recognized that actually I was just wanted to do maths and that was fine. Nobody tried to talk me out of it.

BH: Did you compete in any of those Math Olympiads as a school student?

VN: Yeah so I took part in the UK ones, and I did just about well enough to be invited to a few events, sort of training camps and things and then didn't make it any further which was fine, I wasn't very interested in the competition part of the competitions, I loved the fact that they gave me interesting maths to think about and I loved that when I got to go to a couple of these events I met other young people who were also super excited about maths and we could talk about maths but also talk about not maths, I mean it's not like we talked about maths the whole time but just interacting with other people who didn't think I was a bit odd for enjoying maths.

BH: [laughs]

VN: So I loved all of those things about doing the competitions. The actual competitive part didn't interest me very much. I wasn't very motivated by that.

BH: Oh, I won't ask you about medals or anything like that then.

VN: No, don't. [laughs]

BH: [laughs] Tell me, where did you go to university then as an undergraduate?

VN: I was an undergraduate in Cambridge.

BH: You were getting pretty good marks then at school.

VN: Yeah I guess so. [laughs]

BH: What was it like going to Cambridge then? Going from, you know, school level mathematics to big league?

VN: Yeah I loved it because there was lots of interesting maths to think about and there were lots of interesting people around to... chat about maths and other things. So it was definitely not clear to me going through the last couple of years at school that I would make it Cambridge, not clear at all. [laughs] I still remember the results day and trying to believe what the piece of paper said, so, yeah, I did not take that for granted at all, but I loved it. It was really exciting to have lots of time for mathematics and not having to do other things that I didn't enjoy quite so much.

BH: Was the demand difficult though? I hear from a lot of people that go to Cambridge that suddenly think, gah, I gotta work so hard and this is like, it's like a real change of gears. Did you not find that?

VN: I think I'd already been used to working quite hard. One of the things I really liked about the Sixth Form College was that we had quite a bit of unstructured, you know, free time in between lessons and I could crack on and work on some maths and I enjoyed working on Olympiad problems and the problems that I had to do for the Cambridge kind of paper. I just got on and worked on those in a pretty self motivated kind of way, so I guess I was already used to spending a long period of time sitting and failing to solve a maths problem, so when I got to Cambridge it felt like [laughs] quite natural to spend lots of time...

BH: [laughs]

VN: ...sitting and failing to solve maths problems 'cause I'd done that already. And I did solve some of them but... I was already, I guess, quite used to grappling with that. It was quite intimidating being in an environment where the buildings are how ever many hundreds of years old and you keep being reminded that Isaac Newton was a student here and that kind of thing, so there was quite a lot of imposter type feelings and should I really be here...

BH: Yeah.

VN: ...but I enjoyed the mathematics a lot.

BH: And also obviously you've probably gone from being mathematically a pretty big fish to just being another... person who's pretty good at mathematics? Like you're suddenly you're surrounded by the cream of the crop. How did you find that adjustment?

VN: That is true, but again because I'd been involved in these training camps [laughs] I'd already been a very small fish. [laughs]

BH: Yeah?

VN: So I'd just love the fact that there were other people around who were keen to discuss mathematics and so on. Not that my entire life revolves around mathematics but...

BH: I don't think I've ever spoken to someone who sounds that they were so prepared for university and found the transition so natural.

VN: I think... [pause] looking back it's a bit of a surprise and... [laughs] and it was... demanding and the workload is intense but... I guess I was sort of up for

that challenge.

BH: And then how was your undergraduate sort of years at Cambridge? How did things evolve for you there?

VN: Yeah I mean like everybody, ups and downs, but I kept enjoying the mathematics. I found some interesting ways to do mathematical things during the summer. Not the first year. I got a job and earned some money doing something not quite so exciting.

BH: Well you gotta tell us what that is!

VN: Yeah, I worked for a teddy bear company.

BH: Like what doing what?

VN: Yeah I spent... a bit of time doing admin for them and sorting out some spreadsheets and I spent a bit of time packing teddy bears in cardboard boxes. Which is cool just not very mathematical.

BH: [laughs]

[gentle piano music]

BH: At what point did it become clear that you know you were gonna go further than just an undergraduate? Like you weren't going to go off to the city and become a stock broker?

VN: I must've made a decision about that at some point. I don't think going to the city and becoming a stock broker was ever really something that I thought about doing. I don't really see myself in that environment. I was applying for internships for the vacation between my second year and third year and I was

offered a sort of position in a sort of financial sector kind of thing but I was also lucky enough to have the opportunity to do a research project and somebody was going to pay me to stay in Cambridge and do maths over the summer so I decided to do that instead. [laughs] And then I spent the next couple of summers working for NRIC which is a maths education project and really enjoyed that, really enjoy getting more insight into kind of maths education and how people learn mathematics and how we can support students with learning mathematics. So, it just felt really natural to think well actually I want to stay on and do the fourth year, the Masters year and, yes I think I would like to do a PhD. And keep doing some more maths, I didn't feel like I was ready to stop learning mathematics.

BH: How does life change when you go from undergrad to Masters to a PhD? Like how does life change and how does the mathematics change?

VN: For me going from undergraduate to Masters didn't feel like very much of change because the format of the course was quite similar. It was a taught Masters, it's a one year, the final year of an MMaths so it was sort of more of the same except that I was...

BH: Yeah.

VN: ...specializing a lot more and had chance to try to choose courses and that was quite interesting just finding out more about which bits of maths I particularly enjoyed and realizing that some bits of maths were not my natural habitat. Going to do a PhD then was quite different, because, it's not so much structured time, you don't have lots of deadlines each week, it's I guess more like having a job, [laughs] somebody gives you some money and you have to do some work. But there was a lot more sitting in my office staring out the window doodling with ideas trying to figure out what I was supposed to be doing and trying to read research papers and understand what they were going on about and... and so on and so it was quite a different experience from somebody

presenting a lecture course where they've organized the ideas very carefully and the stuff's pretty well understood and it's been around for a long time so people have worked through and found a really nice way of approaching the ideas and so on, so the PhD kind of apprenticeship in research I guess felt... quite different. [pause] Working pattern and I could sort of go to work in the morning and sit in my office and then go home in the evening which is quite different from being a student and just working in my room whenever I felt like it.

BH: You talk about some areas of mathematics not feeling like your natural habitat... and obviously other ones did can you tell me about the bits you liked and didn't like and why you think that's the case? Like is just the wiring of your individual brain, was it just the personalities of the teachers you had? How does that unfold?

VN: I don't know. This is something I've wondered having now taught lots of undergrads and sort of watched lots of undergraduate going through their journeys of finding what excites them mathematically and I think it was partly just which questions I instinctively was interested in being able to answer. I don't mean like problems on a problem sheet but... [pause] I guess a piece of mathematics that's been developed to answer a question. The reason someone has proved a theorem or comes up with a new definition or organized a piece of work is that there trying to answer a question and some questions I've found just instinctively... I thought gosh that's a really interesting question, I'd like to know the answer. And others not so much. I think I also found there was a bit of... trying to find what level of abstraction suited me so some maths is very very concrete and some maths is very very abstract and lots of maths is somewhere in the middle and some bits actually I just don't instinctively think as abstractly as that or... this is too applied for me, so... I think it's partly about, yeah, individual differences and also... which bits that I enjoyed enough that I wanted to put the work in to try to understand them. [laughs] So inevitably I was more inclined to work hard on things where I thought actually I'd really like to know the answer to this. I'd really like to understand what this is about. This is really cool.

BH: A lot of mathematicians when I've spoken to them about this stage in their career, I've been surprised by the number of them who've talked about they've made a choice based groups of students they liked or a supervisor they liked and things like that rather than the mathematics itself. It sounds like your decision making there was based very much on the work, the content.

VN: I think to a large extent it was and the people around me some of them were specializing in the same things as me and some of them were going in different directions and so on and so I didn't feel like that was a big pull. Of course when you have a really fantastic lecturer then the work feels more understandable and maybe you have a clearer sense of why it's exciting and you know you can be inspired by somebody, so I'm sure that was a factor but I guess some of the people who taught me who were inspiring were in bits of maths that I didn't then go on to pursue. [laughs] And there were also some people who were not quite so inspiring. [laughs]

BH: What was your area of specialization? What was your PhD in?

VN: My PhD is in additive number theory. So I was interested in number theory and combinatorics so I told my mum I was doing a PhD in adding up whole numbers, and she said Vicky...

BH: [laughs]

VN: ...you did that when you were five and I said yes but this is adding up whole numbers. I guess one of the things that I like about the area that I was working in was that it pulled together strands from different bits of maths so the things that I ended up using to prove a theorem in my PhD thesis were not necessarily things I thought I would be using when I started. I quite like that thing of different bits of maths coming together. I think we often think of maths as being separate boxes of pure and applied or this is number theory and this is

analysis and this is geometry and this is differential equations or something but of course actually it's really interconnected and I ended up using ideas that I'd first met in a nominally applied course as a second year undergraduate but turned out to be helpful for grappling with a problem about whole numbers which I thought was quite cool, so that flavor appealed to me somehow.

BH: Do you look back at your PhD thesis fondly? Did you discover something interesting?

VN: [laughs] No. [laughs] Not very. [laughs]

BH: [laughs]

VN: The theorem that I proved is of... I would say limited interest in a way... [pause] the point wasn't so much to prove the theorem as to see whether the techniques could be used to solve a problem of that type.

BH: Hmm?

VN: So what I was doing was taking work kind of ideas that Hardy and Littlewood from the first half of the 20th century had developed but then combining them with work by my supervisor Ben Greene and his collaborator Terry Tao to try to apply those ideas in a sort of different context, so, in a way the result itself was not ... so exciting it was more being able to apply those techniques combining the older and the newer to make it work out that was I think the thing that I find interesting. I mean it's kind of cool to have proved a theorem, I'm glad to have proved a theorem. [laughs]

BH: Yeah! Also, Hardy, Littlewood, Green and Tao, you're dropping... I'm not mathematician and even I know they're big names.

VN: Yeah they're quite good names to drop, aren't they?

BH: Yeah! [laughs]

VN: [laughs]

BH: So, at any point during the PhD did you have that feeling that, oh... I'm not gonna do it. It's going nowhere? Or did you steer the course pretty well on that spectrum between despair and cruising easily, where did you fall?

VN: Uh... I think I spent a lot of my PhD feeling very doubtful that I would ever get a PhD. [laughs] I remember having...

BH: Yeah.

VN: ...conversations with friends in other subjects and I think in some subjects it's just a very different kind of experience you can sort of start out with this is the question I'm going to tackle and you do a literature review and then you think deeply and you write and you think and you write and rewrite but you sort of know that you're going to come up with a thesis, it might be a better thesis or a less good thesis but you will have a thesis.

BH: Hmm.

VN: Whereas the kind of work that I was doing, it wasn't clear, at least to me, that I was gonna prove this theorem. [laughs] And if you don't prove a theorem you can't write a thesis saying well I tried very hard and I didn't prove a theorem, that doesn't get you a PhD thesis.

BH: Right.

VN: So, I worked on more than one problem during the course of my PhD and there was one that I kept going back to which is the one that I ended up

solving and it had different facets to it so when I'd spent three months being stuck on one direction I could switch to a different aspect and try something different and occasionally I'd try a different problem altogether but it wasn't clear to me until really quite close to the end whether I was going to solve the problem and exactly what the thesis would be about. Which I found... a bit unsettling, maybe some people are very calm about these things. I found it a bit worrying, am I ever going to finish this thing, but... yeah, got there in the end and having a supervisor helps with that.

BH: Do you remember a moment? Do you remember a breakthrough or walking across a bridge and suddenly all it came to you...

VN: [laughs]

BH: ...or lying in bed or something where you realized, I've done it. I've proven it.

VN: There wasn't one moment like that. There were different bits of the problem that I had to solve so it would be a case of getting one bit done and then moving onto another and so on and so it felt to me more like...

BH: Hmm.

VN: ...chipping away at a problem. I don't know I sort of have this mental image of a very hard stone ball and every now and then I'd manage to chip a tiny little piece off it and... just occasionally I'd have chipped enough pieces off that a really big lump would come off and sort of something would open up a bit more but, it wasn't one kind of eureka moment or anything like that.

BH: You end up with Michelangelo's David at the end?

VN: [laughs] If only. [laughs] If only. And then I'd go and talk to my

supervisor and I'd say well this is where I've got to and we'd chat about it and he'd suggest some directions for attack and I go and sit and doodle at my desk and stare out at the window some more. I think a lot of my better ideas came when I was doing the washing up or going for a walk or those kind of activities where your brain is a little bit occupied with something else but not too occupied, I think, can be good for having good ideas.

[gentle piano music]

BH: So you've got your PhD, congratulations.

VN: Thank you. [laughs]

BH: Now what?

VN: [laughs] Yeah, I wondered that too. And I spent as lots of people do lots of time coming towards the end of my PhD applying for lots of jobs and not getting them and I was applying for postdoc type jobs, so the next step in the academic pathway.

BH: Hmm.

VN: And... I'm not sure I was totally sure that that was the right fit for me but it seemed like the thing that you should do, and I applied for lots of jobs and got rejected for lots of jobs and you sort of think, well I'm not sure about this. And then completely randomly I spotted an advert from one of the colleges in Cambridge who were looking for somebody to do a few hours a week of teaching for their undergraduates and to be, what was called a Director of Studies, so like they're personal academic advisor to their maths students.

BH: Hmm.

VN: And I thought well that would be a really cool thing to do. It's just a one year appointment. They said you could do this alongside finishing your PhD and I thought well that would be a really interesting thing to do alongside the fourth year of my PhD, it would help the finances a bit but also I'd really enjoyed the undergraduate teaching that I'd done already during my PhD. They said that it would be suitable for a PhD student or also a postdoc and I thought well somebody with more experience is going to apply for this, I'm not going to get this job but I might as well apply for the practice and somehow got the job and that was fantastic for me actually so I was at Mary Edwards College for a year as the Director of Studies and working with the maths students there and... really enjoyed that, really liked the environment I was in. Really liked being able to be there as a mentor, advisor, support, teacher for these students and that then turned into a full-time job for a couple more years, so I was at Murray Edwards doing lots of teaching alongside other bits and pieces and then the other bits and pieces sort of evolved some more so I was working on a maths education project then for a couple of years alongside teaching at Murray Edwards. So I worked on something then called the Cambridge Maths Education project, it then became Underground Maths and I did that for a couple of years designing resources for A level maths students and teachers. So, sixteen, seventeen, eighteen year olds and their teachers alongside teaching undergraduates and I didn't see any of that coming.

BH: Yeah?

VN: There was no [laughs] there was no plan to do any of that as I came to the end of my PhD but when I looked back over my PhD... there were lots of things I'd enjoyed and I felt there were the things that I'd enjoyed most and that I done most effectively have been about communicating mathematics and teaching and sharing mathematical ideas with other people more than sitting by myself in an office trying to prove a theorem. Which is a fantastic thing to do wasn't my thing to do, maybe.

BH: So what do you do now, how do we get to where you are now?

VN: Yeah so six years ago, a long time now, I moved to Oxford.

BH: Hmm.

VN: I have this great job title, I'm the Whitehead Lecturer at the Mathematical Institute and I am a Supernumerary Fellow at Balliol College.

BH: Alright, alright, I'm gonna try to say that. Supernumerary Fellow.

VN: Very good.

BH: [laughs] What does that mean?

VN: Somebody once corrected it, they thought it was a typo when they were writing my name down for something and put Supernumeracy Fellow and thought it was about maths, which I loved.

BH: Alright.

VN: It means that I'm just some random type of fellow. So yeah I have this great job title that tells you nothing about what I do but...

BH: [laughs]

VN: What I do in practice is I teach undergraduates and I do maths outreach, public engagement with maths and the role in college, I'm a tutor for students at Balliol, so I work with the maths undergraduates and teach them and I'm also available for them to come and chat to me individual about whatever and then I lecture in the department and do other interesting mathematical projects either by myself or working in collaboration with colleagues.

BH: I want to talk to you more about sort of outreach and books and a few other things you've done, 'cause that's obviously what you're known for, and you're a bit of a superstar in that area. But before I flatter you by talking about that, let me ask you this... where does someone who does what you do fall in... [pause] the math pecking order amongst all the bigwigs in the coffee room? You know, the people who are doing like, you know, pure research and things like that? Do they respect and love the teachers or is there kind of like this sniffiness or I always wonder about that.

VN: I guess within the Oxford Maths Department for example, different people have different roles and there are some people who are just doing research. I'm really unusual in having a teaching focused role that doesn't involve research. Most people do both.

BH: Hmm.

VN: And I guess inevitably some people enjoy teaching more and feel that that's a more important part of their role and for other people it's a sort of taking them away from things that they would like to be doing or quite a lot of work or whatever but I really like finding other colleagues who are interested in teaching and discussing those ideas with them and so on and so no I'm not remotely as important as the people who are kind of proving spectacular...

BH: [laughs]

VN: ...theorems and changing the mathematical world and I'm immensely privileged to be in a department like Oxford where I have colleagues like that. Teenage me watched the Simon Singh Horizon program about Fermat's Last Theorem...

BH: Hmm.

VN: ...when that came out a long time ago and I always recommend that to people if they haven't seen it. I think it's on iPlayer so you can watch it, at least within the UK, for free, and it's fantastic.

BH: Yeah.

VN: And teenage me would not have begun to comprehend that I would now work in the Andrew Wiles building and that Andrew Wiles who put that final very large brick in the wall of Fermat's Last Theorem is a colleague and that's surreal. One of my colleagues, Roger Penrose, has recently won the Nobel Prize. I don't really know what I'm doing in a department with these people [laughs] but I feel very lucky.

BH: I mean you're obviously very accomplished mathematician but do you ever feel an envy of those people who are gonna, you know, have their names on things forever and who inspired you when you were younger? Do you ever wish that that was your job? Like, you know, solving the Riemann Hypothesis?

VN: No, not remotely, I have no [laughs] no aspirations to my name being on anything longterm. If I have a little bit of an impact on the students that I work with that for me would be amazing. I'm not... concerned about there being a theorem named after me or anything like that. I have no aspirations in that direction.

[gentle chimes]

BH: I wanna ask about your latest book, 'cause I'm very curious about some of the things in it, but before I do I wanna ask you about mathematical craft.

VN: Yes! Mathematical craft.

BH: Tell me about mathematical craft. What does that mean?

VN: I just like doing craft and I like do maths and so for me it was really natural to try to combine the two. [laughs] So, every now and then I sort of have an idea of, oh maybe I could explore this piece of mathematics through this particular technique and a craft that, you know, I might've been sitting on the sofa knitting watching the tv in the evening anyway and I might as well knit something mathematical rather than making a jumper or something.

BH: Can you give me an example of one or two of the things you've done?

VN: Yeah so, one thing that I did was make some bracelets to explore the distribution of the prime numbers. Someone gave me a book, it's called something like Bead Crochet for Mathematicians, I'm not sure that's exactly the name but it's something like that. And I'd never heard of bead crochet before but I just looked at this and though this is really cool and... so you make a torus, in the jewelry they call them bracelets... [laughs]

BH: [laughs]

VN: So you make this sort of donut thing.

BH: [laughs] The jewelry community. [laughs]

VN: [laughs] You make a kind of a bracelet out of beads. So it's a sort of cylindrical tube that you can join up at the ends and the book as some fantastic designs in it which I found really inspiring but that sort of got me thinking actually I could use this to illustrate some particular feature about prime numbers which was something that I'd been discussing with school students for a while and so on and that was really and then you make something that's... visually attractive and people are kind of curious and oh, what's going on there and...

BH: I'm looking at a picture of it now, it sort of looks like, you know, like you say, like a torus, like a donut, made of all these tiny little beads and the one I'm looking at it here like most of the beads are blue and there's this just random scattering of gold beads amongst the blue beads and presumably those gold beads represent the distribution of the primes?

VN: Exactly, yeah, so the gold beads are the primes in the sea of blue of non primes and it does look kind of random and yet... there's this potential structure to it so it's a way of visualizing something about mathematics but also I think there's something tangible about when you make this as a craft object, I've knitted scarves, I've stitched greetings cards as well, and there's something about it being a physical object that somebody...

BH: Yeah.

VN: ...can pick up and look at or it just it's a different way of engaging, I guess and for me it's a natural thing to do because I like knitting and crochet and stitching and so on. If I were a more technically minded person I'd would be making clever video visualizations I guess, but that's not me.

BH: Well, maybe we can have a chat about that later. [laughs]

VN: [laughs] I'm always up for collaborating.

BH: Super. Now, you've written a couple of books. I'm not gonna ask you much about your first book, about prime numbers, because... I wanna ask you about that for some Numberphile videos another day.

VN: [laughs]

BH: But, I do wanna ask you about your most recent book. Why Study

Mathematics by Vicky Neale.

VN: That's the one.

BH: Before we talk about the question of why study mathematics, let me ask you, why is there a polar bear on the cover?

VN: Yeah the publishers told me that I should tell people they'd get that question answered if they read the book. [laughs]

BH: Ahh.

VN: So...

BH: Okay.

VN: There are sort of two reasons for having a polar bear on the front. One is...

BH: Hmm?

VN: ...important message about the power of mathematics to address Climate Change and the other is... slightly less serious illustration of mathematical ideas which features a polar bear somewhere else in the book and I'm not gonna say anymore about that right now, if that's okay.

BH: Ooh, Okay. No spoilers here. You have to buy the book if you wanna find out why there's this huge polar bear's head peering out of the cover at the potential readers.

VN: It's a great polar bear.

BH: What is the point... of this book? Why Study Mathematics. What's the book trying to achieve?

VN: The book's designed for students thinking about options at degree level to help them think a bit more about, is a maths degree right for me? Is that what I want to do? Which maths degree might I do, given that there are lots and lots of maths degree out there. Where might a maths degree lead me later in life? And also then hopefully for teachers and parents of those students who might be supporting students making decision, I guess trying to, in a way fill in the gaps that prospectuses leave. University prospectuses have lots of great information and now we're doing it all online there are videos and lots of information out there and I guess this book is trying to pull together some of the things that you might not find in the prospectus about what kind of things might you cover in a maths degree and is that the good choice for you?

BH: So it's quite like a focused book, it's not just for the person in the street who, it's not like one of these popularization math books that someone like me would pick up just to see some cool stories? This is a real... got a real utility this book?

VN: Yeah, it has a definite focus, and it's part of a series, the idea came from the publishers, the London Publishing Partnership who...

BH: Hmm.

VN: Have this vision for a series so there's also Why Study History and Why Study Geography out there and there are more on the way I gather.

BH: Hmm.

VN: So it is designed for a particular audience but I'm hoping that it will be of interest a little bit more broadly, so I can imagine for example that a teacher who

is a terrific maths teacher having done perhaps physics or engineering degree or something might find it useful to be able to dip into the book and have a sense of some of the mathematics things in a maths degree that they can then share with students for example, so, some of the book is quite practical about how does teaching work in a maths degree and how does assessment work and how do you choose between different degrees and what kind of careers are there but there's also I've tried to give people a taste of some of the topics that you might come across in a maths degree and actually that's... that was an interesting challenge because brilliantly there are lots and lots of different maths degrees in the UK. I think this is a really good thing because it means that people can choose a course that suits them but trying to work out things that lots of maths degrees have in common was quite interesting so exploring some of that. So I've tried to pick out a few different themes and give an idea of where they might go on to, so differential equations tying into modeling disease which at the point when I started writing the book seemed like an important topic and then we had a global topic and it became daily national news which was kind of striking.

BH: Hmm.

VN: But also links between linear algebra and JPEG image compression for example, drawing out different ideas. Ramsey Theory which is a sort of branch of graph theory that links up with ideas in networks and so on and so trying to pick out some things, maybe things people might have seen before but hopefully also lots that people wouldn't have come across before.

BH: Is this kind of a bit like a Lonely Planet, though? Like are you saying well if you go to the University of Nottingham and if you go to Cambridge you'll get this? Are you making that granular a comparison or is it more sort of broad brush overview and you're not sort of naming names?

VN: It's a bit more broad brush, I'm not naming names, not least because courses change overtime and I don't want...

BH: Yeah.

VN: ...the book to be out of date too soon, but...

BH: Yeah.

VN: When I was choosing a university, it wasn't apparent to me what a variety there was. One of the phrases that gets used sometimes is that you can think of maths degrees as being more or less theory based and more or less practice based. So some are more theoretical and academic and some are more concretely tied to how you might use those ideas in an industrial context for example. In reality most degrees are someone on this spectrum, it's not that they're one or the other. But those kind of things were not at all clear to me when I was applying for university and I think it could be hard to pick that out, so what I'm hoping is that by reading the book people will then be able to look at the UCAS website to look at individual university websites and prospectus and sort of have some questions in mind to ask themselves, I guess, of what are the things that I should be thinking about when I'm looking at these maths degrees that will help me decide is this a good fit for me?

[gentle violin music]

BH: Vicky you mention not wanting the book to be out of date... and you also mention briefly the pandemic that everyone in the world is living through. Is your book pandemic proof? You know, if you're writing about what it's like to go to university and be taught and it seems that how we're being taught at university is changing at the moment, like how's that an issue for you?

VN: It was something that I was really aware of because I was putting the finishing touches to the book in the spring, at a point when I was teaching all of my students exclusively online and... so...

BH: Yeah.

VN: I'm really conscious that our practices are changing. I think, at the point when we hopefully have the vaccines... we have more flexibility about how we do these things, what I'm hoping is that we are going to hang on to the things that we have learnt that we can through these situations that actually are fantastic for teaching and learning and...

BH: Hmm.

VN: ...regain some of the things that we've been missing and actually with my own teaching this term working with my students, we've been doing a bit of mixing and matching so I've been making lecture videos because I would otherwise have been lecturing to a room of two hundred students and that's clearly not possible at the moment but for the small group teaching where I'm doing tutorials and classes with perhaps two or three students or perhaps ten or twelve students, we can do that, socially distant with face coverings and so on in a room together. And I'm hoping that as we move on through the next three to five years that we will be looking at how we go about doing our teaching at university level and thinking well, what's the most effective thing for students' learning? What is the best for students? How can we help students in the most effective way and maybe some of that is online. I think there are some advantages to lecture videos but also having the face to face, so, yeah. It will be interesting to see how that evolves over the coming months and years.

BH: You mention that this book is part of a series for... you know, *Why Study History*, et cetera et cetera. Did any part of you feel like, you know, you were at a sort of a friendly competition or as an advocate for mathematics against those other subjects? Like you're having to make the case, come and study mathematics instead of history, is that part of this?

VN: I don't want to think of myself as being in competition. I said early I'm not really a competitive person. I think...

BH: Yeah?

VN: ...my main priority and have this thought in mind when I meet students at open days for example, is that I want students to be making an informed choice, and I want students to pursue a path that feels right for them, knowing everything that they need to and I absolutely think it's terrific that there are lots of people who go and study history and geography and all of the other things because as a society we need people with lots of different skills. I also think that maths is a really terrific thing to study and that we probably need more maths graduates for society so if I can help people to have the information that they need to make that informed decision about is this right for me, can I see myself doing this for the next three years or something, that's my goal for the book.

BH: It sounds like, you know, you've have an education and a career that's had it's usual share of ups and downs and challenges and things like that, but generally it sounds like it's been fairly smooth sailing and it's also been bit of a fait accompli that you would be a mathematician. Does that make you the best possible or the worst possible person to be counseling about why study mathematics?

VN: I think that's a really fair question and definitely seventeen year old me wasn't making a difficult decision about whether to study maths. I was trying to work out where to study maths and will I get in and what can I do to prepare and all of those kinds of things but for me should I do maths or something else was not a difficult decision, but I have since then worked with quite a lot of students and have had the privilege of being alongside students as they've been going through their mathematical journeys and arriving as undergraduates maybe with particular career plans maybe with no career plans at all and seeing how they've then found their mathematical feet, decided what kind of job they

want to go onto next or do they want to go do further study or something. So, I hope that I have been able to learn from then...

BH: Hmm.

VN: ...possibly more than they've learned from me... and also talking to friends and colleagues in other universities and getting ideas and experiences from people teaching on these other different kinds of courses has really informed how I've written the book because my own personal teaching experience has only been in a couple of universities but I've hopefully drawn on expertise from others.

BH: I mean you've written a whole book on it, with answers the question why study mathematics, and I encourage people to go and have a look but perhaps to finish our talk today could you give me one good reason why someone should study mathematics? If someone's out there and they're at that crossroads and maybe mathematics is for them, maybe it's not, and they're having to make that key decision and I know everyone's different and has unique circumstances, but you could perhaps give us one reason why they should study mathematics?

VN: [laughs] Well, one reason out of a whole book is as you say, an interesting challenge, I think the... maybe the short answer is the flexibility that mathematics can give you, if you are interested in mathematics you can find your corner of mathematics, the kind of mathematics that you find most interesting and it gives you flexibility about what you go on and do next and maybe your priority is to find a career that allows you to support your family and have the life-style that you want. Maybe your priority is to have an intellectually challenging career. Maybe your priority is to have a career where you can have a really positive impact on wider society and for all of those kind of routes, mathematics is potentially good. You can study mathematics to help people, you can study mathematics to make lots of money, you can study mathematics to have lifestyle that gives you a good work life balance, so flexibility I think is the

key. [music fades in] If you enjoy maths go for it.

[music fades up and continues]

BH: You can find out more about Vicky, her work and of course her books by checking out the links in the notes from today's episode. [music continues] Numberphile is supported by the Mathematical Sciences Research Institute, again, there's a link in the notes. I'm Brady Haran, and you've been listening to the Numberphile podcast.

[music continues and cuts out]