

Numberphile Podcast Transcript

Episode: The Hope Diamond - with 3blue1brown

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Grant Sanderson makes incredibly popular math videos - but his views on math education may surprise you.

[3blue1brown on YouTube](#)

[Grant's 'Hope Diamond' Eye](#)

[The actual Hope Diamond](#)

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Brady Haran [BH]: First of all let's deal with the Transatlantic thing, do I call you Grant Sanderson, [changes pronunciation of vowels each time] Grant Sanderson? Grant Sanderson? Grant Sanderson?

Grant Sanderson [GS]: So all of my Britain's relatives call me Grant [like haunt or font],

BH: Grant [repeats].

GS: So I would have a certain affection if that's the way that you wanted to say things. I would say Grant [like ant or plant], Grant Sanderson.

BH: So you go the ANT in the Sanderson, not the AUNT in the Saunderson.

GS: Yeah, getting into my Virginia roots I guess, but yeah.

BH: Okay, alright I will try for Grant but I may slip into Grant occasionally.

GS: I've never been asked [music fades in] about how to pronounce my name. I've always thought of it as a standard non-mispronounceable thing.

[music continues]

BH: No, well I can... as you see I can mispronounce both of them.

GS: I wouldn't consider either a mispronunciation.

BH: Okay.

[gentle music continues]

BH: Hi, I'm Brady Haran and this is the Numberphile podcast. You've probably figured out today's guest is a guy called Grant Sanderson. [whispers] Graunt Saunderson. Now Grant's the man, the brains, and the voice behind 3blue1brown and if you know what Numberphile is you probably know what 3blue1brown is, 'cause it's an incredibly successful, brilliant Youtube channel all about mathematics.

[music continues]

BH: Today I'm gonna be talking to Grant about that, and about other bits and pieces from his life and mathematics, but before we get started the thing I really wanted to establish is this. Why call the channel 3blue1brown?

GS: I'll start by saying there's two ways of explaining it. So the first is the very

direct, it's a weird name... it's named after the logo which is a loose depiction of my eye color, which is 3 quarters blue 1 color brown, on the right side. Although the closer I look at it sometimes I realize it's not as clean a fraction as that, but whatever.

BH: Right?

GS: I...

BH: Gimme a look, hang on!

GS: Alright, alright.

BH: Yeah I'd say maybe it's about like... two-fifths.

GS: Either way, you know we can acknowledge that's a weird name. Putting it as the logo, I mean there's some meaning to that because in the same way you'd put your name on your work... I like having a genetic signature. And the whole channel is about seeing math.

BH: Yeah.

GS: And seeing it in different ways, and to some extent maybe like I wanna show people the way I see it, right? So some sort of individuality there maybe makes sense.

BH: So this is your eye, we haven't explained... I interrupted and didn't let you explain properly. You've got this thing, what's it called in your eye that makes the color...?

GS: I think the official name is sectorial... sectoral heterochromia, basically it's just two colors. So there's like a segment that's brown.

BH: Right.

GS: And then the rest of the eye forgot to pigment itself, so it's a different color. Like you see it dogs a lot. Huskies that have...

BH: Okay.

GS: Multiple different eye colors.

BH: But for someone who's never seen Grant by the way in person, it's not particular noticeable.

GS: No!

BH: You'd have to be right up close and looking for it like, you look like just like a blue-eyed guy but it's just like a slight little... little tinge in one eye, it's quite, you know?

GS: I used to notice... like if someone would notice it in my mind that would up them in the like ladder rung of friendship as, oh wow, we've made enough eye contact that we're now at this point where you've noticed this weird...

BH: [laughs]

GS: ...and otherwise not super noticeable feature about me.

BH: [laughs]

GS: Which is maybe why I had that as a weird part of my identity so much so that I'd be willing to name a Youtube channel after it.

BH: Right.

GS: You also have to remember like I wasn't necessarily thinking of this is going to be a channel that's gonna grow and I wanna have it out there. I was just putting a name for a thing that I wanted on a particular project that I...

BH: Yeah.

GS: I didn't necessarily think strategically, oh if I want this to be ranked high in search algorithms for math how is it gonna go? It was kind of just a silly little thing to put there.

BH: So you created this really cool little like stylized logo of the eye and that's kind of... that's on everything you make that's like your...

GS: Mhm.

BH: That's your brand. As you said you didn't know how successful this was all going to become. If you could go back in time would you still go with that, or would you give it a more math search optimized name, or do you think the name helped? The quirkiness of the name has helped in your success?

GS: Well also this gets to the second answer on why'd I name it... I have a strong belief that names should be weird. Should be something notably different. You know if you're running like a pie shop in your town, it should have the name pie in it so that people know what they're looking for, but if it's an entity on the internet, and I do think there's an element of building your own brand into it, you know, you look at, you know, whatever your most popular website is... a Google, a Facebook, or a Twitter, they're objectively weird names. The first time you ever heard one of those names, it's just weird. So I kinda wanted to lean into it that way. The only name I can think of for a company that I actually think is actively bad is a place I used to work for... I think I might be... yeah I'm

wearing their shirt right now. It's name is Affirm. A F F I R M. Which... yes that's a fine name, they do things associated with payment and they wanna affirm that it was a valid payment. The problem is then you're talking to someone, they say, where do you work? You say, oh I work at Affirm [a firm]. [pause] [laughs]

BH: Okay... yeah. [chuckles]

GS: Which firm? Okay... no it's [sighs] it's a stupid name.

BH: Okay.

GS: There's also in Silicon Valley someone named Accompany as in they accompany you through your life but boy is that not... so.

BH: I work for Accompany [a company], yeah...

GS: Unless there's name collision, I think not only is it okay to be weird, there's an advantage to that so I don't know if I would change it if I went back in time. In the same way that Kurzgesagt... Kurtzge... whatever it is...

BH: Yeah.

GS: The fact that that's the first example that comes to my mind for weird names is good for their branding, so.

BH: Yeah.

GS: They shouldn't change it.

BH: They kinda tried to change the name a bit, didn't they?

GS: Did they?

BH: They started... they tried to push it more called In a Nutshell, which is what Kurzgesagt stands for I think.

GS: Hmm.

BH: And like I think there was like a backlash in the end they were like, no you're right, let's just stick with it.

GS: That speaks to what the Internet likes, once they latch onto a memeiness, right?

BH: Yeah, yeah yeah. So one last thing about the name then, because you were saying before... that you know, you're quite an introverted person, you're not like really super outgoing, do you find though having that name and people knowing that's why that's called... results in people like starring at your face and your eyes...

GS: [laughs]

BH: ... more than you're entirely comfortable with when they met you for the first time?

GS: Oh... I would...

BH: When I met you for the first time...

GS: Sure.

BH: I straight away... I wanted to see it. [chuckles] like, you know...

GS: Yeah, a little bit, but I mean... I'm not, you know, George Clooney

walking down the streets someone saying, hey look! There's the 3blue1brow guy!

BH: [laughs]

GS: No, it's because I don't really have a recognizable face either... it's not like a main part of the channel that someone would know it so.

BH: Yeah, yeah.

GS: Every now and it happens that someone might recognize... actually you know what happens often is they'll recognize me by the work I'm doing on my laptop if I'm at like a cafe or something.

BH: Ahh, yeah, yeah.

GS: Because they're like pi creatures and on it and such.

BH: Yeah I don't so much mean like strangers coming up to you and like...

GS: Sure if at like at a conference and that kind of...

BH: Yeah, yeah yeah.

GS: Yeah, it happens a little bit... but...

BH: Alright.

GS: Honestly usually how it happens they're like, can I see your eye. [pause] And then they're... it's like looking at the Hope Diamond, you're pretty disappointed that it's not actually that noticeable a feature. [chuckles]

BH: Oh. You realize you just compared your eye to the Hope Diamond...

GS: That's not the intended!

BH: [laughs]

GS: In how underwhelming it is!

BH: Okay.

GS: Right? I think the level of hype of the Hope Diamond compared to what it looks like...

BH: Yeah.

GS: ...has the ratio as... I dunno if you'd call it hype.

BH: [laughs] Yeah.

GS: But the fact I named a channel after my eye, to what it actually looks like. That ratio is the same even though the absolute magnitudes are quite different.

BH: Okay. [laughs] very cool.

[gentle chimes play]

BH: If I had met you when you were like a school boy, or very young, would I... would it have been predictable that you were gonna end up being like... a math filmmaker type person. Like was the writing on the wall, was that... were you the math kid?

GS: Uh... math, yes. Filmmaking, no. I did not know and still really don't know how to make videos but I've always been into math and I think some of

my earliest memories to point to this fact, I had a dad who was very interested in making me curious about the world. One game that he would play... he'd stack sugar cubes in interesting geometric patterns, you know, maybe it would be like a three by three by three cube of sugar cubes and say how many are there in here? So, you know, if you're very young you don't really know about multiplication and maybe you try to count but there's one you can't see so there's some notion of pattern recognition there and if I would get the answer right, he'd feed me a sugar cube... so [chuckles]

BH: [laughs] okay

GS: Pavlovian affection, [laughs] and then he'd put them in more and more interesting patterns.

BH: Yeah.

GS: He also... man he must have put a lot of time into this project. He made this thing where he could sort of stack marbles in interesting pyramids but one was like a hexagonal pyramid. So he would drill these very precise holes and everything...

BH: Was it like sphere packing, or?

GS: Yeah it was like a sphere packing thing, I guess, again it was a notion of just counting things in certain patterns and at that point more so than the lesson itself I think looking at your dad be so willing to spend a lot of time in a project about a thing makes you interested in that thing, right?

BH: Yeah.

GS: And he himself, you know, he's not a mathematician, I don't think he actually went much beyond Calculus in school...

BH: What did he do? What was his work?

GS: He's a pilot actually.

BH: Oh, right?

GS: Yeah.

BH: Yeah.

GS: So he...

BH: So he's pretty comfortable with numbers then isn't he?

GS: He's comfortable with numbers, he loves reading about sciencey stuff, right? Like he follows your channels, that kind of thing, but this wasn't like the mathematician trying to make his son into what he is.

BH: Yeah.

GS: He was actually a very adamant that my brother and I not follow in his footsteps into like Navy and commercial pilot 'cause he thought that was becoming a more and more difficult career path.

BH: Yeah, yeah.

GS: But as far as like instilling a love for curiosity and that a specific character of that curiosity is towards patterns and numbers.

BH: Yeah.

GS: That started very young.

BH: So you were always on this math path. You were like the math kid? And getting the good marks and like... and it was inevitable... it wasn't like you had other ambitions or passions that were gonna... that could have taken you elsewhere?

GS: Yeah I think if you interviewed someone in my high school and you asked about like that Grant Sanderson kid, you would hear math in their first sentence somewhere.

BH: Really?

GS: I wouldn't be surprised.

BH: And Hope Diamond, I hope.

GS: Oh yeah! He has eyes like the Hope Diamond...

BH: [laughs]

GS: At least what all the ladies would say.

BH: Yeah, [laughs]

GS: At that time.

BH: Alright. So the path was inevitable and then what happened when you finished school where did you like, where'd you go to college and stuff?

GS: So I went to college at Stanford, and it's at that point I started getting pretty heavily seduced in the direction of computer science. And, you know,

there's a lot of parallels between computer science and math. Not just in so far as the latter applies to the former, but the structure of writing a good program is similar to the structure of writing a proof, and things like that. And I loved it, right I think one of the first things that I made that wasn't assigned to me was a four dimensional grapher. 'Cause I just wanted to see what 4 dimensional shapes looked like. Hey I can make the computer show me what their shadows look like.

BH: Right.

GS: And that just felt awesome. And it's very empowering and it's very different from math in that you have an entity telling you when you're wrong, the compiler, and you have to own up to that fact, [laughs] right?

BH: Right. yeah.

GS: It's not like an English essay where you can argue about whether your point was interpreted appropriately, no... you're wrong you have to live up to that.

BH: Yeah.

GS: And that makes you improve yourself. And it's also very precise and technical, so obviously aligns with math.

BH: So were you majoring in math and like dabbling with computers on the side or where you doing computer courses at Stanford?

GS: Computer courses. Yeah, so I was majoring math, I always knew I would wanna major in math and then oh I'll always take a computer science class as well because you know, math is actually a fairly light major, as far as units are concerned. And the people I started to hang out with were much more on the computer science side of things. And you know, you're much more influenced by

the people you spend your time with than you are by... pre-established passions, in some way.

BH: Yeah.

GS: So... like the first summer after my freshman year I sort of landed an internship that I didn't have the merit for but was happy to be given the opportunity at a certain place in Silicon Valley that started off as a less than fully technical position but you know, once you're in an organization and you sort of sniff around and find the right people and you ask what they're working on and you say, hey can I help with that in some way?

BH: Yeah.

GS: I got a little bit of more concrete programming experience and again, you know, that just sort of bumps up the addiction.

BH: What happened then? Were you being seduced away or not? Like what stopped you saying... throwing in mathematics at that point and saying okay I'm gonna sign on for computer science? I'm loving this, all my friends are into it and...

GS: I think it's the difference between programming and software engineering whereas soon as you have to make a bunch of different components work together in, I don't wanna say unsexy ways 'cause that makes me sound like a prima donna who only wanna works on things that are super interesting. But there are aspects that I just felt weren't in my wheelhouse as much and are kind of... I dunno it's a... if you're trying to get some old system to talk to another old system and that's what it takes for the company to actually have a valuable product that's less inspiring than creating your own four dimension grapher and things of that sort, right? Like what programming means can be quite different and I think it becomes progressively less sexy the farther you trudge into that

career, is the view that I got.

BH: So is that a feeling like you didn't wanna end up being just like a small cog working on technical problems, you wanted to be making things that were like... you wanted to have more control and do more cool things?

GS: If I'm really honest with myself I think it might have been kind of indulgent in that I felt, hey no I love math, and I had this notion of that is a possible career path is to do the PhD, be a mathematician that kind of thing, so maybe I should try some career path that lets me fulfill that love of math or not necessarily the traditional one like try something a bit weirder. So like by the time I was finishing college, I'll probably jump back and forth here a little bit...

BH: Yeah.

GS: But I had made I think one or two videos... that were on what is now the channel.

BH: Yeah?

GS: And those had started as like a mix of math and coding project because I wanted to have my own tool for visualizing things and one thing led to another where that made it possible to have this position at Khan Academy creating math videos.

BH: Okay.

GS: So I started to think okay maybe there's a possibility for a less traditional path into some career where you are engaging the math and also programming for that matter in the ways that are more fun and let me see if I can try to forge something out here. It's a little weird, it's a little less known, I don't have a concrete plan about what three years from now looks like but I have a sense that

like the positioning is probably not too bad if I have like you know Khan Academy is a meaningful name in the world of like education so...

BH: Yeah.

GS: That's not a bad feather to have in the cap.

BH: So those first couple of videos you put on Youtube, that you know ended up helping you get noticed by Khan Academy and pushing you to where you are now, what made you put those on Youtube though? Like... you don't seem like a show off...

GS: Yeah.

BH: ...who would wanna show everyone his work and stuff like that. Like what made you wanna make it public and put it out there?

GS: The most honest answer is probably that people like you, the fact that this was somewhat established, I didn't... so I didn't really know the notion of what it meant to like be a Youtuber. To give an example when I didn't put that first video out, you know, you get some email from Youtube that says like, ah you have twenty-seven subscribers and I remember thinking, what's a subscriber? And so I had a notion that like Minute Physics is a thing, Numberphile is a thing, there are humans behind them that in some sense this is a part of their career. So that wasn't completely foreign but anything more specific than that wasn't there. So I think if I had... if it had been, you know, five years earlier, that probably wouldn't have been my instinct. I'm not really a first adopter in that way. That some other people... they see this new thing, they want to share what they're doing so they put it out there.

BH: So you were consuming a bit of Youtube content, so it was like...

GS: Yeah!

BH: It was in your... on your radar to put something on Youtube just because you'd seen other stuff on Youtube?

GS: Yeah. And I mean I think this... like there's a whole category of importance for the kind of work that like you do or Henry do or Dustin did that's like way early that is extremely hard to quantify which is the number of people inspired to do similar things. I definitely know at least one... do you know the channel Welsh Labs? It's like another... he does some really good math stuff.

BH: Yeah?

GS: He has this series on imaginary numbers that's great for example. And talking to him he said, my channel probably wouldn't exist if Minute Physics didn't exist.

BH: Yeah?

GS: Because that provided a bit of the inspiration and also you know... pattern matching isn't great but it's a way to get started and as soon as you get started then you mold something into your own. It provided a pattern to match from for a style that felt more approachable than like being on camera which a lot of people aren't comfortable with.

BH: So these videos you make, like you know, are good and therefore your end up getting...

GS: [chuckles] They weren't. I'll tell you...

BH: They're not good?

GS: They weren't great.

BH: Okay.

GS: The very first video... I still feel a little ashamed of, but at least it got the ball rolling.

[gentle violin music plays]

GS [from clip]: E to the π I equals negative 1 is one of the most famous equations in math.

BH: It resulted in you getting work at Khan Academy.

GS: That's true, yeah.

BH: Yeah.

GS: What was more responsible for that was the conversations that started to be had where I, you know, went down there for lunch and I really connected with the people working on their math side of things. So I had these projects and I think at that point there was then enough good will that they could see the good in them and maybe look past the amateurism of how they were put together. Also because Khan Academy isn't necessarily about like fancy videos that are super well polished. Maybe that actually played into it, whereas if I had been a trained filmmaker that might have counterintuitively worked against me.

[gentle chimes play]

BH: So just going back a little bit then, at one point do you make a decision or is not a decision? Is it something that just happened accidentally, between a being

an actual practicing mathematician and trying to...

GS: Mhm.

BH: ...solve problems and being an educator or an outreach type person?
What like, what made you choose one fork?

GS: Well, I think maybe around senior year of college, I thought it could be a good idea to take a gap year at the very least between undergrad and PhD, which is common in some disciplines but not too common in math and not necessarily smiled upon by graduate departments. Two things probably informed that. One, having had internships that were totally outside of academia in that time realized it is very beneficial to get your head out of academia, for self improvement, for just better knowledge of about how the world works, for just meeting a different kind of people, all of that. So, you know, I think it was much more likely if I was gonna be a successful mathematician, it would be because I had a slightly different past than it would be because I was the greatest math. Because I wasn't. And the other thing was a little bit of doubt about the specific field that I wanted to go into and it's I think very important, you know, if anyone's going into some PhD, do it based on who you're working with first, right? You know, like what person will be advising you if you're in more, you know, more of a science, like what lab group you're gonna be in. Rather than what is easiest or what has like the best brand name associated with it. And I 'cause I didn't have that clarity, I just felt uncomfortable setting in stone anything that would be effectively like a five year lockdown. So, a little bit more time to explore different things felt like it was needed. But during, I think that first year, it was definitely in my mind this is a gap year, and this is... I will at some point like go back and maybe go down that path, but I do want to keep my mind upon, too. If there's a different path that exists and another factor coming here also is [chuckles] a little bit of skepticism about the stability of the university system and especially the American university system, through the next few decades. Where I don't know if I wanna throw all of my eggs in a basket that has like...

trillions of dollars of debt as like as a direct consequence of it in the background. It's hard to know how things pan out for like what happens to what currently exists as student debt that some bank counts as it's assets when suddenly they realize that it won't be repaid ever, but I can't help but feel that the job prospects for working mathematicians aren't gonna be super great as a consequence.

BH: Okay.

GS: That's just my own cynicism. [chuckles]

BH: Alright, so what you thought... you thought there was gonna be more stability on Youtube?

GS: Honestly, yeah! Not Youtube per say but the internet. Like I'm much more bullish on the notion of establishing a platform for yourself rather than being in a old system. Maybe that's a little bit naive, I think that's definitely informed by having had one's formative years grown in like a Silicon Valley environment rather than other ones.

BH: Yeah.

GS: But, I do think that. I don't think Youtube itself will be like the stable entity... you know... twenty years from now, but the things that it can lead to... yeah! If it works.

BH: So take me... take me through Khan Academy to 3blue1brown, like what...

GS: Yeah!

BH: What happened? How long were you there and what were you doing and then how did you... evolve?

GS: At the very beginning, so they had this thing they called the Talent Search, which it was always unclear to me exactly what that was. Is this a recruiting thing, I would ask? They would say, kind of. But it was a thing where they invited people to submit educational videos and they would select some winners and like bring them out to Khan Academy and to Youtube to like tour around. And it was kind of a recruitment thing because they were growing their content team behind just... Sal putting out videos.

BH: Yeah.

GS: Nevertheless it took a little bit of pushing and weaseling to turn that into any kind of job offer. And you know the way that happened is I first offered to just do like two weeks of sample work. Like I will write some things, see if you like it.

BH: Yeah.

GS: And kind of let it grow out from there. Right, it's always a foot in your door situation. And so I was eventually hired, again it wasn't like a long term thing. It was a one year fellowship, and there were... so there was like a biology fellow, there was an electrical engineering fellow, and there was people they would bring in usually having just gotta their PhD. Like the electrical engineering fellow had like finished a career at HP.

BH: Right.

GS: So very different and strange group of people but...

BH: What stage were you at thought? You just graduated?

GS: I just graduated undergrad, I was like under-qualified in some sense but I

like to think I know how to explain things and to like empathize with a student.

BH: Yeah.

GS: And in some ways I think you're better at empathizing with a student if you haven't been spending your last, you know, five, ten years in research.

BH: Yeah.

GS: Because it's a very different dynamic.

BH: Yep.

GS: So I start making multi-variables calculus content for them, which is not just videos but also like articles and exercises and such. And then like any job there's a bunch of... just odd job little things here and there outside of that. And so when I started like 3blue1brown was not a big thing by any means. It was... like a thousand subscribers. It was just a side project.

BH: But the channel already existed at this point?

GS: It existed.

BH: Yeah.

GS: It existed.

BH: Yeah.

GS: It wasn't big... so then we progress further through the year and every now and then I put out something on the channel and at some point it fell... some of the videos fell into the good graces of the recommendation algorithm,

not on like a viral scale of things but you know at that point if you see that, ah, that has like twenty thousand more views in the last month, like that can be a big thing to you.

BH: Yeah, yeah.

GS: I did like a project with Steven Strogatz which was really cool for me that he was even open to that.

[Gentle dulcimer music]

GS [from clip]: For this video I'm doing something a little different. I got the chance to sit down with Stephen Strogatz and record a conversation.

GS: For those who don't know he's like a popular math author. He submits like columns to the New York Times and he's been on Radiolab a number of times. And I think he's very open-minded to new math outreach things happening.

Stephen Strogatz [SS] [from clip]: Yeah so it's this complicated word... first of all Brachistochrone, that comes from two... gee I have to check are those Latin or Greek words? I think...

GS [from clip]: I'm pretty sure they're Greek.

SS [from clip]: Okay...

GS: And so the channel grew a bit. Long story short, the questions then started to arise, what is the relationship between 3blue1brown and Khan Academy?

BH: Right.

GS: The question should have been asked and addressed long earlier.

BH: Right.

GS: Like at the beginning, but partly it just wasn't big enough... enough of a big thing. Partly they didn't have a precedent of other content creators. And as those questions started to arise we did a couple things. We're like maybe we marry the two.

BH: Yeah.

GS: And then we realized oh that's actually a bad idea. Unless it's gonna be a full... like it becomes part of Khan Academy and rebranded to Khan Academy. Or they're totally separate things.

BH: Yeah.

GS: And like long story short it sort of made sense to... like part ways.

BH: Yeah.

GS: In one way or another. And either that would mean, okay I'll get a job somewhere else or like go back to trying the PhD thing and the channel will still be a thing on the side.

BH: Yeah.

GS: Or... you know, let's see what it looks like to spend full-time effort on it.

BH: So you'll go all in on it for a while and see if you can make it big?

GS: Which, you know, I wouldn't have opted in for, without any external pressure or knowledge at that stage. It was... it wasn't tiny, I think it was maybe something in the sixty to eighty thousand subscriber range, right?

BH: Yeah, yeah.

GS: So not negligible, not something I would recommend someone say oh I'm gonna try this as a full-time job, right?

BH: Yeah not big enough to like make a full living out of.

GS: Exactly.

BH: Living in the Bay Area. [chuckles]

GS: [laughs] Exactly! Right.

BH: Yeah.

GS: But I'm young and I'm not tied to a family or anything like that so if ever there's a time...

BH: Yeah, yeah.

GS: This is the time. And that proved to be valid and again I benefit from the fact that Youtube and the industry surrounding Youtube had existed for a while. So, Patreon was a sort of a mature... or maturing thing at that point. A notion of, you know like sponsorships or such were there and I sort of was of this like let me try all of the things and see what works out and then over time I've been a little bit more... I dunno... thoughtful about exactly how I wanna approach stuff.

BH: So after you'd left Khan Academy and then you started going like all in

on 3blue1brown and then like you know... it exploded really quickly, like it grew like really... it became massive very fast. Do you think that was because... because you'd gone all in? You were putting out more videos? Or, you were putting more time into the videos, so they were better? Or, there was... it was a coincidence like what? It seemed like as soon as you said I'm going all in on this, it went big straight away.

GS: I think... more time into them definitely helps. You know, like I said I still feel like there's a lot of aspects of just filmmaking I don't really know, but certainly I've been like learning more of time. And I like to think like the videos have been getting better and hopefully two years from now I'll look back at the ones today and cringe for some aspect of them, right? So I think that's it. I mean there were a couple punctuated moments of clear helping.

[VSauce Clip]: Hey VSauce! Michael here.

GS: At some point Michael Stevens of VSauce mentioned it.

[VSauce Clip]: This channel is fantastic by the way. I'm a huge fan, the visuals and explanations are top notch.

GS: I didn't know about that ahead of time or anything and I just noticed one day suddenly there's a huge growth and like you can see in comments like, I came here from VSauce.

BH: Yeah.

GS: And I had never met him so I kind of reach out to say thank you in some way, and it turned out the way he came across the channel was... one video I made called like, Who Cares About Topology? And I had felt proud of that video, actually, when I made it. That was the first one that I made actually after leaving Khan Academy and really like pouring myself into it. So, maybe in that way that

was kind of a nice little payoff there.

BH: Yeah.

GS: One actually huge helpful thing from... and I mean from the very beginning. Henry was like very comfortable just providing advice and mentorship on various things.

Henry Reich [from clip]: Hey it's Henry, thanks for watching.

BH: This is Henry from Minute Physics.

GS: Yeah Henry Reich of Minute Physics.

BH: Yeah.

GS: He's just the nicest guy in the world.

BH: Yeah?

[Minute Physics Clip]: I was inspired by my friend Grant Sanderson who makes videos over at 3blue1brown, you should go check 'em out. They're great longer form math videos. You learn a lot in them.

GS: I dunno, as he and I got to actually know each other more we realized that we connected in a number of different domains. Like, oh we each play the mandolin, after having like grown up playing the violin and...

BH: [chuckles] Okay.

GS: We enjoy like the outdoors and running. Like there's a number of ways we like personally clicked a little bit more.

BH: Yeah.

GS: And obviously we're both nerds about physics and math.

BH: Yeah.

GS: So him both providing advice and also like he was very kind in terms of mentioning the channel on his which you know he didn't have to by any means.

BH: Yeah.

GS: We did a collaborative project later on. Things like that just sort of helped out. And I think also, you know, I think it's important to read the negative comments and when they're written in good faith, like take them to heart for improvement. You know there's a lot of things I was doing earlier on that at the moment I felt was the right way to do, that was just wrong.

BH: What's an example of that? What's an example of a comment that came from a total stranger that changed the way you were making your videos?

GS: Okay, so the very first video I put out, I was talking pretty quickly in it. And I think at that point I was pattern matching more than I should off of various, you know, like internet memey Youtube things where it's just this firehose of information. You're talking faster than someone can understand but that's exactly what's pleasing about it.

BH: Yeah.

GS: And that has a role. That obviously can get very popular on the internet in some domains. But... I don't think I recognized that in the context of math... you know, it takes a lot of brain energy to understand what's going on.

BH: Yeah.

GS: And it goes from, you know, in a context like history, it's kind of pleasing to have facts thrown at you in a certain mindset.

BH: Yeah.

GS: In a context like math all that does is like bring to mind days of confusion in school that were painful that you don't want. What you actually want is to understand something and to understand it, it has to be paced better. So...

BH: I have to say that's like one of my favorite things about watching your videos, is unlike... 'cause my videos I always get told are too long by like... you know, family and friends. And I say, no no no, I want it to be at the pace that I understood it when I was filming it.

GS: Mhm. Yeah!

BH: Like to go at the speed of thought. I think you do it even better in your videos. I was watching your Fourier one this morning actually and like... sometimes... you just stop for...

GS: [laughs]

BH: ...three or four seconds. And like... something can just soak into my brain. It's like you'll just say a point and you'll like, you're just like going, hmm.

GS: [chuckles]

BH: Did you hear that? Did you understand that? And I'm like grateful for those pauses, so I do I think you're pacing's very good. And you think your

viewers informed that?

GS: Yeah!

BH: By telling you, slow the hell down.

GS: Oh exactly, right, [laughs] in language either that forceful or more.

BH: Yeah. [laughs]

GS: And you know some aspects of like which of the visuals were more confusing, you know sometimes I would be hesitant to improve things because... [groans] like that's gonna take a lot of work to make it look in this different way.

BH: Yeah.

GS: It's hard to think of more specific examples but... obviously there's, you know, especially as things grow more than you start to get negative comments that aren't even written in good faith.

BH: Yeah.

GS: If you're small enough, luckily the only people who are crazy enough to stumble across your channel are into niche things and... like willing to give you some sense of good will.

BH: Yeah.

GS: So I think a pretty good rule of thumb, if it's something written with proper grammar, listen to it. If it's something written without proper... and you know, maybe disregard it and make sure you have a reason in your mind why you're disregarding it.

BH: Yeah.

GS: You know, I'm not saying listen to what people tell because sometimes they are wrong for like whatever reasons.

BH: Yeah.

GS: But... I do think the whole movement about like don't read the comments or don't let that get to it or you know haters are just gonna hate. That that can be taken a little too far. I'm super biased by having like a math channel on the internet which is much less inflammatory than some other people's content.

BH: Yeah.

GS: So I acknowledge that, you know, I think there's a strong role for criticism.

BH: I mean what percentage of comments on your videos would you guess... you read?

GS: Oh... these days... not as many as... if it's the day of...

BH: Yeah?

GS: If it's the day of a publication I try to read all of them.

BH: Yeah.

GS: As far as those that like ambiently coming in since then, you know, when you're like bored sometimes you're scrolling through things. [chuckles]

BH: Yeah.

GS: And like one of the things I might scroll through is recent comments. I almost never read replies to comments, right because, partly because that's less visible in Youtube when you're just scrolling through things.

BH: Yeah.

GS: Which is unfortunate 'cause that's where more substantive discussion might happen.

BH: Yeah.

GS: But I dunno, it's certainly less than ten but it's an unknown unknown because I don't stay exposed to it, right?

BH: For someone who's never seen your videos before, and I don't think there are many people listening to a Numberphile podcast who won't have seen your videos before. [chuckles] How do you explain them? Like say I'm a taxi driver.

GS: Mhm?

BH: Let's role-play this!

GS: [laughs]

BH: I'm a taxi driver. You get in the taxi.

GS: Yeah.

BH: I'm like, hey man! What do you do? How do you answer that?

GS: I will often say I run a Youtube channel about math.

BH: Do you with math straight away or do you wait? Or will just say oh I run a Youtube channel and hope they don't ask more or?

GS: I go into math because I dunno that satisfies the intent of the question. I know sometimes people want to just shut down the conversation about what do you do but more often than not someone actually wants to have a conversation so...

BH: Right.

GS: For god sake give 'em something to work with.

BH: So you say I run a Youtube channel about math. Oh really? How does it... what does it do? Like are you in the videos, or what do the videos look like? How does it work?

GS: Usually the first question is, what level math? Like is it for high schoolers or do you make like tutorials to help through homework?

BH: Yeah.

GS: Or like oh is it like you put out one a day of like homework help. I'm like boy do I wish.

BH: Yeah?

GS: And at this point even though I've been asked so many I always just falter on... what level is it? Who is the target audience? I don't know.

BH: Yeah.

GS: So I try to say, if I'm doing a good job I want the video to be accessible to a curious and smart high schooler but still interesting to like a PhD student.

BH: Yeah.

GS: I don't always do a good job and those are like hard topics to find but that's the goal. And then I might give them some examples where I say, you know, a lot of the things will probably be categorized as like college math in some way.

BH: Yeah.

GS: Like I did series on calculus, one on linear algebra but I also try to do every now and then things that not math per say but can be a gateway drug into it. Like, how does bitcoin work? Or what are neural networks?

BH: But I mean your videos have got a very distinctive look and the way you make them is like the thing isn't it? So do you go at... how do you explain that?

GS: Uh yeah... I... perhaps that's where I should start. Is I should say [laughs] the thing that I try to make the channel do more than anything else is look visually distinctive and put animations first in the explanation rather than making them a supplement to the explanation. Like if I'm thinking of a topic it's better if I think this is the core visual around which the narrative will revolve. Rather than writing a script and then later thinking, hmm what visuals will I put to this? I am definitely a big advocate also of while I'm animating things letting what I discover while creating the visuals change what the words will be.

BH: Right.

GS: I know some creators, they'll do it the other way around where they like,

they lock down the words and then they're just putting visuals to it 'cause they don't want to scope creep that comes from that change which maybe I'm a victim of because many of my videos are twenty to thirty minutes but hey, that's what you get.

BH: Yeah.

GS: Yeah if someone's really curious at that point and about... like what I mean by trying to put visuals first... depending on what mood I am or what environment we're in I might just pull one up and show it, 'cause you know I don't have the thousand words that match that picture.

BH: Right.

GS: Necessarily.

BH: It's interesting like you say, ah I'm not a filmmaker naturally, but the very thing you're saying is actually when I was taught to be filmmaker at the BBC by the guy that came and like did a lecture to us and that, the one thing that he taught us was to do exactly what you're doing and it's let the pictures, the visuals, in this case it was video and film...

GS: Hmm.

BH: But in your case it's animation. Was to let the pictures dominate the script and the script is almost the last thing you write.

GS: Hmm!

BH: When you got all your pictures and you put them and you see how the story looks visually. So you know, maybe you are. Well you're thinking like a news journalist at least.

GS: What else did they teach you? I should learn more from this. [laughs]

BH: [laughs] Yeah, well, yeah, no it's interesting. Some of the things they taught probably wouldn't be useful to an animator but... so when you've got an idea presumably then before you even write a script you'll just monkey around with animations for a few days, will you? And look what happens and what's pretty and what's nice and what's interesting?

GS: Yeah. If I am ahead things and on the ball, I also try to do sample lessons with people. I'm doing a project right now on quaternions which is kind of a weird and difficult topic. I've probably done twelve sample lessons with various people who've just...

BH: Who are your test dummies?

GS: So usually friends or sometimes if I... the other day actually like ran into someone I just hadn't seen forever in a cafe and we were just chatting and rather than doing the traditional, what have you been up to, what's going on in life, you know, after getting through that a little quick I said, hey, can I try to teach you something? Do you have a half hour?

BH: Yeah.

GS: And that, I mean... that's fun for both of us I think 'cause I knew he was at least somewhat into like technical topics. I also teach. I have a couple like private students that I like tutor now and then. I'm very on and off about it because you know how it is with like scheduling but I think that's important to keep up. Some of the topics I do on the channel are conducive to using them, they're high schoolers, as sample students. Some of them maybe less so, but when it's possible I try that.

BH: Do your tutees love having a famous Youtuber celebrity as their tutor?

GS: I think, well, so I mean I've been with them for a long time. Long before the channel existed so I think they're just sort of bemused from the sidelines about the fact that I went from just being like the random dude who would occasionally come over and teach them things to like I guess there's a channel associated with this now. Because it started much younger, and we just... they're more like cousins at this point really. That was never something [notification alert chimes] that colored the relationship.

BH: How unprofessional am I for leaving that on?

GS: For shame, Brady. For shame.

BH: I'm sorry, let me turn it off.

[chimes play]

BH: These trial lessons you do with people like when your test driving your next video, are you trying to stick vaguely to the script that's in your head or are just like you know back of napkin two guys talking over a pint and then later on, you know, it will become the script? Or are you kind of test driving how you think you're gonna do it and how the lines you're gonna use and things?

GS: Much more back of the napkin. The goal is to find the things that are confusing that I didn't think were confusing.

BH: Right.

GS: That's the end goal and so... who knows maybe if I was on top of my game I would come with better prepared articulations of the points. But part of it, it's a forcing function to actually get the writing done. [chuckles]

BH: Right.

GS: Because it's hard to write to things. But if you're speaking to someone you will output words and sometimes you output some words and you think oh, yeah that is the way I wanna phrase it. [chuckles] Right? So...

BH: Are you using the animations at this point? Are you pulling out a laptop and trying to integrate that or?

GS: Sometimes. Um... usually not because it's earlier in the process so instead people have to deal with my terrible drawings. Um... so yeah there are definitely... there's the phase of letting people inform what it'll be and then while I'm animating and like put together stuff then that also helps shape what the words will be. So those are usually two distinct phases. Sometimes like I could... I dunno... I might even try this with you after we record. I have a couple animations what will be a follow on project.

BH: Hmm.

GS: That I could just like show and it would be interesting to see like reaction or what questions come about.

BH: Yeah.

GS: But that's a sign that I'm ahead of the game more-so than I usually am.

BH: So as your enterprise is expanding and obviously it's become really a successful channel and people want more and more from you, are you turning into like a business with employees and things like that? Or is still just you slaving over a computer, or...?

GS: Very short answer. I tried it a little bit. Having other people on board just to kind of experiment with that and I think that could have been a proper and successful path if the goal is more content and if the way to do that is with multiple channels where you're giving complete autonomy to the individuals. What I found is it's actually very hard for me to... often hard for me to articulate what I don't like about something. And when you're doing that in your own head that's totally fine, you can say no to yourself twenty times and not sacrifice any social capital. I just felt like this constant divide on... I don't wanna rob someone of autonomy if presumably you found someone because they're able to create really good things.

BH: Yeah.

GS: But I also have a particular character that I think is in the channel and I don't know if the smartest thing for that channel would be to compromise that character.

BH: So you think like the videos... and I would agree with this by the way... that a lot of the videos are made by your personality. They have to be mostly made by you or they wouldn't be what they are?

GS: I do believe that, and I feel kind of weird and mildly egotistical to even say it out-loud. Because then it's like oh you have such a great personality that like your content will be better than someone else's. And it's like not necessarily, it's just that's what it is and that gives it a certain consistency. The analogy I kind of made to a couple people when I was talking that is maybe tortured... if J. K. Rowling, when she was writing Harry Potter books, after the third book, said like hey, this is going pretty well! I've got more funds now, you know, I could bring on some of the world's greatest writers, we could have a hundred Harry Potter books. There's something wrong about that. And it's hard to put your finger on why that's wrong. There are better writers J. K. Rowling, absolutely. There would be more Harry Potter content. There would be niche fans who would love a

hundred Harry Potter books and yet there's something that's just not... it would have lost its magic. No pun intended. Again it feels kind of weird and egotistical to say that 'cause like oh, your eyes are like Hope Diamond, your videos are like Harry Potter.

BH: [laughs] Yeah.

GS: [chuckles] Like that's not necessarily what I mean.

BH: Yeah.

GS: But... I wrote a whole like Patreon post sort of trying to express my thoughts on this because I wanted... again like when you're forced to articulate something it clarifies thoughts.

BH: Yeah, yeah. No, no. I understand you, like people will say the same thing to me. They'll say oh you should, you know, they know I do collaborations with various universities and they'll say oh you could have hundreds of people doing what you do with all the different universities.

GS: Mhm.

BH: And I'm like... yeah I could but like I dunno I feel like my videos are my videos and I ask the questions and make them that way and that you know... I want them all to be like that.

GS: And I'm sure people also are like oh you could hire an editor.

BH: Yeah.

GS: But... I mean you tell but I would imagine a larger part of what goes into the creation of your work is making the choices for what is interesting...

BH: Yeah.

GS: And it's not just this rote grunt work of oh, you're editing, you're cutting it down. No! That's the substance.

BH: Yeah, yeah. And sometimes when I do get a little bit of editing help it'll be like, oh no you can't cut that bit!

GS: [laughs]

BH: That's the best bit! And they'll be like, no, no, I thought that bit had to go. And I'm like no! That was the one thing that had to stay in the video.

GS: [laughs]

BH: So yeah, there is that, there is that tension but then you know you are one human and it does limit what you can do.

GS: So the way I just thought about this is I previously had had thoughts, okay I just wanna produce a ton of content. If I could even have like one video per week, if I could have like Essence of Blank series on all the topics of math that would be great. And kind of backing up and saying that's not necessarily what I want. I want there to be more math content. I don't think the best way to do that is for it to all be under one umbrella, but, to like inspire people, maybe even provide them with the tooling for it. Shout people out when they deserve it and it's appropriate. Like all of that will help there be more math content. My role should just be to spend as much of my own time not on any managerial, but just on like creation of things that I think wouldn't be created otherwise. That means there will be less content. I was talking to you before recording about how I'm feeling antsy that it's been forty days since I've published a video. Part of the reason for that like the project that's coming up, I feel really excited about. And

it'll be distinct. I can almost guarantee it's a project that wouldn't have happened if I was like running a small company. 'Cause it would make zero economic sense to like throw my time into that way.

BH: Yeah.

GS: But maybe there's a certain beauty to that that like this is the kind of thing that in another instance of the world wouldn't have existed. Maybe people like it, maybe they don't, but the more you do things like that, you know, that's the only way you'll expose to yourself to creating something that people find genuinely special.

BH: Do you put the reason you do the videos down to like some altruistic reason? I mean obviously your business and its your career and its how you put food on the table.

GS: Sure.

BH: Is that what it is? Do you do... will you wax lyrical about how you wanna inspire the next generation of mathematicians?

GS: [laughs]

BH: Or is it just about like a passion to get it out there? What's kind of... is there something like there motivating you or is just what you've fallen into or...?

GS: I mean I think they're are some Youtube creators sort of... there's like different generations of education creators. You know, I think there are some in like the... my generation so to speak that viewed it as a job. This is what I will do as a career to put food on the table and obviously as you say that's some component of it but...

BH: You were kind of talking in that way in some ways, you know, it sounds like you were making a calculation. You were saying, I think universities have got this problem and like there's a problem going down this path and you kind of identified a career path.

GS: I will say... I didn't think Youtube would be that career path actually. Like this is part of why being a part of an organization like Khan Academy felt so alluring. I thought oh this is great, I can have my Youtube presence be an aspect of my like online identity that helps me move from one place to the next, but like... yeah... math is niche like it wouldn't necessarily work out. I thought it would be much more akin to, you know how like Katie Mack being popular on Twitter probably helps... well it's hard to know depending on like which academic environments but that's not a bad thing to have going into something like slightly different, but you know, obviously some point on my mind that was like a path. To address your original question, do I wax poetic about the influence it might have on... young mathematicians to be. I mean I do... there's an element... [groans] geez it's hard to articulate because anytime you do something...

BH: And I know it's hard to articulate and not feel like I sound like an idiot.
[chuckles]

GS: Right! 'Cause here's the thing. There's a way that I'm very sincere when I say I want to inspire more people to love math. I want more people to self identify as loving it. Whether that means fanning the flames that already exist which with a channel like mine or yours is probably ninety percent the case or in those rare special cases sparking that flame to begin with. I'm sincere when I say that. But it wouldn't be the full truth if I didn't acknowledge part of the reason I make the videos... I just like making them. I think there's an element of enjoying learning something and if you want to explain something to someone else that's what's gonna make you learn it the most. It's purely self contained. Purely in my own world the pleasure and value that comes from it and that if no one else was

watching them... or rather if as many people were watching them but somehow I could put on an omniscience cap and know that it had zero influence, right, like the ones that were going love math loved math, the ones that were gonna hate didn't see. There was no influence.

BH: Yeah.

GS: I would still really enjoy making them for those more selfish reasons and I don't... you know... it's hard to know if you can break it down oh it's forty percent this, twenty percent that. Like anything in life the motivations for doing something are extremely muddled and it's hard to be honest with yourself where they come from.

BH: When you're going to the process. Obviously it's quite a long process making one of your videos because they're so long and they've got so much animation in them and they're just so dense and you've thought about them so much. Of all the steps in the process from the sitting down talking to people to the initial monkeying around with the animations to see how it's gonna look to writing the script to the final push when you're actually making it, like is there a part of that you don't like? Like is that final push, you know, that final week where you're like okay now I actually have to make it, is that like a slog? Or are you getting...

GS: That's the best part!

BH: That's the... but that's the best part?

GS: So like the animating for example...

BH: That's the worst part for me. [chuckles]

GS: So I animate things programmatically. And I love programming and I

think it's... here's what I like about it. [pause] There's just you know what needs to be done. It's kind of grunt worky but there's tiny little micro problems to solve but they're not too hard so like a lot of people disparage the notion of grunt work. That's the most relaxing and get into flow kind of style of things. The part that will be the most uncomfortable is writing it. Right? And especially if I like haven't done sample lessons or if it turns out I wasn't clear on what the idea would be, that's the part that's the most creative but it's also the most painful. And I think this lines up with a lot of other like quote unquote creative work, is the thing that people like to think they enjoy. Ah, this is the like I'm creating a book or writing it in some way. It's actually a very painful process and then the more rote things, if it's you know like mowing the lawn or something like that. It's actually quite enjoyable 'cause you know you're making progress, it's very clear how much progress has been made.

BH: [laughs]

GS: And it's easy to get a little bit addicted to that. [pause] At least I think, maybe that's a personality type.

BH: Tell me about like the ten minutes before you make a video go public and that ten minutes after. Are you...

GS: Mhm.

BH: You strike me as a personality type that would not enjoy that ten minute period of pressing the button and... 'cause you... and finding out how it's first received or if you've made some whopping mistake or...

GS: Oh oh yeah...

BH: You know?

GS: I'm not as much that personality type where you know you get neurotic about it. Certainly maybe I used to get more butterflies in the stomach as if you're about to give a talk when you hit publish which is silly because you're just in a room alone.

BH: [laughs]

GS: These days I'm much more, you know, I try to early release to some people so that they can catch mistakes. So there's... it's not a discrete moment of it was unpublished and now it's published. That helps a lot.

BH: Right.

GS: Then I hit it and you know, I get a little addicted to reading the comments and initial replies, so often it becomes a very unproductive day. [laughs]

BH: Yeah.

GS: Like if outputted things as frequently as you did I would never output anything at all, right? Because... nothing would get done. Yeah, I think it's actually fun. I enjoy that part. I also enjoy public talking and that sort of thing because you can get energized by that.

BH: Yeah.

GS: I can see why I would come across as that type, maybe getting like the more nitty gritty you get into in the details of making a video and the more time you put into it, it feels like that's all the more weight that goes into that moment of publication.

BH: You were obviously quite at good at mathematics. You know, you got into Stanford and that sort of thing. So you obviously have like a talent for

mathematics. Does any part of you wish... that you'd become a mathematician. Do you ever feel like you're a sports commentator and you wish you'd been the quarterback? Like... you wish you were the guy solving the Riemann Hypothesis?

GS: I mean... part of me's just aware that I'm not that good. I think there's some things that I'm quick on. I think there's some things I'm really slow on. Sometimes that's to the benefit because understanding something slowly can give you something better than understanding it, I dunno, over a longer sense. Maybe part of the reason I never actually did follow through on the traditional PhD path as much as I would like to claim, ah it's cynicism about the university system and it was a calculated choice... an element of that was an insecurity knowing that there's just a lot of people way better than me. I don't know if my predilection for math is well tailored to research as opposed to trying to come to clear understandings of already known things.

BH: But does that make you even more jealous of those people and wish you were one of them? Or you're just quite comfortable with your lot? Like, 'cause I couldn't do any of that stuff but I spend all my time with all these Nobel Prize winners and Fields Medalists and that and like... I have like a kind of envy for them. I'm like, oh good on ya, that's like...

GS: [laughs]

BH: That's the real work, you know, I'm just here explaining the greatness of others. And even though I know I couldn't be great I still wish I could have been.

GS: Yeah, I feel that. I mean I definitely do. How cool would it be to just actually put out original research and feel like you're solving problems other people haven't? I also in a way that is silly if I'm honest with myself can get just intimidated by mathematicians when I'm talking to them. They're all nice, normal humans but it's a little bit of an inferiority thing knowing, ah you have a

background and a patience with the subject that I don't have and maybe haven't displayed the same way. So yeah, I feel that.

BH: What's next? What's the next like... what... are you a planner like that or do you just fall with, you know, it sounds like you've fallen from one thing into another in some ways, like?

GS: A little bit. I mean I've got long list. I have the list of topics that I intend to cover.

BH: Yeah.

GS: And then as people make requests maybe it goes on there. As I stumble across there maybe it goes on there. And every now and then I resort the list. But the way it goes, you know, someone says, oh let's do this thing. You don't that thing, or you come across some random little thing. Often if I've just done a very big project I want to sort of exhale by doing a smaller one.

BH: But is it all online video for you now? Like do you think that's it...

GS: Mhm. Hmm.

BH: I'm a filmmaker now. Or do you think, no, you know, this online videos gonna go the way of the dodo and I need to be making three dimensional goggles things or I wanna write a book or like have you got plans beyond video or you think that's just your hands are full now.

GS: Yes. I do want to do things that are not just video. There's one vague possibility... I won't talk about it because it's enough of a vague possibility but there are things on the horizon that I think you definitely want to spread yourself away from video per say, the one I'm working on right now that I was talking with you before is... it's like more than just a video. It's gonna be a interactive

video type experience that... is different and if people seem to like that maybe it makes sense to expand that out more and rather than choosing a different existing medium... forge the way in a new type of medium.

BH: Yeah.

GS: Or maybe people won't like it and it goes nowhere. Fun to experiment.

BH: Yeah.

GS: I would do more writing. Not just about math but in general but writing is slow as you know. Maybe that turns into a book at some point. Uh... maybe not. Yeah I think I would be disappointed in myself if you fast forward two years and the only thing I have going on is online video.

[gentle piano music]

GS: When you were starting Numberphile, I kind of wanna turn that same question you were asking earlier about the influence you wanted to have. Was that a thing on the mind like inspiring young students, getting more people into math? Or is that... again like the spirit of the question is to know to what extent are other people like me in their motivations? [chuckles]

BH: Yeah.

GS: Like [chuckles] to you in particular.

BH: I mean, no I was just talking to a bunch of math teachers a few days ago so I got asked about this so the question is fresh in my mind. I guess I don't have like the loyalty and the history with math that you do. So it's not like, you know, this is my... passion that I want to push the barrow for. With me... with Numberphile and with all my channels... it's never about trying to advance the

subject. It just so happens that these are subjects that I find really interesting. Like I find mathematics... I'm not very good at it but I find mathematics really interesting, I find chemistry and all science interesting. And as just like a storyteller and a journalist I just have a compulsion that when I find something that I find interesting, that tickles my brain, I just wanna tell other people like I just like... it's like an addiction. Storytelling and sharing cool stuff is an addiction. And... you know... I can't come home and tell my wife about every interesting thing I find out about prime numbers...

GS: [laughs]

BH: 'Cause she finds it a bit boring.

GS: [laughs]

BH: But luckily I live at a time when instead...

GS: Sure.

BH: There's this piece of technology that means I can go and make a film and tell a story and tell thousands and thousands of people and if that makes someone wanna be a mathematician... fine. If it makes them hate mathematics... I'm surprised but fine.

GS: [laughs] Sure.

BH: I don't know feel like... I have an agenda to change people's lives. I just want people to know cool stuff. A really good example of that though isn't video, it was I once went down into the Bank of England's gold bullion vault which is under the streets of London in a really busy part of London. It was the first time cameras had been allowed in there so it's a really rarely seen thing.

GS: Hmm.

BH: It was pretty amazing. And I went down there and filmed it and whatever and then came back out above the street and like you I went to go and have lunch and go to Starbucks or whatever. But I just felt like... there was like... I felt all this adrenaline and goosebumps 'cause I'd just seen this... you know, four hundred billion dollars worth of gold, it was the most amazing sight I'd ever seen with my eyes. And I just wanted to go up to people in the street who were just walking along on their phones and going about their business, all the crowds of London, I wanted to grab them...

GS: Do you know?! [laughs]

BH: I wanted to grab them by the collar. There's this amazing thing and you don't know it but you have to know it.

GS: Mhm.

BH: And I think that like that side of my personality is why I make the videos. When I sit down with a mathematician and they're explaining something to me and they say let me show you this cool thing and let me tell you this cool fact or piece of trivia and it's something I understand [chuckles]...

GS: Mhm.

BH: Like it just sends like I get these chills down my spine and I can't wait to make the video because I want other people to experience those some chills. I don't care what job they do. I don't care if they're watching it just for fun on their lunch break or if it makes them go to school. I feel really good...

GS: Hmm.

BH: When they say, and I'm sure you get this all the time, I feel really good when they say, oh I'm gonna study mathematics at university or I'm...

GS: Mhm.

BH: I've changed my major because of your videos. You really inspired me. That makes me super super proud and happy but it was never why I did it.

GS: Hmm.

BH: And it was never what I'm thinking. I'm never sitting there making a video thinking, well this gonna make people want to be mathematicians for sure.

GS: [laughs]

BH: I'm just thinking, ah man, this fact about pi is gonna knock people's socks off.

GS: [laughs] What's funny, sometimes when I'll get those messages and they're like ah I'm gonna study math as a result, I... sometimes I'll reply with this, and sometimes I just think it in my mind, study computer science, at least as well...

BH: Yeah? [laughs]

GS: But... I dunno if you should study... I dunno if everyone should study math. I think they should like it and take some classes in it. I don't know if like the math major is actually the best way to spend your college time and I would feel much more comfortable telling someone, study computer science and take as many math classes as you feel comfortable with. So... every now and then like someone will also email like hey I'm really struggling on deciding between like math and you're like videos have inspired me but like I also like programming or

I also like physics and in that case I'm like... do the other thing [chuckles]. Also definitely don't listen to some dude on the internet [laughs].

BH: I know, yeah.

GS: Tell me what to do like I don't know your situation... but...

BH: Yeah.

GS: I don't think it would be good if everyone wanted to be a mathematician because the cold hard truth is it's not useful enough like pure math in and of itself isn't useful enough for too many people to be doing it. I'm gonna make that statement, I don't know if I stand by it.

BH: [laughs]

GS: But I think I do.

BH: Okay. You can retract it at a later date.

GS: [laughs]

BH: There's an asterisk on that one.

GS: We can agree that unless there's, you know, artificial general intelligence feeding us all of the food we want in the world like there is... a... a point at which there are too many mathematicians. Like, you don't wanna hundred percent of the population doing it because then no one gets fed. You don't want even fifty percent because there's just other... more interesting things to do. For math's sake also I think, you know like in the same way that the Manhattan Project pushed forward physics because it threw a lot of otherwise only on the blackboard theoretical minds into a circumstance where, look this has to work,

right?

BH: Yeah.

GS: The atmosphere might blow up if the...

BH: [giggles]

GS: ...calculations go wrong here, so don't mess them up.

BH: Yeah.

GS: I think that is good for physics and in much the same way fields tangential to math are very good for math. And I say that as someone who gets very turned on just... that's not the phrasing I want [chuckles]

BH: [chuckles]

GS: I'm very tickled by math for it's own sake. That's not necessarily applied but I... the more time that passes the more weight and legitimacy I think the tangential fields deserve in its place. I also don't think math should be this mandatory class that you teach at every year of school all the way up. That feels antiquated to me. I think programming should be that instead. I think math should have the roll of science, where it's there a lot, especially in elective forms and I think that exposes to actually feeling passionate about it in a way that it's hard to feel passionate about something if a school is forcing you to do it.

BH: Do you think society needs to be more math literate? Like do you think it's bad that people don't understand mathematics better. Like do you... doesn't matter?

GS: A lot of that math literacy rhetoric I don't necessarily buy. People make

the case in statistics, ah you have to understand the statistics that you're reading from the news, but the fact is... even if you understand it pretty well you still have to rely on like the good faith of the journalist to have dug up like the right information to be showing you because maybe if you're an absolute like professional statistician and you have access to the right data sets you can cross check it all and that's a level of literacy that will make you view the articles with the appropriate skepticism. But I don't know if zero to ninety percent actually gets you that much more... more of a truth seeking place in politics and in culture than it would just to actually have a good journalist [chuckles]. Certainly with a lot of other math, like I don't think when it comes to calculus like why should you know calculus? Most people don't need it. Most people don't need group theory. I think these things can add value to your life in terms of the way that you think, so that seems good, if they want it. If they don't want it, like don't shove it down their throats, make sure it's available to them if they express even an inkling of curiosity in that direction. You know the phrase like a little knowledge can be a dangerous thing, [chuckles] I think that definitely falls in... you know... you get someone who's taken one statistic class and suddenly they're looking at every news article they read and they're like ah but that's not what that number means. It's like even if it's not I don't know if that's brought you any closer to the truth.

[gentle chimes play]

GS: People who study math should do more to study storytelling and like performance art related things. Partly because what a lot of people who go into math end up doing is teaching and conveying it in some way. So being able to tell a story actually seems important. And being able to be comfortable in front of a crowd also feels important and that's certainly if you fall into the stereotypes about the kind of students who study math, that's not the default option. To take an improv class or to go, you know, take a short story class by opting in rather than having that forced to you, but I think that's very important.

BH: Of all like the STEM disciplines, I don't know if you would agree with this or not, but I feel like mathematics is the worst at outreach as a whole. Of like compared to like... compared to physics and chemistry and engineering even like math is like the... is the worst at selling itself as a whole. Do you agree and if you do... why do you think that is? And if you don't... well okay.

GS: I have no idea and the reason I have no idea is because my circles are all around math communication by virtue of like what I do.

BH: Yeah.

GS: So my exposure is, hey there's a lot of math outreach! Like this great book was just written, what are you talking about?

BH: Yeah.

GS: But so then I know okay I have to put a brake on that. But I have no idea how much I should shrink or grow that skewed perception.

BH: Yeah.

GS: I do think that most... math lessons and math text books are... I would say are... objectively less approachable than Introductory Physics textbooks and science textbooks. Because there's certain... cultural tendencies around how to describe something where logical precision naturally takes precedence over pedagogical clarity. For example, very common to open a textbook and see the definitions of things... after all how else could you start? In order to talk about the things you must know how they're defined. But that's a bit like teaching a baby how to speak by giving them a dictionary, right? It's actually quite intimidating. This is part of why Wikipedia is so unreadable for math, is that, unless you have read enough to understand either the core nuggets of those definitions or the idea that you're not supposed to understand the definitions yet,

that that will come from examples, you're immediately turned off. Whereas I do think like computer science, partly because it's such a young field, doesn't have that as the same cultural problem and there's much more of a... standard for motivation behind a given difficult topic before you get into it's meat.

BH: That's a good observation about Wikipedia, 'cause I so often find myself going to Wikipedia for help when I'm researching a subject or editing a video and it is no help to me ever.

GS: No.

BH: In mathematics.

GS: It's horrible.

BH: Yeah.

GS: Like I find some value from it and I feel like the only reason I do is because I've sort of learned how to read it.

BH: Yeah.

GS: Actually on the queue of videos [hesitates] maybe this conversation will help push me in the direction of making it more like... how to read a textbook. Because I don't think you should read it linearly like the way you would read a novel. And I do think there is a notion of getting better at that or worse at that. For example start by looking at the exercises at the end of the chapter because those give you a sense of what kind of problems you'll be able to solve. Also it'll give you a sense, if you don't understand those exercises because they all use the jargon that was developed in the chapter, that entire subject for the moment is just like getting you out of a hole that you've dug yourself. [chuckles] This happens a lot in math, you define a whole bunch of things like what is a

topological set, and then you solve problems about the nature of topological sets. And it takes quite a while before you get to a point of... who cares about topological sets? So if you notice that and you say, hmm this chapter isn't gonna be where I know why this is important and that's a good thing to know ahead of coming in. Whereas another time maybe you see an exercise that's understandable without the jargon and that's a sign, hey, this means I'm learning tools that are useful in a different way. And that really shapes the way that you look at the whole chapter. Don't read the definitions first look at the examples after that. When you see a theorem don't read the proof, view it as a personal challenge. Like a bunch of little things there that kind of took me a really long time to actually stumble on and I'm sure there's other good tips that just made me slower at learning math through college.

BH: I'll tell you what I'm taking away from this, not that people should read textbooks definitely obviously but they should be written definitely. Maybe that's your thing, like maybe that's... I would love to read a math textbook that you did.

GS: [laughs]

BH: Maybe that's your longterm project. If anyone out there makes math textbooks...

GS: [laughs]

BH: Get in touch with GRANT SANDERSON [exaggerated pronunciation],

GS: [laughs]

BH: or Graunt Saunderson depending on where you're from and get him to write your textbook. Would you write a textbook?

GS: It seems like a lot of work but I can't rule that out.

BH: That would be fun. Turn it on it's head, yeah. Questions at the start.

GS: The untextbook.

BH: The untextbook. [laughs]

GS: [laughs]

[bell chimes]

BH: I like it.

[chimes fade out]

BH: Well that's it for today but if I may do a bit of a... [gentle music quietly plays] a post-show debrief. Firstly and most importantly if you've not yet seen a 3blue1brown video make sure you do. Just put 3blue1brown into your search bar of choice. Grant's not hard to find. And of course I'll include some links to his stuff. This podcast is made possible by help from the Mathematical Sciences Research Institute in Berkeley, California. [music continues] But this episode was also supported by Meyer Sound and they're also in Berkeley. [music continues] Now they're not here to sell you anything, but they do love sharing with people about their research and latest developments from the labs so if you're curious a good place to look is their website Meyersound.com and just find your way to the News or About sections of the website. The Wikipedia page about Meyer Sound is also pretty good actually. [music continues] I'll include links in the show notes. Now the Numberphile podcast will be back very soon, you're probably aware this is a bit of a new things for us and you can give us a real boost by doing all those usual podcasty things like subscribing, reviewing, rating. Just tell your friends about it, it really means a lot. Especially at these

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