Gracie Cunningham's questions

1. How did people know what they were looking for when they started theorising about formulas because I wouldn't know what to look for?
2. Once they did find these formulas, how did they know that they were right?
3. Why is everyone being really mean to me on twitter?
4. Why did a physicist who's followed by Barack Obama retweet me?
5. Is this number 5? I can't count.
6. Is anyone gonna post this on twitter?
7. Why are the only people who are disagreeing with me the ones who are dumb, and the physicists and mathematicians are agreeing with me?

My answers:

1. Formulas are about spotting patterns and seeing things in common between different situations and wondering why that is going on. Mathematicians and physicists are curious and want to keep asking why things are happening, just like you. They are also lazy - or rather, they want to be efficient, so that if they see something similar happening again and again in different places they want one unified way of understanding it so that they don't have to start from scratch every time. That's what a formula does: it expresses a way of understanding many situations at the same time. That's why instead of numbers we have letters. The letters can then represent *any* number, so you're really writing down something that's true about an infinite number of things rather than just one thing.

It's possible that the reason you feel like you don't know what you're looking for is that you've only been taught math very out of context, like it landed from out of the blue from nowhere. Whereas if you kept noticing a similar thing over and over again in your life you might start wanting a shortcut so you don't have to figure it out every time, and you don't have to look it up. Nowadays we can look everything up really easily but that's because someone else has already figured out the answer.

2. I think this second question is absolutely key. How do people know they're right? In life, many people think they're right for no particularly good reason, just an inflated sense of their self-worth. In academic disciplines there is an agreed framework for assessing whether something is right or not. Each subject developed across time by people agreeing about what a good framework would be for that type of question. For math the framework is logic, and math results are proved using careful logical steps.

The question about straight lines is really profound though, because how do you prove that every straight line has the formula "$y = mx + c$"? That comes down to defining what a straight line even is, and that comes down to making very careful and precise definitions of what geometry is. Mathematicians spent centuries trying to do that and eventually realised that there were way more types of geometry than they thought there were, and that straight lines only have the formula "$y = mx + c$" in one type of geometry, and in other types of geometry they have different formulas. This is if you define a straight line as "the shortest path between two points". So really, it's not absolutely true that a straight line always has the formula "$y = mx + c$", it's only true in that particular type of geometry. In fact it's practically a definition of that particular type of geometry.

3. I think that people are being mean to you on twitter because, first of all, unfortunately, many people on twitter like being mean to women, especially young ones. There are a lot of people on twitter who get their self-esteem from feeling more intelligent that someone else, and so to boost their self-esteem they have to go round telling other people how stupid they are. They can't do it so much in real life because in real life it will probably be rather apparent that they're not so intelligent after all, but on twitter they can pretend. They particularly have to be mean if they feel threatened. So the fact that you went viral feels like a threat to them (because they think they deserve to go viral, not you), and the fact that many mathematicians and physicists are saying your questions are *excellent* is also a threat to them.

4: I think this is part of 7 so I'll answer it with 7.

5. Yes it is the number 5! It's completely understandable that you lose count while you're asking interesting questions to a camera. I do that too. I think it's because the part of the brain that's thinking and communicating interferes with the part of the brain that's counting.

6. This has answered itself: yes!

7. I think physicists and mathematicians are agreeing with you because we know that our subjects stem from deep questioning and curiosity, which is what you seem to be showing. We also know that these questions are not well addressed in typical math education, and that it's one of the reasons math is very misunderstood. We are also not threatened by difficult questions, and some of us get our self-esteem from helping people understand stuff, not by making others feel stupid. I think that some people who aren't actually mathematicians but think of themselves as "math people" have a very fixed view of what math is, and it has to line up with what they think they're good at. If it starts to veer into something they're not so comfortable with they have to deny that's really math because it's too much of a threat to their math self-esteem. They might cling to the idea that memorising times tables is important, for example, perhaps because that's something they were really good at. Or they cling to the idea that calculus is the pinnacle of high school math achievement, perhaps because that's the class in which they were able to excel when many others feel by the wayside, and it made them feel good about themselves. It has probably never occurred to them to ask probing questions like yours, and thus they have to deny that those are good questions, in order to keep up their self-image.

I hope you will continue to ask probing questions. I hope that more math classes address those probing questions and help everyone to see how important they are.

Best wishes,
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