Interview with Sir Timothy Gowers

Sir Timothy Gowers is professor of mathematics at the University of Cambridge, Fellow of The Royal Society, and Fields Medal recipient. His e-mail address is W.T.Gowers@dpmms.cam.ac.uk.

Editor's Note: *Since this interview, Gowers has been awarded the 2016 Sylvester Medal of the Royal Society of London and the De Morgan Medal of the University of Cambridge (see Mathematical People, page 1063).*

Diaz-Lopez: *When did you know you wanted to be a mathematician?*

Gowers: It was a gradual process encouraged by the education system in Britain, where you specialize quite early. At the age of sixteen I was already doing just math and physics. Then, going to university, I had to choose one subject and that subject was clearly going to be mathematics. Later, when I had the chance to specialize in either pure or applied, it was clear to me that pure is what I wanted to do, and at each stage I wanted to get to the next stage, so if you continue that process then, by induction, you end up as a mathematician.

Diaz-Lopez: *Who encouraged or inspired you?*

Gowers: I had a particularly good primary school teacher who told us about π when we were five years old. Then, when I went to my next primary school, the wife of the headmaster was a Cambridge math graduate and she also told us about things that went well beyond the things we were supposed to be learning. After primary school, again I had somebody who was maybe overqualified for the job, somebody who had been a fellow of King's College in Cambridge in mathematics and then decided to switch to school teaching and was very inspiring. Finally, when I went to Cambridge, my director of studies was Béla Bollobás, who went on to become my research supervisor and was also a very inspiring mathematician.

Diaz-Lopez: *How would you describe your research to a graduate student?*

Gowers: The area that I mainly work in is additive combinatorics. I am drawn to combinatorics because I like problems with elementary statements, problems you can attack with elementary-ish methods, by which I mean ones where in order to start you don't have to spend two years reading literature. But I also don't like it when they are too elementary, so I like having some tools. In fact I like to have the illusion to have discovered the tools by myself, even if I am rediscovering well-known tools. I also like (what I call) impure combinatorics, combinatorics that intersects with areas like analysis, number theory, and group theory.

Diaz-Lopez: *What theorem are you most proud of?*

Gowers: The quantitative bound of Szemerédi's theorem. You might think that's a strange choice because it's just giving a new proof of an existing theorem but because the bounds were new there is a new aspect to it, and the methods that were introduced were new and turned out to be quite fruitful for a number other things. It led on to interesting developments.

Diaz-Lopez: *What advice do you have for graduate students?*

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keep asking more and more questions

Gowers: Keep active the whole time. For example, if you are trying to think about a hard problem and you are feeling stuck, ask lots of questions and try to analyze why you are stuck. Think even whether you should switch to a different problem, but not too fast because if you keep doing that you will never do anything. One of the most important things is to keep asking more and more questions and eventually you will find some that you can answer and are interesting, or will help you answer other questions. Some of my best results have been a result of trying to solve unsuccessfully one problem but developing ideas that enabled me to solve others.

Another piece of advice is to keep mathematically curious to the extent that you would be interested in proving things even if you know they are known results. Don't be too hasty to look at the literature to find out whether something is known because if you manage to prove it by yourself you will really understand it. So keep on thinking and if you keep on thinking and having ideas and generating and learning for yourself, eventually the results will start coming.

Diaz-Lopez: *During one of your talks at the 2016 Joint Mathematics Meetings you mentioned that we should think about teaching people how to do research. Is there a way you can teach someone how to do research? If so, how would you do it?*

Gowers: I strongly believe there is, but I can't just at the moment properly justify that belief. It's a project I have in the back of my mind. I have thought quite a lot about the research process while I have been doing it, partly because that's a good thing to do because if you are constantly analyzing what you are doing you can think about how you can do it better or more quickly. At some stage I want to try to set some of the ideas down on paper but right now I haven't gotten them in a sufficiently organized form. So, I am guilty of the crime that I am accusing others of not having diverted enough efforts to explaining how to do it but I do have it as a resolution to do something about that at some stage.

Diaz-Lopez: *You also mentioned the idea of automated proofs. What are your views on the subject and what do you aim to achieve?*

Gowers: It's very related to the previous question because one of the best ways of thinking in depth about how humans find proofs is thinking about how would you automate the process of finding proofs. If you can explain to a computer how to find a proof, you can probably explain it to a human. It's maybe more difficult with computers because there are lots of little things you can take for granted with humans but computers need a lot more help.

The main thing I would like to do is to concentrate on what Mohan Ganesalingam and I called extreme human-oriented automatic theorem-proving. It consists of having computers prove theorems in the sort of ways that humans would do it, not just doing a massive search until you happen to stumble on something that's correct but doing a search process that involves this top-down approach that humans will often have. In such an approach, you have some vague plan for how it works and you try to put in the details and some things work well and other things don't work and you have to modify them and so on. Getting all that to work on a computer is an extremely ambitious goal, obviously. What we have been doing at the moment is trying to do quite easy things in specific subdomains of mathematics, not because that's what really interests us but because you have to start with something.

What I would hope is that there will be two activities: thinking very hard about the research process from the perspective of explaining to humans how to do it, and the bottom-up process of getting a computer to be able to do most sophisticated things. At some point I would like those two to meet in the middle, so the computer can do the easy stuff and then they can get this sort of advice about how to do harder stuff which they will then be able to act on. That's certainly a long-term project.

Diaz-Lopez: *When do you think this will be achieved?*

Gowers: It depends on what you count as the end goal. At this time, I don't see any fundamental obstacle to have computers solving problems that bright undergraduates can solve in an hour, but it's a lot of work and it's not clear when that work is going to get done and by how many people. I would hope that within 10-20 years we can get computers that can do reasonably routine things but sufficiently unroutine to be useful. For example, if you work in one area then something that seems routine to you may seem extremely unroutine to someone in a different area. It would be very helpful to have a computer that can do routine things in all areas of mathematics. Particularly, it will be helpful if it works in this human-oriented way I just described.

Diaz-Lopez: *Do you think machines will ever replace us (as mathematicians)?*

Gowers: It will be a gradual process. People will start using computers more and more to help with their research (as we already do), and each new step will make our research life easier. For example, think back to when we didn't have the Internet, how hard it was to get a hold of a pre-print. So, if research gradually gets easier, each new change will be embraced until eventually we won't need to put in much thought at all to prove things.

At that point I suppose you can ask: Will we not lose very valuable skills? I don't know the answer, and that could be a problem. On the other hand, if one thinks about the use of calculators: I grew up not having calculators, learning how to do long division and now, in principle, if I had to divide one big number by another I know exactly how to do it but I can save a lot of time by using a calculator. That seems to be a good system. We could have a system where we would continue to teach people mathematics, but we might think more carefully about what we taught people, so that when we use computers to find proofs we would know what was going on. It's not a completely straightforward question, but in general I am relaxed about the idea that the age of mathematical research may be finite and if it is then we will find other things to do.

Diaz-Lopez: *You have mentioned that there is a need to reform our journal system. You recently created an arXiv overlay journal,* Discrete Analysis. *Can you say more about this project?*

Gowers: *Discrete Analysis* is meant to be a reasonably broad journal, but broad in the sense of the interests of the editors, which are additive combinatorics, analytic number theory, and other related areas. We are managing the journal at an extremely low cost. I estimated that our annual cost will be comparable to the cost of the article processing charge for one article in one of the traditional publishers' journal. As you mentioned, it is an arXiv overlay journal, meaning that our published articles live on the arXiv; there are no charges for readers and no charges for authors. I hope this will be a catalyst for other people to do the same thing. Part of the reason that the current publishing system hasn't collapsed is that there isn't an alternative out there waiting, and this is one of many different attempts to make a start.

Diaz-Lopez: *Any final comments?*

Gowers: Don't necessarily accept that the way we transmit mathematics at the moment is the best way.

Credits

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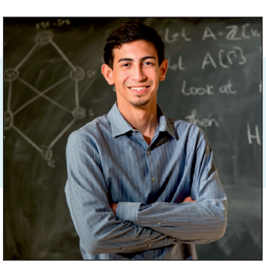

Alexander Diaz-Lopez, having earned his PhD at the University of Notre Dame, is now visiting assistant professor at Swarthmore College. Diaz-Lopez was the first graduate student member of the *Notices* Editorial Board.