Interview with Dr. Gaurav Bhatnagar

Dr. Gaurav Bhatnagar is a Visiting Associate Professor at Ashoka University. He obtained his Ph.D. in Mathematics from The Ohio State University in 1995 under the direction of Stephen C. Milne. After his Ph.D, he spent one year each at Ohio State and the Indian Statistical Institute, Delhi. Subsequently, he joined the industry, where he made a significant contribution to the teaching and learning processes of Indian schools. Since September 2015 he has held visiting positions in Indian Statistical Institute, Delhi, University of Vienna and the School of Physical Sciences (SPS), JNU.

How and why were you first attracted towards mathematics?

In high school I got into the company of some friends who liked to discuss science and mathematics. There were some special showings of Carl Sagan's "Cosmos" in the American Center in Delhi, which was close to our school. We would watch and then discuss what we saw. There was an atmosphere of discussing scientific and math-

ematical ideas. In Class 11, I took a mathematics Olympiad exam conducted by the Delhi School Teachers association. There was a question there which I had not seen before and I managed to do it. It gave me a big kick, a feeling of exhilaration that one gets on getting a creative idea. I thought I will feel so good all my life if I do mathematics.

Is there any book which has influenced you a lot in your education, teaching and research? Please tell us about a few such books.

Whenever I took a course in a new subject, I looked for a book which was easy to read and which would give an overview of the subject. It would give me the idea of what was to follow. Usually such books emphasize the history of the topic. A few examples: *Galois Theory* by Ian Stewart, *Complex Analysis* by Stewart and Tall. Nowadays I find many such books.

The biggest influence in my teaching methodology was a course on number theory I took at Ohio State. This was the Ross program, conducted for very bright high school students, but graduate students were allowed to take it. The main idea of the course was a huge number of problems which were designed to help discover the ideas and then learn how to prove the statements. It helped me realize that it's not so important how well I teach, what matters is how well students learn. And the truth of Halmos' statement: "mathematics is learnt by doing mathematics". So I try to design my courses to encourage students to do a lot of 'doing'.

While writing research papers, I am influenced by popular fiction more than any mathematics books. I want my papers to tell an interesting story. I also want them to be easy to understand, so that more people will be able to read them if they come across them.

Can you tell us about a few books written for laypersons in mathematics that you particularly like and would recommend others to read.

There was one book which really helped ease my study of mathematics, especially where it came to understanding proofs. It was a book of logic puzzles called *What is the name of this book?* by Raymond Smullyan. Another one I really liked was *One, Two, Three, Infinity* by George Gamow. I also recommend *The Man who knew infinity'* which is a biography of Ramanujan and Hardy. Finally, *A Certain Ambiguity* written by Gaurav Suri and Hartosh Singh Bal has very explicit discussions of the emotions one feels while studying mathematics, as well as some interesting philosophical discussions regarding the foundations of mathematics.

In today's world one of the prominent sources of knowledge is the Internet. Do you use the Internet regularly for your work? If yes, then please tell us about a few resources that you frequently use. Or, websites which are dedicated to science/mathematics that you particularly enjoy reading?

I use the Internet all the time. Whenever I don't know something I google it. I find Wikipedia quite useful. Sometimes just googling a topic will lead to a bunch of interesting books/notes/expository papers which people have written to explain something. At least one is sure to explain in a way I can understand. Whenever help is required for programming, it is usually very easy to find. Another very useful resource I use quite often is MathSciNet[1]. It is especially useful to get to know what

[1] A subscription based service from the American Mathematical Society which features reviews of mathematical papers and books. Available at `http://mathscinet.ams.org`.

others have done in a particular area. Finally, for expository notes, Quanta Magazine[2] has become quite popular.

I use the graphing calculator at `https://www.desmos.com` a lot, especially for teaching. I have downloaded a version of the symbolic algebra package Sage from `https://www.sagemath.com`. It can also be used online.

I should mention `https://oeis.org`. This is a website of 'interesting' integer sequences. Whenever I run across any new sequence in my work, I check if it has been studied earlier from this site. Often one finds references there which lead to more ideas and connections.

Please tell us briefly about your thoughts on mathematics, students of mathematics, mathematics teaching and education, and research.

I believe mathematics is an 'arts subject' and should be taught this way. Yes, it is useful, but the beauty of mathematics is easy to appreciate, and is a better reason to study it, than the fact that it will turn out to be important sometime in the future. My focus while lecturing is to communicate the beauty of mathematics as I see it. But as far as my students go, it doesn't matter how well I lecture. They will learn if they do a lot of problems. So I design my courses accordingly, and give lots of homework.

Regarding research. I really enjoy expository writing. Once I write something, I feel I have understood it. I enjoy collaboration. Some of my research came about since I wanted to learn some technique from a friend. One of the themes I come back to repeatedly is a discovery approach to Ramanujan's identities; this leads to some new results too.

Students of mathematics tend to do very well in other fields too. Learning mathematics is about learning a way of thinking. I can do no better than to quote Girish Karnad (translated by Sugata Srinivasaraju[3]). Here is what Karnad says.

> *As a student of mathematics, initially, I was not very loyal to the subject. It was to score high marks that I took it up. But when I got immersed in it as months passed, I began to understand its rhythm, its pitch, its progression, and crescendo. Its beauty danced in front of my eyes. A character in Aldous Huxley's novel weeps at the beauty of the Binomial Theorem. There is nothing surprising about this reaction when numbers unravel their mystical attributes wave by wave, branch by branch. I realized the impact that mathematics had on me when I started writing Tuglaq in Oxford. I solved the structural issues like I would while working on theorems. I first figured out what internal network and relationship different aspects and characters of the play had, what its balance at various points were, and what happens to that balance if the play progresses in a certain direction, just like it happens in a theorem. The technical training, I needed to write plays came from mathematics.*

[2] `http://quantamagazine.org`

[3] Mint, Accessed Jun 13, 2019, `https://www.livemint.com/news/india/the-untold-story-of-girish-karnad-1560438038742.html`