Interview

Teaching, Learning, and Growing in Mathematics: Interview with Satyanarayana Reddy

Fig: Satynarayana Reddy By S. Reddy

Satyanarayana Reddy is currently working as an Associate Professor at the Department of Mathematics, Shiv Nadar University, India. Prof. Reddy is an active member of the MTTS Trust, funded by NBHM. He did his Ph.D. at Indian Institute of Technology, Kanpur, India. His research fields of expertise include algebraic graph theory, linear algebra, combinatorial matrix theory and Algebraic Number Theory.

Prof. Reddy recounts his early days and influences during the student days. We discuss, among many things, his mathematics, the state of Indian education, MTTS, and his days in Kanpur.

Purnima Tiwari: Good morning Dr Satya. We welcome you on behalf of Anveshanā. So, let us begin with the questions.
How was your childhood? Were you interested in any subject while you were growing up? Did you want to become a mathematician from the start?

Satyanarayana Reddy: No, my childhood was completely enjoyable, rather jolly. I never thought of something as my goal, so mathematics was not at all a part of my life at that time.

In my childhood, I didn't like any particular subject as such. I mostly enjoyed playing games, and roaming around with my friends. Most of my time passed in that way, and there wasn't any particular goal in my mind. Actually, even up until 10+2, there wasn't an inclination towards mathematics.

I have an ordinary family background, so when I came to know that we enter intermediate college after 10th standard in Andhra Pradesh, we would then have to wear pants. Up until then, I used to wear shorts and that was when I got an opportunity to wear trousers and that gave me the motivation to do well in my class 10^{th}. During the 10^{th} class, I started liking mathematics comparatively more than other subjects, but it was mostly natural to me and I scored more, so I started liking it. That was the reason I chose MPC (Mathematics, Physics and Chemistry). But later on, when I went to B.Sc college, I again chose mathematics and computer science because it was the time when computer science was advancing and I thought mathematics, physics, and computer science are good subjects to take up to settle down early. At that time, in particular, in the second year, Group Theory was being taught as a part of our syllabus. That was abstract, up until then everything was normal and I didn't have much motivation to do analysis or geometry. I was not reading things properly until then. Luckily, group theory was a new concept for me and I was enjoying it. I even started explaining it to my friends and then eventually we were introduced to Ring Theory and Vector Spaces and slowly I started getting interested in Algebra. This is what prompted me to pursue mathematics and then I applied for MSc. But most of my friends then were inclined towards computer science since that was believed to provide us with a job. I also applied for MCA and I had my exam at NIT Surathkal but I did not know how to reach there and it took me more time than usual to reach and in the process, I even got sick and had a headache on the exam day and I did not qualify the exam by half a mark. But luckily, simultaneously I applied for an MSc Mathematics at Andhra University and I got selected there, I ranked 20th in the list and I joined as a student in Pure Mathematics.

PT: During your undergrad, were there any other interests? Were you the kind to follow what is taught, or would you also venture outside and learn on your own?

SR: In particular, the Group Theory part had helped me. Somehow I got really interested in the abstractness of the subject. There was a textbook by *S.Chand* that helped me in understanding the concepts. I didn't do anything other than that. I didn't take any tuition at any point in time for mathematics but because of my financial constraints, I had started teaching by then. I taught school children and they would usually come for mathematics and while teaching them I got really interested in the subject. Going through class 9^{th} and $10th$ problems again helped me a lot.

Aayush Verma: Was there any mathematician whose particular style of mathematics and thinking impressed or influenced you?

SR: Frankly speaking, back then, it wasn't really like that. Actually, I didn't get through the course work properly or even read things properly, so completing the syllabus and scoring good marks was my focus then. However, now I realise that the way of reading wasn't correct. There were a few faculties who influenced me by the way they taught but there weren't many people, whom I was inspired by.

AV: Do you remember the names of the faculties who inspired you?

SR: Yes, a few. Prof *K. L. N. Swamy Sir*, in MSc mathematics. At the PhD level, my supervisors influenced me. I had two supervisors, one was *Prof Shashank K Mehta* from the CS department and the other was from the Mathematics department, Prof *A.K. Lal* [Arbind Kumar Lal], and both were very helpful. AK Lal Sir's influence was more. I used to go to his office several times and he would ask me to sit along with him and then would explain things to me and also Shashank K Mehta would allocate one hour to me, every week, in order to read and present so these two people had a good impact on me. But mainly, at the completion of my PhD, in the last semester, there was an MTTS programme conducted in IITK itself and I requested Prof Santanam to attend the MTTS program as an observer. In the first class, I listened to Prof Kumaresan Sir, and I realised that his way of reading was completely different. His teaching style influenced me a lot and afterward, I saw a change in my life. I can say that his one talk completely changed my life. He started with analysis, and up until that point of time, I was completely scared of analysis; even my PhD was in Algebraic Graph Theory. I kept avoiding analysis because I was afraid of it but then I listened to him for the first time and actually, he was just teaching undergrad-level analysis, but I was afraid of even that. He started with the Archimedean property and its applications and proved several results in one class, which really was eye-opening for me. From that point in time, I was more confident.

Also, indirectly, *Keith Conrad* who is an algebraist also helped me. His website articles[1] on Group Theory and Ring Theory helped me a lot. I used to visit his website and he had a good influence on me, though I have never met him but he has helped me. Another person along the same lines was Prof B Sury; his articles helped me a lot. But all of this happened after MTTS came into my life.

AV: You went to do a PhD at the Indian Institute of Technology in Kanpur, how did you make this decision? Was there something or someone you wanted to work with at IITK?

SR: Yeah, actually because of my financial constraints, after my MSc, I started doing jobs to make a living. I was initially working in Andhra Pradesh but after my marriage, I shifted to

[1] https://kconrad.math.uconn.edu/blurbs/

Fig: Campus clicks of Indian Institute of Technology, Kanpur (IITK). By Aayush Verma

Hyderabad and I joined an engineering college there, where I worked for almost five and a half years but by that point in time, there was a QIP (Quality Improvement Programme), which is for teachers, and was held in IITK. So there was a professor of Mechanical Engineering- Prof Bhaskar Das Gupta, and he was the organizer as well as the main instructor. So I came to IITK to attend the program and I was very much impressed by the overall atmosphere there; the peacocks, the beautiful campus, among other things, and I immediately thought of shifting here. Then I went back to my college and talked to my colleagues and I wrote the GATE exam which I wasn't aware of earlier, but luckily my colleagues told me, and one can write JRF too but by then, I had already crossed the age limit, and the only possibility was GATE so I sat for that, and I got a good score. I came to IITK in December, and then in June, I applied for there, but I didn't get the admission then. I then met with Prof Arvind Kumar Lal before leaving IITK, and told him that I have been teaching discrete mathematics for a long period, in particular I was interested in working in Graph Theory so I wanted to work with him. He told me that I had to apply again and qualify to make that possible and he told me that if I cleared the exam and then the interview, we could discuss it. So I started reading again and applied next December and got selected. That is how I got into the PhD program there.

Devang Bajpai: Can you describe your IITK days, did you enjoy the big campus?

SR: Yes, I joined in December 2006. So I was basically there from 2007 onwards. It really was one of the best times in my life, because that was the place where I realised what I knew and what I didn't. The first thing was to unlearn, which was very important for me, and the other was the seminars. It was great for me to be able to listen to those seminars and it was a new experience, and that gave me a little confidence. Another advantage was the different

departments, the faculties from very reputed institutes, and the liberty to attend their classes. One can attend any class and that was an advantage in IITK which helped me in taking some courses in CS, and I noticed the importance of Mathematics in all the departments.

Bhaskar Das Gupta influenced me a lot, he is actually from mechanical engineering but he wrote a book on mathematical methods, and later he also conducted the QIP programme again, when I was there as a PhD scholar and he introduced me as a tutor. I was fortunate that he was so cooperative with me throughout my period there. In other aspects too, IITK is a big campus, with a lot of greenery as well as sports facilities. I used to play badminton, go swimming and cycling. Regarding food too, it was the best. The halls, the canteens, and all the facilities are good and available at a nominal cost. In all aspects, IITK was wonderful. Even the Doa canteen, Chemical Canteen, everything is good there. Even the workers there are very polite and respectful. One of the beautiful things about Kanpur is its affordability. People are very cooperative there.

DB: Did you spend your time in the campus or went outside too?

SR: Even outside the campus, ChinaTown and other places were good. Bada Chauraha and other places were great to visit.

DB: As you mentioned that you were interested in sports, so did you enjoy any sports in your childhood?

SR: Actually, back then, it was rare for me to stay at home. I would always be out with my friends, playing cricket, badminton, tennis, running, and other athletics.

AV: As you mentioned, one of your advisors was AK Lal. Who was the other one?

SR: The other was Prof. Shashank K. Mehta from the CS department, and both of them worked in Graph Theory. I had actually attended a course under Prof. Mehta and asked him if I could do some reading work with him; that was the way I worked with him. I joined under AK Lal and he was very supportive and told me that I could take Prof Mehta as a co-advisor too.

AV: What were the works they were doing back then?

SR: Mainly Arvind Kumar Sir was working on Algebraic Graph Theory, in particular related to Laplacian matrices of trees, which is called the second smallest eigenvalue connectivity. He was working on that along with his supervisor and another student. His supervisor was Prof Bapat. He had many students, two of them were AK Lal and Prof Sukanta Pati from IIT Guwahati. I was interested in that too but the problem to me was assigned by Shashank K Mehta and I continued that problem as I had started reading with him while doing his course. Even AK Lal helped me a lot with his input while writing the paper.

AV: Do you remember the problem?

SR: The problem was to consider a graph X, i.e. with vertices and edges, and then consider an adjacent matrix A, and take A^2, A^3, and so on, and then collect them and observe how the entries change, or if there is a common pattern. For example, if you take a photograph made up of pixels, one can observe many pixels are equal, then the question arises that how many of the pixels have equal values? So if I take A^2, A^3, and so on, then how do I predict the pixel value at different positions? Like that, if I now take a graph and take its adjacent matrix, then I can find its powers and check how the entries change. Now that is the broader view of the problem, but the question was if I could predict the values.

AV: Were there any other people in the Department of Mathematics and Statistics at IITK to whom you talked a lot?

SR: Now the thing was that since you have a course work, after joining you have a year to do the course work and finalize your area of research and advisor. Besides that, there was also an exam one had to qualify to get started with the PhD. And the institute pays you to do some coursework and TA duties, so I had a few, and I worked under many people.

AV: What were the courses you were taking in that one year? Do you remember anybody that you had worked under as a TA?

SR: I took some compulsory courses, such as Algebra, Analysis, and Differential Equations, and some elective courses such as Algebraic Graph Theory, and Approximation Theory. There are some courses for Engineering, like MAT101, where all engineering students would come, which were approximately 700, so a room called lecture hall-7 was used, since it had the capacity to hold more than 700 people. These courses are generally taught by 2 faculties and there are tutorials for 40 students at a time in the Tutorial Complex. So, many times, there were Prof P. Shunmugaraj, Prof Piyush Chandra, Prof Bahuguna, and many other professors, under whom I worked. Sometimes Algebra was taken by AK Lal, and a few times by AK Maloo Sir. In fact, I took a Commutative Algebra course from him and even worked under him as a TA.

Actually, my supervisor and AK Maloo Sir were close friends. So sometimes Lal Sir's students would be Maloo Sir's TA and vice versa. Once what happened was- while I was a TA under Maloo Sir, I had corrected a question by a student that was attempted in a different way and I didn't read properly so I gave very less marks, then the student went to Maloo Sir, and then Prof Maloo asked me to come to his office and explained me what happens if students get less marks than deserved. The student lost confidence hence, he would come and check the papers every time we conducted exams. So one should be very careful while going through answers and solutions, and this incident influenced me a lot.

DB: How was your PhD Defence? Who was sitting on your committee? Any questions you remember from that committee?

SR: Prof R. Thangadurai, from HRI, came for the PhD exam. It went well. After the defence, my supervisors told me that I did a wonderful job. But of course, I also made enough efforts to try to make it clear to everyone and tried my level best to think about how to present things, especially while going for walks in the morning. The committee members asked me some technical questions, like the future aspects of the research and other similar questions. There is an area named Statistical Design Theory, and as I have mentioned the problem I was tackling- so, as I was trying to attack this problem, I visited the IITK library several times, and once I observed a book on Statistical Design Theory that fascinated me and I came across something called 'association schemes' and figured that the problem was related to this. It deals with strongly regular graphs, among other things, and R.C. Bose works in this area. So, I then started working on it, and the questions I was asked were majorly focused on this. I was mainly confined to regular graphs, distance regular graphs, etc., so they asked me to find out what happens if the graphs are not regular and there was another question regarding application.

So in my area, what one does is- take a graph X and then deal with the adjacent algebra of X, i.e., you take a square and so on and you take the polynomial algebra of A. Like $f(x)$ defines a set of all polynomials in x, and coefficients from the fieldX, instead I had it for A- the Adjacency Algebra. So they asked me about the properties of the same and their applications.

PT: You mentioned that there was a professor from HRI for your PhD defence. Have you ever visited HRI?

SR: Yes, I did visit HRI, actually because of Prof Thangadurai himself. I visited for the first time as an observer, which was for a week and I was very happy, it is a wonderful place. And later, he himself asked me to come as a tutor for AFS. AFS is an Annual Foundation School for PhD students. The participants appreciated me and wrote very positively about me and following that, I have visited several times there.

DB: Your paper received first position for oral presentation on Respectable Graphs, at a national seminar held at Brahmanand College, Kanpur on February 12, 2011. Can you share what inspired your research on this topic and the key insights from your presentation?

SR: Actually, until then, I didn't have a paper, and this was when I presented one of my works which was not a part of my thesis. I defined it and presented it there and luckily I won the first position for that. It was a very happy moment for me as my research got some recognition and later I submitted the paper and it got accepted. At present, I may agree that it is not that good an achievement, but I did feel very proud at that moment. I will never forget this and the city of Kanpur.

The work was about two graphs, say X and Y are said to be respectable if one is a polynomial in the other- this means that the Adjacency Algebra of X is equal to the Adjacency Algebra of Y. So, if you take two graphs, X and Y, and let A be the Adjacency matrix of X, and B be

Fig: Satyanarayana Reddy speaking in a workshop on *Diophantine Equations* at Himachal Pradesh Unviersity in 2014. By Satyanarayana Reddy

the Adjacency matrix of Y, then the set of all polynomials in A and the set of all polynomials in B- these two algebras are the same and then we say that these two graphs are respectable. This sort of work was done earlier by Prof Beezer and others and they defined something called Orbital graphs among other things. So I defined this and when it got accepted, I felt very happy. I do believe that it was a good achievement for me.

PT: You mentioned that MTTS has drastically changed your opinion on academia. How did you become a part of MTTS? How would you describe MTTS for the young scientists in the making?

SR: It was certainly my bad luck that I was not aware of MTTS up until my PhD. So I would definitely tell everyone who knows about MTTS to enlighten others about it too. MTTS has a different methodology, the one that is actually required for thinking in Mathematics. So in particular, MTTS encourages you to think more, to first think and then write, it focuses on allocating more time to thinking. Generally one is in a hurry in trying to complete the syllabus but instead, MTTS focuses on taking a particular topic and asking several questions on that itself. The more questions you ask, the more you learn about it as well as its connection to other areas.

One must not be in a hurry. So if you study a definition, then ask several questions about that definition before going further, do not stick to the textbook, and collect more examples, and you will learn that whatever you have asked is what has been asked in the textbook questions. This makes one enjoy it a lot, and is required for every mathematics student. You must not follow somebody, and believe in yourself, and then ask more questions- this is what MTTS

Fig: A celebration with B. Sury and others. By Satyanarayana Reddy

also emphasizes. How I got into MTTS was that, on the feedback forms, the participants had mentioned my name. In 2013, it took place in NIT, Surat and I again went as an observer and even there the participants wrote about me. The interaction with the students helped me.

Once a professor had to go to IIT Patna for MTTS but he couldn't and I was told a day before by Prof Santhanam to go the next day, and since it was a good opportunity, I accepted and went. In the beginning, I had joined just for the one-week programmes. Later, I got involved more, and I myself conducted an MTTS camp as a local coordinator in SNU itself, in 2015 & 2016. I was also a part of the faculty.

PT: How was the celebration of Prof Kumaresan's 74 birth anniversary organized by the Curry Leaf Club? Could you tell us something more about him as well as the club?

SR: So MTTS alumni have a club[2] which was started in 2020 during Covid time. One of the things that happened good in that period was the comfortability with online meetings. The club was started with the intention of giving back. In 2020, some students established contact with Kumaresan Sir and started the Curry Leaf YouTube channel[3] and they started interviewing him and other people and the channel flourished. Later they started the society, and the MTTS trust tried to help them and I was made one of the Faculty Advisors. The club mainly targets MTTS alumni to give talks and share their experiences, and there is also an MTTS summer Programme, and the participants who had given the presentation there could

[2] https://sites.google.com/view/curryleaf/
[3] https://www.youtube.com/@curryleaf6377

also give a virtual seminar presentation on this channel. Now, there are so many talks that are given by students on the Curry Leaf Channel. There have also been many Panel Discussions, and several different types of activities have been conducted. This is definitely an inspiration for many people to start a society and imagine what wonders could be done if people met in-person.

PT: How was the name 'Curry-Leaf' chosen?

SR: Actually Curry Leaf is a technique that Prof Kumaresan uses. So while proving, in Analysis what we generally assume is to add something to both sides and then subtract it in the end. So when we have to compare, let's say A with B, to show that A<B, then it would be difficult, hence what we would do is take a C and show that A<C and C<B, then this would imply that A<B, by the transitive property. Sir referred to this and the Triangle inequality as the Curry Leaf technique. While using curry leaf in dishes, we use it for the flavor and put it aside while eating, so Curry Leaf refers to that.

DB: What are your current work interests?

SR: I am continuing with Algebraic Graph Theory, in this you construct a graph and then take its Adjacency matrices, Laplacian Matrices, Distance Matrices, Eccentricity matrices, etc., but now if the graphs are being constructed from Algebraic structures, then you take a group G and the vertices are the elements of the group and there is an edge between them if they commute or one is the power of the other or one generates the other, etc., in particular, I work in generating graphs and the cyclic subgroup graphs- on which the vertices are the cyclic subgroups and there is an edge between them and one is contained in the other, i.e., there is an immediate containment like Hasse Diagrams in Lattice theory. So most of my work focuses on that for now. Earlier, I also worked on Circulant Graphs, mainly, they have applications to Signal Processing, and this work is still being continued. Also, I work in Adjacency Matrices, which are non-negative matrices with entries o&1. So we take a non-negative matrix and figure out if they are totally positive or totally non-negative.

AV: As you have mentioned a lot about interactions in your journey. We would like to know what you think about 'thinking' and 'explaining' when it comes to mathematics.

SR: Of course in order to explain something, one needs to think, and hence both are necessary. But it is always better to learn more by discussions and explanations. I suggest that everyone must discuss, give talks, give seminars and hence one must keep adding to the knowledge on the topic they are interested to give a talk on. Collecting information would make a very good expository talk on that particular topic. So before giving the seminar, one needs to think a lot about the presentation, and try different patterns. Keep coming with fresh ideas and in case you are unable to think, revisit the concept, collect more information and then again start thinking and that helps you improve. Even after the talk is complete, you must keep on

thinking and improving. It is better to have some sort of 'treasures' with you, some topics that you are ready with.

DB: Is there any mathematics textbook that every undergraduate must read? And why would you refer to them?

SR: It depends upon the requirements of the students. For Undergraduates, at this juncture, the foundation book by Prof Kumaresan Sir, Bhabha Kumar Sharma and Ajith Sir is good. Mathematics has a language, we use something called quantifiers in there, definitions, and the way of stating definitions properly- so the foundation book helps you with all the subjects that you must have done earlier. There are several other books, for leisure reading, like 'What is Mathematics', among others. Now depending upon the student's interest, for someone interested in Algebra or Linear Algebra, then Linear Algebra done Right by Sheldon Axler is a good book. Hence, every area has a different good book.

Another suggestion by me would be Elementary Number Theory by David Burton which is more like a novel and it motivates one very well. It is a book that one can complete on their own and it gives one a lot of confidence. In Elementary Number Theory, the questions are very simple and the proofs are small, which helps gain confidence.

PT: A career in mathematics is not seen with excitement among younger people of India in comparison to other streams, what do you think we are missing here?

SR: First of all, a student must listen to their heart and realise what they are naturally interested in and they must discuss with other people but must not blindly listen to them, and instead listen to their heart. Coming to Mathematics- it's just like a mother. Mathematics is always with you; if you believe in mathematics, then it will take care of you. Using mathematics, one could even earn by providing classes, as I did. For girls who get married and there's some financial constraint or something goes wrong then at least they would have Mathematics to get some earnings.

For other areas, every subject needs mathematics, there is no question about it. Recently, if you look at Coding Theory, or Cryptography or Cyber Security, E-business, Online Marketing, Movie Making, Computer games, Medicine, Bioinformatics, Complex Networks, etc.- all require mathematics. For example, if you go to networks and ask what are all the places that Air India will connect, or Indigo will connect etc., all of them can be expressed by graphs and there are so many different areas that can be connected using Mathematics, i.e., via mathematical modelling. So Mathematics is always better to learn, even if you are not pursuing a career in it. It helps you with other careers as well. I would say the same again, if you believe in mathematics, then Mathematics will be with you, wherever you are or whatever area you choose. Mathematics will help you excel in that field, be it banking, insurance, or product sales, all require a mathematical model. Climate change too requires mathematical modeling. Whatever area one takes, mathematics is definitely required- so, if you believe in mathematics,

it will take care of you.

PT: Do you have any hobbies or interests outside of Mathematics, and do you think that those help you in drawing inspiration?

SR: No, I do not actually have anything like that. Teaching, and interacting while doing mathematics is mostly what I do. If I have some works in signal processing, then there the nth roots of unity have a lot of importance, for example, fast Fourier Transform, Fourier Transform, and Discrete Quotient Transform- they are all related to the nth roots of unit., which fascinated me, so I have some good work in that area.

DB: How has SNU been for you? How do you balance the dynamics between research and teaching there?

SR: At SNU, we have a mathematics major course, for BSc students, which is a four year program. It is basically BSc research., and the students are completely confined to mathematics, of course, they have some UWE (University Wide Electives), and CCC courses but the major chunk is done in mathematics. In the first two years itself, they complete Calculus I, Calculus II, Algebra I, Algebra II, Linear Algebra I, Linear Algebra II, Analysis I, Analysis II, and hence they are already equipped with some essential material. Now, in the next two years, they are ready to explore higher Mathematics, hence they come to ask us if we can offer them Commutative Algebra, Galois Theory, Coding theory, Combinatorial Design Theory, Cryptography, Measure Theory, Mathematical Finance, Combinatorics, Algebraic Combinatorics, Algebraic Graph Theory, etc.

I actually have six journal papers up to now with my undergraduate students. I could tell you a few stories about them. When I was taking a Number Theory course, one of the students asked me about the Euler-phi function, that is, the number of numbers that are relatively prime to n. In the class, a student asked me what if I do not want to count all the numbers, but the numbers that are relatively prime to a given number and are composite, i.e., the non-primes that are relatively prime to the number. I did not know the answer then, but when I came to my office, I wrote a program and collected the data, and we sat together, observed the patterns, and wrote a paper.

With another student, I worked on graph theory connected to analysis; one of the other works was LCM of n-tuples and Alternating Sign Matrices. Luckily at SNU, we have a course called Undergraduate Seminar and that course has no syllabus, one can explore to whatever depth they want. They can take a topic and read and this is a very nice break for them. Up until then, they have been reading some syllabus textbooks, and this particular course lets them choose their own topic without any pressure. They can even take up higher mathematics, like Algebraic Geometry among others, and can learn on their own. They can even take a particular topic and research it. In one of these courses, I gave a student the topic of Alternating Sign Matrices and there was a lot of research and learning, and then we finally published the work.

There is another thing called OUR at SNU, which refers to Opportunities for Undergraduate Research. The students, alongside doing the courses, can take up a topic and do research with a professor. This year too I have a student under me and I have given him the topic of Perminants. As in Determinants, we add and subtract alternatively, in Perminants, one adds all of these. I have two papers with the student as of now.

So at SNU, I am doing research with the students as well as teaching here. It is a very nice platform for me, and I was fortunate to join here. I have the flexibility of visiting places and giving talks as well as being a resource person for MTTS and conducting programs there. It has been a great experience here at SNU so far.

AV: In mathematics, we always tend to lose touch with the ground and become abstract enough to sometimes become 'not understandable' and even 'irrelevant'. How does it look for you? Do you believe that rigor can be balanced between intuition and abstractness?

SR: Actually, it is different for different people- some people are very good with it. As Vivekananda says- 'Concentration is the key to knowledge', and he defined something called, 'the degree of concentration'. So, some people can grasp something very quickly, and their degree of concentration is very high. Like I feel that Prof Kumaresan's degree of concentration is high. Person to person, the degree of concentration changes. Some people can write the first step and skip directly to the fourth, while some have the power to directly move to abstract thinking. We need to understand that people are different; some can observe the patterns and come up with something abstract very quickly, but for me, whatever abstractness is there, I go slow and then observe. One can slowly work out, observe, and then conclude with something. It might take time, one can slowly work, and it may be frustrating but please allocate time- even abstract can be made concrete.

In that manner, Prof Kumaresan Sir's approach of teaching helped me. Some students feel that I am understanding, but if you go to abstractness without a proper ground, then it becomes dangerous. Some students feel they understand but they haven't yet, and then they feel overconfident and always talk about jargon. Hence, one must be careful. There are a few who are great and understand things fast, but comparison must not be done.

PT: What potential corrections should be made in an undergraduate program of Mathematics?

SR: The syllabus I think is okay, the more important thing is to focus on the delivery. The way the students think of themselves is more important. The sort of thinking where one can observe things by themselves is more than enough. Regarding the modifications, it is better that we are using technology, and hence at least in a semester, two courses must have Sage components with them- Sage, Python, or any other programming component. So, if one studies Number Theory, then one must also be able to write programs. Since the future is

about theoretical computer science, everything they learn, they must be able to convert it into computer programs. Algorithms are nothing but proofs and hence these help us to develop better, optimized algorithms, and that also helps one to realise the need for different proofs to the same problem. One does not blindly follow somebody and just starts, they need to sit and think- that thinking is needed and writing programs help with that.

In conclusion, the courses need to have a programming component, not every course but at least one or two must, however it does become difficult to implement with a huge number of students. The other main focus is to change the examination system- mainly, the way of asking questions. Right now, major focus is given on writing examinations, which has to be changed- the evaluation pattern must be changed and there should be a continuous evaluation, students need to know where they are lacking continuously, and that cannot be done with one exam.

AV: People are afraid of asking trivial questions. How do you encourage them to ask trivial questions, i.e., in a math lecture, or seminar, or even in a regular class?

SR: One should not be afraid, or care about what other people think, and hence one must compare their progress only with themselves. If you feel any difficulty, you could talk to your friends or directly to the faculty and hence slowly start asking questions in the class too. With one person, even others would gain the confidence to ask. Some would think that these questions are very easy, but sometimes it isn't easy- not just for you, but for other people too, and hence when you ask questions, you also help others. And a good way to tackle that would be to form a group and then ask questions, which helps a lot with discussions. You must take a definition, try to collect as many examples as possible, look at the patterns, and automatically, the questions will come to you.

DB: Mathematics, for some people, acts simply as a tool, and for some people, it is a form of pure thought. Which culture is weaker in the Indian education system according to you?

SR: Tool is actually the wrong way to mention it. Mathematics is helpful in all careers as I said. Earlier, even Physics majors, Engineering students, etc.- all of them were actually very good mathematicians. Engineering is basically an application of science- so they need to understand the science better, to apply it. Just learning and doing it for a particular problem doesn't clarify the topic in your mind, but if you actually read and ask questions and understand the subject thoroughly, only then do you understand that. Do not underestimate whatever the concepts you are learning, and give time, ask questions, and sooner or later, it comes to you. Hence, Mathematics must not be treated as a tool.

PT: We, at Anveshanā, aim to understand and celebrate the beautiful connection between scholarship and human thoughts. What are your views about the importance of human thoughts in the subject of Mathematics? How important it is- for a student, to develop their own independent inquiries and come up with novel and original

ideas? Lastly, do you have any central advice for young people who want to have a career in mathematics?

SR: First of all, the name that you have chosen, Anveshanā, is a great name. One of my favourite movies is Anveshana- it is a Telugu movie. Coming to the question, look at the subject, Physics, Biology or Chemistry, usually, we are talking about the things that are already there. If you take History, then too, we are talking about things that have already happened, of course, it helps us in many ways. In Physics, we try to understand the already existing things, and in Zoology- you study about animals, etc., but Mathematics is a subject which is created by man and it is already about thoughts, and it was created to solve all these problems. I would repeat again, Mathematics is just like a mother. Even during this interview, the signal transfer takes place; while paying at a shop with the QR code, the coding theory is applicable there; in the transmission of encrypted messages, Coding Theory is applicable, and in Cyber Security too- all these applications come from Number Theory, Group Theory, etc., in Mathematics. As I have already pointed out, Mathematics helps one to think, which helps in every area. Therefore, one must allocate time to mathematics, and read and discuss with their peers. Undergraduate students could discuss with highschool students and try to explain things to them.