

CENTRAL SQUARE
FOUNDATION

The Constant & *the* Variable

Conversations with India's MATHEMATICAL MINDS

FOREWORD BY DR. K. VIJAYRAGHAVAN

The Constant & *the* Variable

Conversations with India's MATHEMATICAL MINDS

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Foreword

As I was wading through the different sections of this book, I contemplated what these different experiences coming together might tell us about how we nurture young students in India and what new possibilities are standing in front of us. In the half-century I have spent in scientific research and institution-building, I have strengthened two convictions: Firstly, India's future depends on those who can think deeply, frame problems clearly and persist through uncertainty. This requires patience and intellectual courage. Secondly, raw intellectual potential is far more evenly distributed than is often visible to us. These variables often determine whether curiosity matures into sustained capability or quietly fades away.

We are at a moment when India has stated clear ambitions in science and advanced research. As I have also said during my time as Principal Scientific Adviser, we cannot blindly import scientific excellence. We must collaborate, but also grow it from within. Our institutions continue to grapple with the challenge of systematically identifying and nurturing talent beyond a small set of cities and backgrounds. However, a failure to do so is not inevitable.

The Olympiad ecosystem offers one interesting model for what capacity-building can look like when identification is paired with genuine nurture. While it may also seem counterintuitive that a specific path of mathematical excellence may be able to speak to larger questions of talent, the conversations that follow prove the opposite. These medallists, mentors, coordinators and ecosystem builders demonstrate how deliberate programme design and action can unlock extraordinary trajectories – a lesson applicable across disciplines and spheres.

The accounts here speak to four truths that shape the Olympiad ecosystem more specifically. First, the pathways that emerge from Olympiad participation lead far beyond Mathematics. They cultivate habits of mind that serve individuals across any demanding field. Second, genuine talent exists everywhere. The work is not to create talent but to build the systems around it. Third, these systems require sustained investment: trained mentors, year-round communities, institutional memory and a commitment that extends beyond awards. Fourth, equity is not an afterthought. Regional, gender and linguistic disparities are structural challenges that demand deliberate response.

I commend this book to students, educators, parents and policymakers. But more than that I hope it moves any reader to ask what systems exist in their own context, where the gaps are and what small, deliberate actions they might take to ensure that the talent around them has room to flourish.

Dr. K. VijayRaghavan

Former Principal Scientific Adviser to the Government of India

Thrill and Joy of Problem Solving







There is a special thrill in staying with a hard idea until it finally reveals itself. Problem-solving teaches patience, curiosity and a kind of confidence that grows each time understanding arrives after effort. The joy is not only in the answer, but in the steady work of returning to a problem, trying something new and noticing the moment when clarity begins to form. This feeling, when confusion slowly gives way to insight, is what draws many to Mathematics and keeps them returning to it throughout their lives.

The stories in this theme explore different expressions of that joy. Some find satisfaction in slow, persistent struggle where months of effort lead to breakthrough moments. Others discover delight in the creative process of building solutions from scratch, learning that elegant answers often emerge after messy beginnings. What connects these experiences is the fundamental pleasure of deep thinking: the willingness to sit with difficulty, the patience to try again after failure and the happiness that arrives when a hard problem finally makes sense. This is the reward that outlasts any medal or recognition.

"The real win is not the medal. It is discovering that a problem can move from 'I have no idea' to 'this is beautiful' if you're willing to struggle, ask for help and keep coming back."



Brute Force to Beautiful Ideas: A Conversation with AADISH JAIN

Aadish Jain describes his early problem-solving style as 'hitting every question with a hammer until either it breaks or I do.' It is an honest account of a journey shaped by the absence of coaching or polished techniques and driven instead by stubborn persistence applied to every problem he encountered. From his starting point in Hisar, Haryana, he fought his way to a silver medal at the International Mathematical Olympiad 2025 and is now studying Mathematics at Imperial College London. His story traces curiosity turning into mastery and along the way, he learned that true problem-solving ability is built not only on effort, but also on the courage to think differently.

From Rockets to Real Numbers

Aadish, before your journey at Olympiads and Imperial College, where did the love for Mathematics begin? Did you always know this was your calling?

Not at all. When I was eight, I wanted to be an astronaut. Both my parents are doctors, so they bought me science books and we watched National Geographic all the time. I thought I loved space and Physics, but gradually I realised what fascinated me most were the mathematical ideas hiding behind stories of rockets, space and the universe.

That is quite a shift, from fascination with rockets to a deep engagement with equations. When did your curiosity about solving problems turn into a real conviction?

During the COVID lockdown, while I was in Grade 9 and stuck at home, a YouTube recommendation led me to the 'Essence of Calculus' series. Then came the linear algebra one and in the last video, something clicked. The idea that vectors are not just arrows but abstract objects you can add and scale: suddenly Mathematics felt like a creative world you could build from scratch. That was when I thought, 'This is where I want to spend my life.'

Did you ever feel isolated being a kid who's interested in Mathematics?

Not really. My school, OP Jindal Modern School, Hisar, had a strong academic culture. Students there regularly prepared for JEE and Olympiads. One of my peers, Larissa Goyal, who was

in the same grade as me, represented India at the European Girls' Mathematical Olympiad (EGMO) in 2024 and won a Bronze medal. Seeing someone from my own batch succeed made me feel that I was not alone in my interests and that there was a clear, achievable path for someone like me.

The Late Start

When did Olympiads first appear on your horizon?

I had heard of the IMO vaguely around Grade 9, but I did not take it seriously then. My proper Olympiad journey only began in Grade 11, which, by most standards, is considered late. That is when I learnt about the four-stage selection process to participate in the International Mathematical Olympiad: IOQM, RMO, INMO and IMOTC and decided to attempt them systematically.

When did you begin seeking support from mentors and how did that shape your preparation?

After RMO, I realised that preparing for INMO needed far more structure than I could manage on my own. That is when I began actively seeking support from mentors. I reached out to my mentor, Komal ma'am, who started sending me carefully designed problem sets and introduced me to new concepts. For the first time, I had someone to critique my thinking, not just my final answers, and to take me beyond trial and error. Until then, my problem-solving approach was essentially using the same hammer on every problem. Working with a mentor taught me when to pause, rethink and choose the right tool instead.

The Hammer Years

What do you mean when you say your early problem-solving style was like using a hammer?

What I meant is that in my early days, I was stubborn enough to somehow reach the solution, but I lacked elegance. I had no real strategy for approaching different types of problems. I just used brute force to get there, by hook or by crook. Whenever I encountered a problem, I would attack it head-on, pushing one idea relentlessly until something worked. If a problem needed a screwdriver, I would use a hammer anyway. If it called for pliers, I would still reach for the hammer. I did not know how to step back and think, 'Maybe this needs a different tool entirely.'

That approach helped me in the beginning. It taught me persistence and how to make use of whatever I knew. But over time, I realised I needed to explore the entire toolbox. I needed to learn when to use finesse instead of force, when to look for patterns instead of grinding through calculations, when to change my angle of attack entirely. Mathematics is not just about reaching the answer. It is about finding the path that reveals why the answer makes sense. And that required me to stop swinging the same hammer at every problem and start asking: what does this problem actually need?

When did you realise that persistence alone would not take you further?

At my first IMOTC in 2024. I watched how others approached problems and it was like seeing craftsmen at work. Their solutions were neat, conceptual and elegant. They would see a structure I had missed entirely and solve in three lines what took me three pages of messy algebra. That is when I realised that I had been trying to build a house with just a hammer. It

had gotten me this far, but if I wanted to grow, I needed the full toolkit. I needed to learn not just how to solve problems but how to see them clearly in the first place.

Finding Family at CMI

What was it like walking into your first IMO training camp at CMI ?

It was like stepping into a family. Until then, I was used to studying alone in my room in Hisar. Suddenly, I was surrounded by people who breathed Mathematics the same way I did. Everyone spoke the same language of problems and proofs. The lectures at CMI covered entire branches of Mathematics I had barely touched: graph theory, projective geometry, advanced number theory. I remember sitting in those sessions feeling both exhilarated and overwhelmed. Here was this whole universe of ideas I had not even known existed. And I was terrible at geometry, which made it even more intimidating.

How did that first IMO training camp go for you?

Let's just say I learnt humility fast. In my first practice test, I barely solved one problem. By the second, I had nothing fully solved at all. When the camp rankings were announced, I was near the bottom. It hurt, but it also lifted a weight off my shoulders. I stopped worrying about proving myself or making the team and started actually learning. I began absorbing ideas, asking questions without fear and connecting with others who were struggling just like me. That shift in mindset turned what could have been a crushing experience into one of the most enjoyable and formative periods of my life.

What kept you going after those early setbacks at camp?

It was the people around me. There were late-night problem sessions where we would struggle together over a single geometry problem for hours. Someone would try an approach, hit a wall and the rest of us would jump in with our own ideas. We shared our frustrations openly, laughed at our mistakes and celebrated the small breakthroughs. Those moments reminded me that learning is not linear and that struggle is not something to hide but something to share. The camp was full of failure, yes, but it was also full of joy and that combination of honest struggle and genuine connection made all the difference.

You mentioned that you were 'terrible at geometry.' Tell us about that.

Oh, that was brutal. During the camp, I picked up what was labeled the easiest geometry problem from an IMO shortlist. I drew the figure, stared at it for an hour and had no idea what to do. That was my rock bottom, a reminder that I had much to learn. What pulled me back was a conversation with Rohan Goyal, one of the past medallists and a mentor at the training camp. After one of his lectures, I found him and confessed that I just could not do geometry. He laughed and told me he had felt the same way in his first camp. His advice was to treat geometry as a long-term project, not a verdict on my abilities. That reframed everything for me. It stopped being a weakness I had to hide and became a challenge I could actually work on.

Mentorship seems to have played a key role in your journey. Tell us more about that.

Absolutely. Another instance from camp that I am recalling is when Rijul Saini, the Deputy Team Lead at IMOTC 2024, became my full-time mentor. His genius was not just in solving problems but in choosing the right ones for me: questions that forced me to think differently and see patterns I would have

otherwise missed. What really changed my approach was how he pushed me to value clarity over complexity. After that, every time I solved a problem, I would ask myself, 'Can this be done in three steps instead of thirty?'

You went from struggling at your first camp to eventually making the IMO team. Was there a moment when you realised you were ready?

During a camp test, we faced a problem about maximising a function sum. Most people recognised and reused a neat symmetry idea from a 2016 IMO shortlist. I had not seen it before, so I reinvented the argument from scratch using a clumsy smoothing technique. It was messy but correct. The graders half-admired it for the persistence and half-despised it for the lack of elegance. That day, I realised I had the grit to stay with a problem for hours and wrestle it to the ground. The next stage was learning to refine that raw energy into something more beautiful.

What was going through your mind when you finally won and stood on that stage with the silver medal?

It was not a triumph as much as it was validation. Validation that curiosity and persistence can carry you from a small city like Hisar to the world stage. The medal felt like proof that you do not need a perfect start or years of coaching from childhood. Guided curiosity, stubbornness and the willingness to learn from mentors can beat perfect timing. That realisation meant more to me than the medal itself.

The Road to Imperial College London

Like most Indian students, you also prepared for JEE alongside Olympiads. How did you juggle everything?

It was chaotic, honestly. After Grade 10, I joined JEE coaching and prepared earnestly for it while simultaneously working for Olympiads and applying to universities abroad. I was clear about one thing though: even if I ended up at an IIT, I would study Mathematics, not engineering. Around January of Grade 12, things became clearer. I had a good JEE Mains score, did decently at INMO and received an offer from Imperial College London. Add to that a direct admission to CMI because of my selection to IMOTC and I realised that the traditional engineering path was not what I wanted. Imperial felt like the right place to explore Mathematics full time.

How does studying Mathematics at Imperial College compare to your Olympiad days?

It is both a continuation and a transformation. Now I work with abstract algebra, Hilbert's Nullstellensatz and geometry theories at a much deeper level. The Olympiad trained me for patience and taught me the comfort of sitting with uncertainty. That is priceless in research Mathematics. And yes, I still rely on my old 'hammer method' sometimes. It is still in my toolbox, but now it shares space with screwdrivers and wrenches. There are nights when a problem follows me to dinner and I zone out mid-sentence because an idea has just clicked. My family recognises that look now and they just let me chase the thought.

You have spoken about the huge impact that mentorship had on you. Are you giving back to younger students now?

I try and it feels meaningful. I teach and set problems for the Sophie Fellowship and Online Math Club, both initiatives aimed at training India's top mathematical talent, run by past medallists. Many of our recent IMO successes are due to these community-driven efforts started by past medallists. Passing that forward feels like closing the circle.

Many students feel it is 'too late' if they start after Grade 9 or worry they are not smart enough. What would you say to them?

I started seriously only in Grade 11! At first, I felt far behind those who had been studying for years, but the love for Mathematics and patience to struggle counted more than timing. It is never too late to start learning deeply. And for those who never reach the IMO or even qualify for camp, remember that Olympiad preparation is not only about medals. It trains you to think rigorously and persevere through uncertainty. Even reaching INMO or preparing honestly for it shapes how you approach all learning. *The medal fades, but the mindset stays.*

Some parents worry that Olympiads distract students from boards or JEE. What would you tell them?

Olympiads strengthen logical thinking, which actually makes JEE easier. Once you are comfortable with abstraction, most school-level questions stop looking intimidating. Instead of being a distraction, Olympiad Mathematics deepens how you study everything else. The skills you build by solving hard problems transfer to every kind of learning.

Finally, what can schools and teachers do to nurture more students as problem-solvers?

I believe teachers play a crucial role in nurturing problem-solvers from an early age. They can introduce students to Olympiads, share unusual problems that do not have obvious solutions and normalise the discomfort of not knowing the answer immediately. For a curious student, even a simple suggestion to watch a Mathematics lecture or permission to explore beyond the syllabus can spark something life-changing. Sometimes all a student needs is someone to say, 'It is okay to struggle. That confusion you are feeling means you are learning the right way.' That permission to struggle without shame, to sit with difficult questions without feeling inadequate, can unlock potential that would otherwise stay hidden. Teachers have that power.

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Aadish's journey, from quietly watching calculus videos to standing on the IMO stage and then diving into Hilbert's Nullstellensatz at Imperial College, London, is not a neat 'child prodigy' script. It is the story of someone who began by hitting every problem with the same hammer, then slowly learned to enjoy building a whole toolkit through ugly 15-page proofs, geometry rock bottoms, late-night camp games and mentors who cared as much about clarity as correctness.

FROM AADISH'S CORNER

Q. Let n be a positive integer. A class of n students runs n races, and in each race, the students are ranked from 1 to n with no draws.

A student is said to be eligible for a rating (a, b), where a and b are positive integers, if they place in the top b positions in at least a of the n races. A student's **final score** is defined as:

Score = $\max\{a - b\}$

taken over all pairs (a, b) for which the student is eligible.

Find the maximum possible sum of the final scores of all n students.

Solution: p. 199

"The joy is not only in solving the problem: it is in the work of thinking about it. That moment, when clarity starts to form after effort, that is what makes problem solving thrilling."



A Journey that Began with 13 Marks: A Conversation with ADITI MUTHKHOD

In Grade 9, Aditi Muthkhod learned to appreciate the challenge of problems that resist quick answers. Her JEE coaching environment valued speed and efficiency, but the Pre-Regional Mathematical Olympiad (PRMO) she attempted asked for something different. She scored 13 marks out of 102, barely clearing the cutoff. But this was enough to show her a world where the joy lay in the slow work of understanding. What followed was a wonderful journey: from representing India at the European Girls' Mathematical Olympiad, to now teaching the kind of problem-solving that once changed her own life. Aditi's story is a reminder that a beginning does not have to be impressive to lead somewhere remarkable.

The Problems That Invited Patience

How did Olympiads first enter your life and what was it about those problems that appealed to you?

I was in a JEE coaching centre. One day they asked us to write a test paper for PRMO. I could not solve most of the questions, but I really liked them. They were not those standard questions supposed to finished in two minutes. You had to sit and think. Sometimes something beautiful came out of it, sometimes it did not, but I liked that feeling. Just because I liked that paper, I decided to write PRMO. My JEE environment was not geared towards people who enjoyed taking their time. Olympiad problems gave me permission to do that.

What happened when the PRMO results came out?

I still remember seeing the marks. I had scored 13 out of 102. I thought, obviously, I am not going to qualify. Then I saw the cutoff was 11. I just sat there thinking, "what is happening?" Maybe I am not as comparatively bad as I think. That small difference made me look at myself differently. However, I did not take Olympiads seriously in a planned way just after that. I did not suddenly decide that I must reach a particular stage. I just kept writing each stage because I liked the questions.

From Blank Stare to Quiet Confidence

In Grade 10 you reached INMO and attended the training camp. In Grade 11 you qualified for IMOTC. How did these training experiences shape your understanding of problem solving?

That one week at the INMO camp was crucial. I saw that other people also enjoy these kinds of questions, and there are folks who even do this for a living. It was the first hint that there is a world built around this kind of problem solving. A world where sitting with hard problems and working through them slowly was not just allowed, but it was the whole point. The IMOTC experience in Grade 11 was intense and very joyful. In some ways, it was better for me that it was online because I am usually shy. For one or two months the whole day was filled with classes, problem sessions and late-night discussions. Past Olympians took lectures. Some of them I could follow, some of them I could not, but it was the best learning time I have had. It showed me that there is a community of people who live and breathe this way of thinking.

Was there a particular moment during your training that stays with you?

One memory that stays with me is from a camp where we were learning inequalities. I had never solved inequalities properly before. Every problem looked impossible. With some guidance I started trying. One problem worked, then another and then another. The person teaching was really happy and the professor who saw my solution was also pleased. I was probably the most surprised though. I had gone from 'I have no idea what to do'

to 'I can actually solve these.' I did not know I was capable of that. It was that moment when something that seemed completely out of reach suddenly became understandable. Not because it got easier, but because I stayed with it long enough for the patterns to reveal themselves. That feeling, when clarity begins to form after you have struggled with something, that is what makes problem solving so satisfying. It builds a quiet confidence. *You realise that 'I cannot do this/ is often just 'I cannot do this yet.'*

The Joy of Exploration Over Judgement

How did you approach the EGMO team selection test and what did you feel when you heard you were on the team?

The EGMO test happened later, in December. I received an email saying I was eligible to write it. The exam lasted four and a half hours on two days, which is a lot. I remember thinking it was fine. I would write it. I liked these kinds of problems.

Seven of us took the test, and for some reason I assumed I would finish last among the seven. Later, I received an email saying I had made the team. My first reaction was that this was not supposed to happen. It felt like a mistake.

Later, I spoke to one of the other girls who had also made the team. She told me she had assumed she would be last. Then I spoke to some of the girls who had placed fifth, sixth, and seventh. All of them thought they would be last too.

Many of us had the same story in our heads.

What did you take away from that experience?

You cannot assume you are the best and you also cannot assume you are the worst. You only know what you know. A lot of my decisions were simply based on thinking that there is nothing much to lose except a few hours, so I will write the exam. I did not practice past papers of anything like that. I just wrote because I liked the problems and because it felt like exploration rather than a judgement of my worth. That mindset helped me more than I realised at the time. When you approach problems as exploration, you are free to think, to try things and to stay with ideas without the pressure of proving yourself.

Finding a Place Where Deep Thinking Matters

How did you eventually decide to join CMI and what was your experience like?

I heard about CMI mostly through seniors from the Olympiad side. For example, Anant, who taught at IMOTC, had joined CMI and there were others who had taken that path. I was looking for at least one person who had chosen this route and was in a good place. That made CMI feel real. Initially I applied without seriously planning to go. Then I spoke to seniors at CMI, some people in IITs, some friends. Slowly I realised that I wanted to be in a place where people cared about 'why' something is true, not just that it works. That was very attractive to me.

My first year was online, which was hard for our whole batch. Many of us were used to being among the better students in

school. Suddenly everyone around you is very strong in Math. You do not know the class averages. You do not know where you stand. Courses are difficult. There was also a lot of comparison. You see someone who is very good at a subject and think, "why am I not like that?". It took time for that to settle.

When we finally went to campus, things became better. We realised professors are actually approachable. The workload was still steep, but slowly I could enjoy the courses without constantly panicking about grades. The community was special. People really were breathing and living Math. We would almost talk in Math more than in English.

The Steady Work of Returning to Problems

Did any teacher shape how you think about this kind of patient, persistent problem solving?

Yes, very strongly. One of my professors, for example, taught with so much energy and care that I remember thinking, if I ever teach, I want to teach like this, or I should not teach at all. Watching that kind of enthusiasm at that age and seeing how much time he spent with each student, had a big impact on me. He showed me that teaching is about staying with students as they work through difficulties, about helping them find joy in the process of understanding, not just in getting the right answer.

Today you are teaching Mathematics yourself. What message would you give to a student who feels problem solving is 'not for them'?

It is not written anywhere what is for you and what is not. If you like problem solving, you are allowed to make it a part of your life. The problems are not supposed to be easy. They are meant to challenge you. But that does not mean they are not for you. Try the exam even if you are unsure. Think of it as exploration, not as a verdict on your ability. There is often very little to lose and there is a lot to discover about yourself.

What would you say to someone struggling with a difficult problem right now?

Stay with it. Return to it. Try something new. The joy is not only in solving the problem, it is in the work of thinking about it, in noticing small patterns, in that moment when something that was completely unclear begins to make a little sense. That moment, when clarity starts to form after effort, that is what makes problem solving thrilling. And each time it happens, you build a quiet confidence. You learn that hard ideas can reveal themselves if you give them time and attention.

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Aditi's journey began with problems that asked her to slow down and think. A test she barely qualified for led to camps, communities and a life built around the joy of deep thinking. Along the way, she discovered that the thrill of problem solving lies not in speed or in always knowing the answer, but in the patient work of returning to hard ideas until they finally reveal themselves. Her story reminds us that there is a special happiness in staying with a difficult problem, in trying something new when the first approach does not work and in noticing that moment when clarity begins to form.

FROM ADITI'S CORNER

Q. Fermat's Little Theorem states that if p is a prime number and a is an integer, then $a^p - a$ is divisible by p. That is:

$a^p \equiv a \pmod{p}$

Provide a combinatorial proof for this theorem.

Solution: p. 200

"You don't need to be fast. You only need to be willing to come back tomorrow. Most good ideas arrive slowly."



Chasing Gold, Finding Play: A Conversation with KANAV TALWAR

When Kanav Talwar opened 'Euclidean Geometry in Mathematical Olympiads' during the COVID lockdown when he was in Grade 7, the first problem stopped him cold. He closed the book in frustration, convinced that it was beyond him. Months later, however, he solved it. *'At that point, I was like, this is it. I am not leaving this. I love this.'* That stubborn persistence would take him to two consecutive gold medals at the International Mathematical Olympiad in 2024 and 2025, making him one of the most promising young minds in India's Mathematical ecosystem.

The Art of Perseverance

What was it that first drew you toward Math as a subject and then to Olympiad-style problems?

I do not remember a time when Math was not around. My sister is four years older than me and at IIT Bombay now. When she was in school, she used to do Math Olympiads, so I knew about their existence early on. She also helped me prepare for my own competitions. She would guide me, telling me 'do this now, do that now.' The whole environment at home was always centered around studying. It did not create pressure, however. It was the way things always were.

My father is the kind of person who would open Math problems anywhere. I remember one time when we were in a hospital waiting room and he pulled up some website with thousands of Math questions. I remember starting in Grade 3 or 4 with problems like 'find the last digit of 32^{100}.' He would do this at any place where we had to wait. We would just sit there and work through Math problems.

What excites you most about solving mathematical problems like this?

There have been a few moments for me which really stand out in terms of that excitement. I remember it was during the pandemic, when out of boredom, I picked up this famous book, 'Euclidean Geometry in Mathematical Olympiads' by Evan Chen. The very first problem in that book was something I kept coming back to for months before I finally solved it. I still remember the diagram I drew. It was a big oval because I was bad at drawing circles back then. I remember my position sitting on the chair. Everything about that memory is still clear in my head.

I remember that there was also a nine-point circle problem. I had heard about it in Grade 6 and did not understand what it was. When I first saw a proof for it, it was too long and complicated for me to grasp. But in this book, there was a one-line proof. I was absolutely awestruck. I stared at the diagram for a good 10 minutes. What made it even better was that each of the nine points on the circle had different proofs and I had done all those proofs two months earlier. Everything just came together in that one diagram.

That was the real point when I went all in on Olympiads. This was in Grade 7. That feeling of everything clicking into place... It is a core memory.

Failures as Stepping Stones

Winning gold at the IMO two years in a row is extraordinary. How was the journey towards this success and what have been your takeaways from it?

In 2022, I gave my first IOQM. It was a peculiar year, since because of the pandemic, IOQM, INMO and the team selection test all happened in one exam on March 6th. I still remember the date. I went in hoping to make it to the top 60 and I ultimately ended up missing the IMO team by just three points. I was not even aiming to make the IMO team. I thought it was too hard. But that near-miss made me realise: I can probably do this. So, of course I remember the date.

In 2023, I made it to the IMOTC, which turned out to be the best 21 days I have probably ever had. We did not sleep more than five hours on any day. We would stay up till 2 a.m. playing social deduction games like Mafia and Avalon, then wake up for morning classes. It was an absolutely wonderful experience.

But then the final selection tests did not go well. I came ninth. The top six make the team.

How did you handle moments such as this, where you fell short of your goals?

I was obviously sad. I did not come out of that feeling pretty easily. It took time. I eventually realised that I don't have to do Math all 24 hours like I used to in Grade 7. I can chill. I can play basketball. I can take breaks. I realised the biggest problem in contests is panic and exam pressure. That really got to me in 2023. I used to watch the clock every minute, because I felt that I needed to think fast.

Then, I tried not watching the clock, but that did not work either. I would lose track of time. My parents put this big clock right in front of me so anytime I looked up, I had to see it, to help me get over my fear. Eventually, I got over those issues. By 2024, I was a lot calmer. I knew I could make it to IMO. I just had to remember not to stress out.

Let us dive a bit deeper into the competition day experience itself. Can you tell us how your experience at the IMO was?

I think the best part is that IMO itself is barely about the contest. The contest happens in the first two days. After that, I got a chance to interact with people from all over the world and bond over a shared love for Math. In 2025, for instance, we ended up gaming with teams from Australia, Luxembourg and Canada. I also prefer IMO's format over other competitions: four and a half hours, three questions. I like to think peacefully and this suits me perfectly.

I am happy for the failures that ultimately brought me here too. They had a big influence. The 2023 failure is why I succeeded in 2024 and 2025. There have been lots of ups and downs and I used to want to erase the downs. But now I realise it is okay to have those downs.

Well-Being and Learning Differently

You spoke about the importance of balancing pressure through enjoyment and especially about your love for games. How did you develop this balance during your journey and has it impacted the way you approach problem-solving?

In Grade 7 and 8, I used to think about Math 24/7. I later realised that I cannot do that forever. I got tired in Grade 9. Now, I have a very dynamic schedule. There are days I do not solve a single problem. I also switch between subjects: combinatorics, then algebra, then geometry. I want to have a fresh mind when I am thinking about a problem.

Regarding gaming, I actually have a very interesting story to share. I watch my school friends play a lot and something I have realised is that they do really complicated calculations in just two minutes when they are gaming. However, if I ask them to solve a simple linear equation, they believe it is too complicated. People think they're not 'Math people' because of how the subject is conventionally approached. The problem is that studying for exams often becomes about memorisation and you cannot get away with just memorisation in Math. You need to understand what is really happening. So, even through gaming, you are actually always calculating and problem-solving!

You are certainly a firm believer in learning by doing. Do you feel like some theoretical grounding in a formal setting is necessary as well, or would you lean more towards other methods of learning?

Theory is definitely valuable, but here is the thing: you can

come up with it yourself. As you solve Olympiad problems, you learn how to build theory on your own. If instead of memorising formulae, you understand the idea and then derive the formulae yourself, it feels like you are inventing something. And if you are inventing something, that is exciting!

This is also probably why I especially love geometry. I can just close my eyes and visualise diagrams, play around with angles and introduce new elements.

My own journey has definitely been heavy on unconventional learning techniques, sometimes born out of stubbornness. I remember developing this knack for problem solving through games very early on. For example, my father taught me how to solve a 3x3 cube in first grade. Then he bought me a 2x2 cube. I told him, 'No, I am going to solve the 2x2 myself. Do not teach me.' I spent a week trying to figure it out on my own. I did not solve it in the end, but I just refused to give up or look at the solution.

Paving the Path Ahead

Beyond competing, you are also involved in teaching Mathematics. Tell us about your journey with the Sophie Fellowship, from being a student to now being the director.

I was a Sophie student in 2021 and learned a lot from the experience. I found a community there and made friends with whom I could talk about Math. I would play Mafia with my friends from Sophie every night. That experience significantly shaped me, and I wanted to give back. Sophie actually helped me start teaching. I gave my first lecture at the Online Math Club through them. It gave me confidence. I felt that it was important for me to become a part of these initiatives, because

a lot of concepts are not really explained well anywhere. It is also hard to learn from books alone. I learned through experiences, through struggle. Now I can share those ideas and experiences with others.

The Olympiad community stems from current medallists who help the next generation. You will probably interview them in a few years!

How do you imagine Mathematics fitting into your future? Is it a curiosity, career, or lifelong passion?

Right now, I am just focusing on solving problems that look interesting. I want to study Math and Computer Science in college, but beyond that, I do not know. I did not expect five years ago that I would be doing Olympiads. Something interesting might come up when I am in college, which I will dive into. Who knows what the next five years will bring? I might end up doing something completely different.

I think the biggest thing I have learned is that you do not have to have everything figured out. I went from being a kid who could not solve the first problem in a book to winning two IMO gold medals, but there was a lot of failure in between. The maturity I got from Olympiads is my biggest takeaway. It taught me to handle pressure, to balance, to think deeply, which is what matters. Whether you end up in research, tech, or anywhere else, those skills stay with you.

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Kanav Talwar is currently in Grade 12 at DPS Faridabad, where he studies alongside a thriving community of young mathematicians shaped by the school's deep roots in Olympiad culture. His story is a testament to his philosophy: Mathematics is fundamentally about thinking, inventing and play. When he looks ahead to college and beyond, he carries no rigid plans, only the certainty that Mathematics has rewired how he thinks.

FROM KANAV'S CORNER

Q. There are 100 chests, each containing some amount of gold and silver coins. Show that it is always possible to select 51 chests such that they contain at least half of the total gold coins and at least half of the total silver coins available in all 100 chests combined.

Solution: p. 201

'If you can find a way to enjoy being confused in front of a problem, then over time the same problem will start feeling like home and that feeling is worth far more and lasts longer than any medal.'



When the Waves Whispered the Idea: A Conversation with DR. PALLAV GOYAL

On a Californian beach, a mathematician from Bhilai jumped in sudden realisation, as the idea that had eluded him for months finally clicked into place. That 'eureka' was not just about solving a research problem but marked a journey that had begun many years earlier in a small-town classroom, with borrowed textbooks and newspaper puzzles. From finishing last at his first national training camp to eventually winning an International Mathematical Olympiad medal for India, Dr. Pallav Goyal's story traces how curiosity outlasts failure and how persistence stitches small moments into breakthroughs. His path reminds us that the real joy of problem-solving lies not in rank lists but in those thrilling seconds when an idea finally reveals itself.

The Power of a Childhood Label

Dr. Pallav, looking back now, where did Mathematics truly begin for you? Not as a school subject, but as something that became part of who you are?

For me, it started with something very human and very simple: as a five-year-old, I was told I was 'good with numbers,' and that line stuck deeper than anyone around me probably realised. Every time my parents or relatives repeated it, it became both a source of comfort and a gentle pressure. I felt seen and I also felt that doing more Mathematics was a way to live up to that image. Growing up in Bhilai, without a strong Math culture around me, that simple label became my anchor.

I had no grand plan. I did not even know what RMO or IMO were. When my school told us that there is an exam called RMO, I went in with curiosity, not a dream of international medals. Only after clearing the first stage did I discover the next, like climbing a staircase I did not know existed. Emotionally, it felt less like chasing recognition and more like discovering the quiet beauty of problem-solving itself.

Once that label took root, how did you begin learning Mathematics in a small town without a strong local Olympiad system?

It felt a bit like trying to assemble a puzzle in the dark, using whatever pieces I could access. There were no specialised Olympiad classes in Bhilai, so I clung to NCERT books, older editions, ICSE texts, practice handouts, anything that had problems at the end of a chapter. Those were not glamorous

resources, but they were mine and I squeezed as much as I could out of them.

I spent long stretches with NTSE-style mental ability questions, newspaper puzzles from Dainik Bhaskar and Sudokus that no one around me took very seriously. On the surface, I looked like a kid passing time; maybe that was indeed the case. But at the same time, I was exploring a world that gave me pure joy, without much consideration about what my final goal was.

When did solving puzzles start turning into the deeper art of writing proofs?

Proofs initially felt mysterious to me. I never had a formal course in proof writing; I absorbed their rhythm by listening carefully to teachers at IMO training camp, rereading arguments and explaining my own ideas to friends.

The emotional turning point came when I realised that explaining a solution to a friend is, in essence, practising proof writing. Convincing myself had always been easy, but convincing someone else meant facing interruptions, questions, doubts and sometimes even blank stares. Those awkward moments were frustrating, yet they gradually taught me that a proof is not only about being correct; it is about being understood. That realisation made the process feel less intimidating and far more personal.

Training Camps, Rankings and a Sister's Belief

When you first entered the camp after clearing the RMO and INMO, what was that experience like?

My first IMOTC was a mix of excitement and fear. It was my first time living away from home for a whole month and I walked in thinking of myself as 'the Mathematics kid' from Bhilai. Then, very quickly, I met people who were solving problems that left me completely awestruck. When the first camp results put me at the bottom, 49th out of about 50, it felt like the floor shifted a little under my feet.

The second year was even harder: finishing dead last was not just a statistic, it felt like a verdict on my skills. I still loved the daily classes, the problem sheets, the late-night blackboard sessions with friends, that part of camp was pure joy. But in the quiet moments before sleeping, I often lay in bed wondering if Olympiads were a world I was trespassing in. It was painful to hold both truths at once: 'I enjoy this deeply' and 'maybe I am not meant for this.'

What helped you hold on long enough to turn that story around by your third attempt?

The emotional bridge between those two worlds was my elder sister. At a time when my parents understandably found a 'Mathematics career' abstract and risky, she looked at me and somehow believed that I meant it when I said, 'I want to do Mathematics.' That belief felt like someone quietly standing beside me when I was not sure I deserved it.

By my third camp, after Grade 12, I went in with almost no expectation of making it to the team. I told myself it would be a one-month break from JEE, a chance to breathe and do Mathematics for the simple reason that it made me happy. The pressure of 'I must make it to the team' had burnt me out before, so letting go of that was emotionally liberating. When I ended up ranking second that year, it was not just a result; it was a deep relief and a testament to the fact that perseverance pays off.

What was the experience like when you reached the IMO stage?

Walking into the IMO as a first-timer, along with five other first-timers on the Indian team, felt surreal. There was pride of course but also a very real fear of disappointing the faith that so many people had placed in me. Ironically, I failed to solve Problem 1, the 'easiest' one on paper and that stung. But then I managed to solve some of the harder problems and seeing the final score stirred up an emotional blend of gratitude, disbelief and a certain humility.

Problems You Can Carry in Your Head

You have said you like problems you can 'carry in your head.' What does that mean for you?

For me, the best problems are like quiet companions. They sit with me when I am walking alone, ride with me in the car and occasionally intrude during conversations I am only half-present in. Algebra and combinatorics, more than geometry, lend themselves to this kind of mental wandering; I do not need diagrams, just a few key ideas turning over and over in my mind.

There's a kind of comfort in living with a problem for months, encountering dead ends I can't quite abandon. And then, sometimes, after all that circling, a proof emerges where every line feels essential, the central insight sharp and clean. It is like suddenly seeing the path through a maze I had been navigating, the route that was always there but invisible until that moment.

That is such a tender way to describe mathematical thinking, like carrying a friend around. Let's come to that day on the beach. What did that 'eureka' moment actually feel like from the inside?

That day, I went there looking to rest. My wife was in the water, enjoying the waves and I was sitting on the shore, supposedly relaxing. But somewhere in the background, a research problem I had been wrestling with for months kept looping in my mind, a problem I could not stop thinking about, no matter how hard I tried to.

My wife turned around and in the space of a heartbeat, saw me go from sitting still to literally jumping up on the shore. Inside, it felt like a knot that had refused to loosen suddenly snapping open. One key idea fell into place, not the full solution, but a clear path and I knew, with a kind of certainty, 'This is going to work.'

When we drove back, there was a mixture of excitement and almost childlike joy. That beach, for me, has become a symbol of what I love about Mathematics: if you live with a problem long enough, it sometimes rewards you at the most unexpected moments, turning an ordinary afternoon into a memory you will carry for the rest of your life.

School Math and the Stories We Do Not Hear

As someone who cares deeply about Mathematics, how do you feel about the way it is taught in schools?

Even as a student, I could sense when a teacher truly loved

Mathematics and when they were just moving through a syllabus. The inspiring ones made me feel seen, as if the subject had depth worth exploring. Others, though well-meaning, left me frustrated, aware that they knew more than me, but unable to connect what they knew to what I was feeling when I did Math.

Take Euclidean geometry. We were taught axioms and theorems, but almost never told the story that this was humanity's first grand attempt at large-scale, systematic deductive reasoning. If someone had looked us in the eye and said, 'This is where the idea of proof really took off in history,' that narrative might have lit a spark in many students, not just the already motivated ones. Emotionally, I still feel that our school system underestimates how much a good story can change a student's relationship with a subject.

Looking at India's larger Olympiad ecosystem, how do you feel about its current shape?

At the very top, places like IMOTC feel world-class; the teachers there are genuinely inspiring and being in that environment can be life-changing. It is a place where you feel that your love for puzzles is not only understood but celebrated. The problem is how few students ever get to feel that.

In countries with Mathematics circles and broad participation, there is a sense that if a child shows curiosity, someone will catch it and nurture it early. In India, a lot of students talented in Mathematics or problem solving never meet the right mentor at the right time. For me, that is the saddest part: not that the peak is low, but that the base is narrow and so many stories like mine never get the chance to reach their own 'beach eureka' moment.

From Olympiad Training to Research Mathematics

How did this whole journey shape the way you now do research and see your peers' paths?

Olympiads nudged me towards algebra and combinatorics, where research problems often feel like grown-up versions of the puzzles I loved as a teenager. That continuity is emotionally comforting; it feels like I did not abandon the child who enjoyed puzzles, I simply gave him more sophisticated toys.

Among my peers, I have seen many drift towards physics, computer science and other fields, but there is a common thread: a preference for environments where curiosity and problem solving are valued. In that sense, Olympiad training is less a medal factory and more a way of shaping how you relate to questions, uncertainty and effort for life.

For students who look at your journey and only see the medal, what would you want them to know?

If there is one truth in my story, it is that enjoying the act of problem solving consistently matters far more than enjoying the feeling of being seen as a 'winner.' I have ranked last at camp, been rejected by universities and spent months stuck on problems that refused to budge. None of those failures show up in a neat list of achievements, but they are woven into every success.

When you compare yourself to others, you almost always feel behind. When you compare yourself to who you were two years ago, you often find quiet progress that no one else can see. The beach moment did not happen because I am special.

It happened because, for years, I kept walking around with my problems in my head even when they made me feel small. If students can fall in love with that process, the struggle itself becomes the reward. Medals and ranks might come or they might not, but the ability to think deeply, to persist through confusion and to find beauty in hard problems stays with you forever. That is the real prize.

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Dr. Pallav's journey, from piecing together NCERTs and newspaper puzzles in Bhilai to leaping off a Californian beach with a research idea finally in place, is not the myth of a smooth genius arc but the story of someone who kept showing up even when every leaderboard told him he was out of his depth. It is held together less by rankings and more by small choices: to return to camp after finishing last, to treat JEE preparation as a detour rather than a destiny, to carry algebraic problems in his head on walks, drives and long flights until they quietly unfolded.

FROM DR. PALLAV'S CORNER

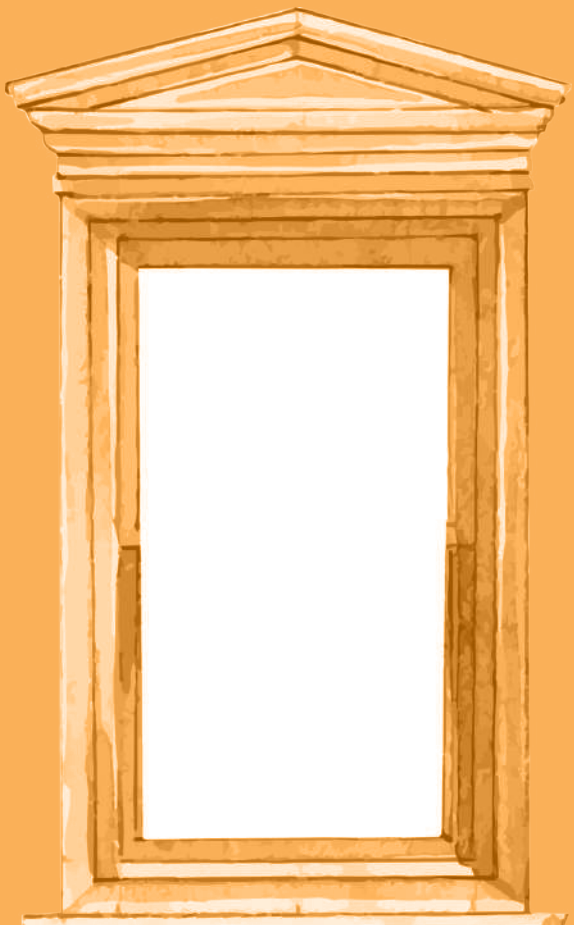
Q. Suppose we have tools that allow precisely the following two geometrical constructions:

1. Given any two points A and B, draw a line passing through A and B.
2. Given a line ℓ and a point A on ℓ, draw a line perpendicular to ℓ passing through A.

Suppose we are given a line ℓ and a point A **not** on ℓ. Use the above operations to construct a line perpendicular to ℓ passing through A.

Solution: p. 202

Gateway to opportunities



Mathematical Olympiads open doors that may not be immediately visible to students. Participation can create pathways to institutions, mentors and academic communities that might otherwise remain unknown. Recognition through competitions creates tangible opportunities: admissions, scholarships, networks and the confidence to pursue mathematics as more than just a school subject. What begins as curiosity about problem-solving can lead to research careers, international collaborations and diverse professional paths that value mathematical thinking.

The stories in this theme explore how Olympiad experiences become turning points, not just through medals but through such pathways and the self-belief they create. They show how competitions serve as bridges between classroom learning and advanced mathematics, how the networks formed during preparation often last into professional life and how the skills developed through problem-solving open unexpected doors across fields and even beyond mathematics. What emerges is a picture of Olympiads as more than contests: they are gateways that transform how students see their own potential and what is possible in their future.

"The gateway is open. The challenge now is making sure every deserving student can walk through it. Olympiad Mathematics is a gateway to a world of possibilities and widening that gateway is an opportunity India must seize."



From One Book to Princeton: A Conversation with SUPRAVAT SARKAR

When a young PhD candidate at Princeton University traces the roots of his mathematical journey to a single book, there is a story worth telling. Supravat Sarkar's path from a Bengali-medium school to winning a Bronze Medal at the International Mathematical Olympiad (IMO) in 2016 and later doing research at Princeton, one of the world's leading Mathematics institutions, illustrates how Olympiad Mathematics can create remarkable opportunities.

The First Spark

Supravat, you have had a remarkable Olympiad journey, from an Honourable Mention at IMO 2014 to a Bronze Medal at IMO 2016. Let us start with the roots. When did you first realise that Mathematics was more than just a school subject for you?

The roots of my passion for problem solving were planted much earlier than I understood. My father, a Physics professor with a deep enthusiasm for Mathematics, would challenge me with intriguing puzzles from advanced classes even when I was in Grade 4. These were not typical textbook exercises; they were real problems meant to spark curiosity and encourage deep thinking. Through these problems, he nurtured my fascination with Mathematics. Instead of memorising multiplication tables, I was solving puzzles, uncovering patterns and exploring logic. That is when I discovered that Mathematics could be not just studied, but truly enjoyed.

How did you discover this world of competitive Mathematics?

I heard about Olympiads in Grade 8 but became serious in Grade 9. Interestingly, I had only one book, 'Challenge and Thrill of Pre-College Mathematics'. I had no coaching and relied only on this book and previous years' questions. With fewer resources, I was forced to focus more sharply and understand every problem deeply.

That must have shaped how you approached the Regional Mathematical Olympiad (RMO) and everything that

followed. What changed after you cleared your first major exam, the RMO?

Clearing the RMO was transformative. I was invited to Indian Statistical Institute, Kolkata's training camp and met other students who were passionate about Mathematics. That was incredibly important. When you are good at Mathematics in school, you often feel isolated. Nobody understands why you find these problems beautiful. But at ISI, I suddenly met students who had also cleared the RMO and were preparing for the nationals. The professors were genuine; they were not just teaching but sharing their love for the subject.

Finding a mathematical community seems to have been crucial in your journey. Can you share more about your experiences with mentorship in these spaces?

After the INMO training camp at ISI, I attended a few sessions at the Ramanujan School of Mathematics, which is run by students of ISI Kolkata for high school students interested in Mathematics. These sessions were invaluable. Mentors like Sayar Karmakar and Ujan Gangopadhyay encouraged us to look beyond competitions and engage with Mathematics as a discipline that could sustain a lifelong journey.

You would have met some of your heroes during national camps as well. What was that experience like?

That feeling was truly surreal. After clearing the INMO, I attended the IMO training camp in Mumbai, where we were taught by the very authors of the only book I had studied before RMO, 'Challenge and Thrill of Pre-College Mathematics': B. J. Venkatachala, C. R. Pranesachar and K. N. Ranganathan. I had spent months immersed in their problems and suddenly, they were teaching us in person. It was hard to believe.

My first IMO was in 2014 in Cape Town, where I received an Honourable Mention. Two years later, I won a Bronze Medal in Hong Kong. Along the way, I met deeply passionate students who shared a love for the thrill of problem solving and honestly, it was never about the medal.

Olympiad training teaches patience and persistence. It helps you become comfortable with not knowing the answer, with sitting through uncertainty and with struggling on a problem until a genuine idea emerges. That comfort with struggle is a skill you carry for life.

Beyond the Medal

Your Olympiad successes opened doors, but it seems the biggest impact was personal development. How did these opportunities change your academic trajectory?

For me, the Mathematical Olympiad experience greatly influenced me. Olympiad training helped me develop strong problem-solving skills, which are essential for research. It exposed me to advanced Mathematics early, led to admission at Indian Statistical Institute, Kolkata without a written test and enabled my growth in my higher education. But, the deeper change was in how I approached problems. Olympiads teach you to think independently and that is the essence of research. That is the compound effect of early problem-solving training.

Olympiad achievements are recognised more widely now. How is the perception of these competitions evolving across India?

When I started, Olympiad awareness was mostly limited to big cities and a few schools. Today, media and government

initiatives have improved awareness and more institutes value Olympiad success in admissions. Chennai Mathematical Institute (CMI) offers direct admission, Indian Statistical Institute (ISI) waives written test. Globally, Ivy League colleges look for IMO medallists. The medals are not just awards. They are gateways to opportunities.

Indian IMO teams consistently win medals now, but outreach to smaller towns is still needed. Wider recognition will encourage more students to see Olympiads as a real pathway.

Beyond the IMO, were there any other competitions which contributed to your trajectory?

Competitions like the Madhava Mathematics Competition, KVPY and the Asian Pacific Mathematical Olympiad exposed me to new ideas, broadened my problem-solving skills and connected me with a wider community of Math enthusiasts. These contests build confidence and spark interests beyond standard topics.

A World of Opportunities Opens Up

If opportunities are gateways, accessibility is the key. What can educators and institutions do to support students from smaller cities or non-traditional schools?

Change begins in schools. Teachers should encourage Olympiad participation and introduce non-routine problems. Outreach programmes, inclusive summer camps and online resources matter, especially for students far from major cities. Materials

in regional languages and alumni sessions can demystify the process for under-resourced students.

You have experienced both Indian and global Math ecosystems. What differences stood out?

Systems abroad, like in the United States, offer flexibility. Students can study courses that match their interests and are encouraged to take part in research as undergraduates. Math circles and clubs nurture talent early. India's pathways are more rigid, with wider academic requirements. If we introduced more electives and recognised Olympiad achievements more widely, many more students would thrive.

You have experienced both Indian and global mathematical ecosystems. What practices stand out that can help India strengthen its support for young talent?

India would benefit from expanding Math outreach circles, regional clubs and consistent mentorship from alumni. Admission routes like supernumerary seats for Olympiad medallists at premier institutes like Indian Institutes of Technology (IITs) and Indian Institutes of Information Technology (IIITs) should be better publicised and broadened. Scholarships and platforms connecting international and Indian mentors would help underrepresented students pursue higher studies and research.

Olympiad training opens pathways in academia, industry, technology and finance. Many peers work in top research roles, at companies like Google, or as entrepreneurs. The real asset is the problem-solving mindset. Olympiad alumni excel in data science, quantitative finance and many other fields. The confidence and network gained through these experiences create versatility.

Many students are not aware of international research programmes, conferences and Olympiad-focused scholarships. Platforms like Art of Problem Solving and Stack Exchange help students build global skills and networks. Making these pathways more visible would help connect Indian students to a broader ecosystem.

What do career pathways look like for participants who may not win medals?

Participating in Olympiads helps students build critical thinking, patience and confidence. It teaches them to tackle unfamiliar problems. Qualifying for national stages like the Indian National Mathematical Olympiad (INMO) opens doors to institutions such as Indian Statistical Institute, Kolkata and Chennai Mathematical Institute. Even students who do not win medals often get into top colleges through entrance exams because they develop strong analytical skills along the way. These skills continue to help them throughout their lives. The Olympiad journey itself is deeply rewarding.

Walking Through the Gate

What message would you give to students who dream of following a path like yours?

Try to love Mathematics for its own sake. Do not do it only for an exam. Think of it as solving puzzles or playing a game. If you enjoy it, it will feel natural. Do not get discouraged by failure. Sometimes it is just not your day. The next problem might be the one that clicks.

I am sitting at Princeton, working on problems that fascinate me, surrounded by brilliant minds, with opportunities I could

not have imagined as that Grade 9 student with one book. More than anything, I developed a way of thinking that helps me everywhere. That is the real reward.

Parents also worry that Olympiads may distract children from traditional studies. How would you respond to this concern?

I never prepared separately for the Joint Entrance Exam (JEE). Olympiad preparation helped me with it. Once you learn to think logically, JEE problems become much easier. Olympiad training sharpens your intuition and sometimes you can eliminate wrong options just by reasoning through them. That is the kind of thinking Olympiad preparation builds. It is deep, logical and creative.

Olympiads are not distractions. They train in clear thinking and creative problem-solving. Whether you go into research, engineering, or any other field, those skills stay with you. Instead of seeing Olympiads as an alternative, it is important to realise that they make many other pathways, including engineering, STEM research, finance and technology, easier.

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Supravat's story, rooted in a single book, strengthened through mentorship and culminating at Princeton, is not just about individual achievement. It shows that with the right spark and support, Mathematical talent can emerge anywhere and go anywhere.

FROM SUPRAVAT'S CORNER

Problem: For $j = 1,2,3$, let x_j, y_j be non-zero real numbers, and let $v_j = x_j + y_j$. Suppose that the following statements hold:

1. $x_1 x_2 x_3 = -y_1 y_2 y_3$
2. $x_2^1 + x_2^2 + x_3^2 = y_2^1 + y_2^2 + y_3^2$
3. v_1, v_2, v_3 satisfy the triangle inequality.
4. v_2^1, v_2^2, v_3^2 also satisfy the triangle inequality.

Prove that exactly one of the six numbers $\{x1, x2, x3, y1, y2, y3\}$ is negative.

Solution: p. 203

"The fact that you have learned to appreciate Mathematics will play a huge role for you, perhaps much bigger than the fact that you have actually qualified the exam."



Evolving A Mathematical Mindset: A Conversation with DR. VAIBHAV VAISH

Over two decades ago, Dr. Vaibhav Vaish stood on international stages representing India at the IMO, earning silver medals in Romania and Korea. Today, he shapes Mathematical talent in India as an Assistant Professor at the Indian Institutes of Science Education and Research (IISER), Mohali. He also serves as the Chief Examination Coordinator for IOQM. His journey reveals how Math Olympiads serve as gateways, not just to prestigious institutions, but to diverse pathways, deeper understanding and the confidence to chart unconventional journeys.

A Different Time

Vaibhav, you have been a part of the Olympiad ecosystem in India for over two decades. What is something that was significantly different when you were a student?

Back when I was a school student, there was no Pre-Regional Mathematical Olympiad (PRMO) or Indian Olympiad Qualifier in Mathematics (IOQM). I participated in the RMO in 1998 and qualified the Indian National Mathematical Olympiad in 1999. The same year, I represented India at the International Olympiad in Romania and then Korea the following year. Both years, I won silver medals, which gave me a lot of confidence.

Things were certainly quite different back then. When I prepared for the RMO, I had a list of 20 books to look for but not a single one was available. Some cities had better ecosystems, but for most of us, if you wanted books from institutes like Bhaskaracharya Pratishthana, you had to send them a letter with a demand draft and the book would come to you. Additionally, when we reached Olympiad camps, there would be books. These were photocopies of photocopies passed down through the years, from someone who had found that book somewhere!

In terms of access, therefore, things have certainly improved quite a bit with internet access. The lack of quick access to solutions had an unintended benefit, though; we were forced to think deeply. You take a problem, you do not know how to solve it, no one around you knows, there is no book to refer to. I do not know if that kind of deep engagement happens as much today, but it was a tremendous learning exercise.

Changing Direction

After such success in Mathematics, you chose electrical engineering at IIT Kanpur. What drove that decision?

The common path for people with my rank would have been computer science. But I was drawn to the idea of working with circuits, designing things with your hands. Robotics really appealed to me.

But during those four years, I realised something crucial: I was probably better at theory than at hands-on work. It is much harder to get something working by hand than to get it working on pen and paper. I suspect if I had chosen Computer Science, I might not have shifted back to Mathematics, because the flavour would have remained similar.

You spoke about gaining confidence in your mathematical ability through your participation in IMOs. Did that confidence persist even during your undergraduate degree?

Absolutely, it did. The reason I felt sure of shifting back to Mathematics was that I had done something which gave me a lot of confidence during my Olympiad days. After qualifying for the IMO and winning medals, I felt that I was good enough in Mathematics, even if it may have been unfounded confidence back then. If I had not participated in the IMO, I am not entirely sure if I would have returned to a subject I had not done anything with for four to five years.

Charting the Path Back to Mathematics

Could you tell us more about the process of navigating your return to Mathematics?

I took a year-long break after my undergraduate study. I was confused about what to do with life, which I think is fair. I did not want to go abroad for various reasons. I looked at what I could do reasonably well in the country. The Tata Institute of Fundamental Research (TIFR) seemed like a good option and that was the only exam I wrote. I had no backup options when I shifted to Mathematics. This is not to say that there are no other avenues in the country, but in my view, science ecosystem in India isn't very visible, especially from an engineering student's perspective.

Does having an Olympiad background create concrete opportunities and ease such shifts between fields?

I have noticed that it is only later when students reach college and sit for placements that they realise the value of an Olympiad certificate. We receive many emails asking for certificates from years back. They realise it serves as a useful asset especially with finance companies that signify it as a sign of potential.

It did provide a launch pad for me as well, but not in the Mathematical journey directly. In my undergraduate years, I got a fellowship which paid for my education. Otherwise, I would have taken an education loan. The scholarship likely came partly because people saw the bullet point of being an Olympiad medallist on my resume. I was also in the first batch of Kishore Vaigyanik Protsahan Yojana (KVPY) fellows who were awarded the fellowship based on our Olympiad participation.

Inside the Research Ecosystem

Once you began your research at TIFR, how did the Olympiad background impact your journey?

The Olympiad background helps you appreciate how concrete many abstract things really are. Think about Minkowski's[1] geometry. Most people encounter it when they study algebraic number theory, so they see it as a tool for building connections there. But I saw Minkowski's geometry in *Mathematical Gems* as a fun problem. It was stated in language you could approach back then. If you have not done enough problem-solving, you do not realise these connections. That concrete understanding really helps.

Were there also downsides to the Olympiad mindset in advanced research?

That is a fair question. Some faculty at TIFR were actually somewhat dismissive of Olympiads. They felt it gets you in a certain frame of mind where finding the solution to a problem becomes more important than identifying structures underlying it, which may lead to deeper Mathematics. I think they have a valid point that should be acknowledged.

In research, particularly in algebraic geometry which I work in, the key is not just problem-solving. You try to understand something well enough so that the solution reveals itself. That is much harder and a different process altogether. Good mathematicians have a knack for picking the right structures, not just solving problems.

[1] Hermann Minkowski (1864-1909) was a mathematician best known for describing spacetime as a four dimensional space

You have worked as a postdoctoral fellow at the École Normale Supérieure de Lyon and the University of Zurich. What did these international experiences reveal about mathematical education in India, if anything?

One thing I observed in France is that there is more continuity between school and university teaching. In the same classroom, you will find Pythagoras' theorem and algebraic geometry being discussed, though we may consider the former to be more foundational, and the latter advanced. That continuity is important. I also appreciate the fact that engagements are open-ended. It is not just one-hour lectures. You are thinking about a problem and engaging with it deeply.

But here is what I have realised: these differences are not just about discipline-specific practices. Our universities and institutions can sometimes feel like 'spaceships.' They are gated communities with everything inside, somewhat alien to the society around them. There is certainly a need for reform in this space, which must begin with a much larger conversation about how we can build connections differently.

Shaping the System

You have now served as the Chief Examination Coordinator for IOQM. How did this role come about and how has your problem-solving journey impacted how you approach it?

Around 2007, when I was at TIFR Mumbai, I reengaged with the Olympiad sphere as a mentor. Much of the training happened in Bombay, so they invited me to teach problem-solving to students. I also served as deputy leader for the Indian team at the Brazil Olympiad in 2016. It was only last year that I stepped into the Chief Examination Coordinator role

at MTA(I). This is now my key participation: organising the IOQM exam.

Last year and this year, we had difficult situations during the IOQM examination. From an organisational perspective, I could have taken various routes. But coming from a problem-solving background, I first decided to formulate the issue mathematically and to solve it and identify centers where the problem was originating. If you're structured about it, you can extract mathematical problems from daily organisational questions! That problem-solving approach affects how I see things, even in something as mundane as organising an exam.

We have touched upon the positive changes in terms of resource availability over the last decade. Being in this role, have you also seen any negatives that have come about?

There are increased mental pressures on students. I know kids who suffered from anxiety because their parents expected them to start solving Olympiad problems from Grade 2 or 3. A coaching culture has sprouted, that is willing to go to concerning lengths which impact student well-being.

My colleague Chetan, one of India's first gold medallists, had this commentary on online coachings for JEE as well as Olympiads: they focus too much on learning tricks and getting results; there is no focus on understanding or enjoying the problem. Not too long ago, there were no tangible privileges tied to Olympiad exams in the way of supernumerary seats. It was just about loving Mathematics.

What can bring about a positive change in our ways of approaching Mathematics as a subject?

One thing I have realised: we tend to focus on getting students higher and higher in the curriculum to complete the course of study. We don't focus enough on things at particular levels

that are enjoyable and can actually lead to new Mathematics, by going deeper into foundational concepts. Knowing these concrete bits and pieces on which Mathematics is built, gives you not just feel-good moments but real chances to do deeper research

The Equity Question

There continues to be unequal representation in the upper rungs of the Olympiad system in India. How do you navigate this as an organiser?

This is a sharp divide in India. People who work on equity are reluctant to engage with the discourse on excellence; people who work on excellence feel similarly reluctant to engage with ideas of equity.

To address this gap, we need to stop thinking in terms of either excellence or equity. We keep thinking about centralised Olympiad exams. Instead, we need to develop stronger regional units. Don't ask 'What are our best participants in Olympiads doing?' Ask 'What are the best participants in Olympiads from Sikkim doing? From Tamil Nadu? From Haryana'. If we compete on a national scale without valuing divergent exposures, we will pick up not only the most talented, but also those with the most access in many ways. Geography is just one such axis to consider. Gender, caste and other differences are harder to bring into the conversation, but we have to start somewhere.

In my personal teaching with undergraduate Mathematics students, I certainly try to be mindful of distinctions. Given an opportunity, I certainly try to engage with students from very different backgrounds.

You've experienced both the opportunities and limitations of the Olympiad system. For students and parents today, what would your advice be?

There are people on opposite ends of the spectrum even today. For those who feel they don't have access to mathematical books and resources: the stress that one has to know a lot before one starts engaging is rather misplaced. Start engaging with the problems without bothering about the prior knowledge, that is when you excel in it.

For those with more access who deal with a larger share of the pressures: enjoy Mathematics and don't rush. During my days, because these kinds of pressures did not exist, I enjoyed doing Mathematics.

Making Olympiad preparation richer by simply throwing more classes, more resources, more events in an unorganised manner actually builds anxiety in students. Look at what happened with the JEE coaching ecosystem. It causes a complete burnout in so many students.

The real opportunity isn't the medal or the certificate. It is developing a relationship with problem-solving where you're comfortable not knowing the answer, where you can think deeply over long periods, where you find joy in the process itself. This ability is what is valuable for any path one might take in life, be it in research or industry.

That is the gateway that stays open for life. The challenge now is making sure every deserving student, regardless of geography, background, or resources, can walk through it.

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Dr. Vaibhav's journey, from limited resources and xeroxed problem sets to shaping India's talent identification system, reveals that Math Olympiads are indeed gateways, but perhaps not in the ways we typically imagine. The true opportunity lies not in prizes or privileges, but in the mindset, confidence and deep joy of mathematical thinking that stays with you long after the competitions end.

FROM DR. VAIBHAV'S CORNER

Q. A game is played between two players *A* and *B* with the aid of a referee. Each player chooses a natural number ($n \in \{1,2,3,...\}$) and tells it to the referee. The referee adds up the two numbers and writes the sum *S*, as well as another number *k* of his own choice, on the blackboard without revealing which is the true sum.

The referee then asks player *A* if they can, through a logical argument, determine the number chosen by player *B*.

- If player *A* says "**YES**", they win and the game ends.
- If player *A* says "**NO**", the referee asks the same question to player *B*.
- If player *B* says "**YES**", they win; if "**NO**", the turn passes back to player *A*.

Assuming that both players are honest, perfectly logical and aware of each other's mathematical capabilities, show that the game must terminate in finitely many steps with one of the players saying **YES**.

Solution: p. 204

"Olympiads are not about proving how smart you are. They're about learning how to think, how to struggle and how to stay curious. That way of thinking becomes a gateway, not just to Mathematics, but to a lifetime of learning."



From a Curious Classroom to the World's Mathematical Stage: A Conversation with PRANJAL WARADE

When Pranjal Warade speaks about Mathematics, she speaks of the curiosity that carried her from Nagpur to international arenas. From being part of India's first-ever team at the European Girls' Mathematical Olympiad to winning a Bronze Medal at the International Mathematical Olympiad, her life is now one of mathematical research and teaching at the University of Chicago. Today, as a graduate student and mentor to younger students, Pranjal sees her journey as a series of opportunities that came her way through perseverance and faith in the beauty of problem solving.

The Early Pull

Before Olympiads and international competitions entered the picture, what was your early relationship with Mathematics like? When did it start to feel different from a regular school subject?

I do not think there was a single dramatic moment. Mathematics was always something I felt comfortable with, but more than that, I enjoyed the process of thinking. Some of my earliest memories are of sitting at home with my mother, working through homework problems together.

She did not have much higher education, but she had a deep interest in Mathematics. We would often struggle together; sometimes we would both be completely stuck, yet we genuinely enjoyed trying to work things out. That experience removed any sense of fear very early on. Struggle felt normal, even enjoyable, rather than a sign of failure.

In school as well, I gravitated towards problems where you had to pause, try different approaches and really reason your way through. It was never about speed or marks for me; it was about the satisfaction of understanding something properly.

As I grew older, I realised that not all Mathematics is about applying formulae. There were problems that asked you to think creatively, to connect ideas across topics. Those were the ones that excited me most, even if I did not always solve them quickly or correctly.

How did this curiosity translate into your first encounters with Olympiad-style Mathematics?

When I was first introduced to the world of Mathematics, I did not know what Olympiads were. Like many students, I

associated Mathematics entirely with school exams. It was only when I started encountering non-routine problems, through teachers and informal exposure, that I realised there was a whole different world of Mathematics beyond the curriculum.

One moment stands out very clearly. When I was in Grade 6, I attended a Mathematics workshop by Dr. Vivek Wagh in Nagpur. I arrived late and, with no seats left, ended up sitting on the stairs. At some point, a question was posed to the group and I answered it aloud without really thinking much of it.

That small, almost instinctive response caught Dr. Wagh's attention. He spoke to me afterwards, encouraged me and in time became my mentor. It was through him that I was first introduced to mathematical Olympiads. Looking back, the journey feels almost accidental, a chance encounter that profoundly changed the course of everything.

As I began exploring this new space, it felt natural to continue. Olympiad problems did not reward memorisation; instead, they rewarded persistence and creativity. Even when I failed to solve a problem, the process itself felt meaningful, perhaps because, from the very beginning, I had learnt that struggling with a problem was not something to fear, but something to embrace.

Discovering a Larger World

Many students talk about the Olympiad training camps as a turning point. What changed for you once you became more seriously involved?

The biggest change for me was realising that I was not alone. Until then, enjoying difficult Mathematics could feel isolating. But through Olympiad camps, training programmes and

competitions, I met peers who were equally excited by abstract problems.

This sense of community mattered a lot. You learn not just from teachers but from peers your age by discussing problems, sharing ideas and seeing multiple ways to think about the same question. This exposure broadened how I approached Mathematics.

One of the landmark moments in your journey was being part of India's first-ever team at the European Girls' Mathematical Olympiad in 2015. What did that experience mean to you?

EGMO was incredibly significant, both personally and symbolically. On a personal level, it was my first major international exposure. Competing alongside students from different countries helped me realise that mathematical thinking transcends national boundaries, languages and schooling systems and is a shared intellectual pursuit.

Symbolically, being part of India's first ever team carried a strong sense of responsibility. It highlighted the importance of deliberately creating spaces that encourage and support girls in Mathematics, particularly in contexts where such representation has historically been limited. Winning a bronze medal as part of Team India at EGMO 2015 was the cherry on the cake, not merely as a personal achievement, but as evidence that when appropriate opportunities and support structures are put in place, girls can compete and excel on the global stage.

Soon after, you represented India at the International Mathematical Olympiad and won a Bronze Medal there as well. How did that experience shape your academic trajectory?

The IMO experience was intense, but deeply transformative.

Preparing for it taught me how to remain with uncertainty. You often spend hours working on a problem without the guarantee that it will lead to solving the problem.

Developing comfort with such uncertainty is essential for research. The IMO experience helped me learn how to understand intensive effort as an integral part of the learning process. While winning a Bronze Medal validated the effort, the deeper impact lay in the mindset it cultivated, one characterised by perseverance, intellectual humility and patience in engaging with complex problems.

Opportunities Begin to Multiply

Olympiad success opens many doors, but students do not always know how to walk through them. What kind of opportunities became visible to you after these experiences?

A number of new pathways opened up for me. Academically, Olympiads strengthened my foundation and made advanced concepts feel approachable. That played a role in my admission to the Indian Institute of Science, Bangalore, where I pursued a B.Sc. (Research) in Mathematics after qualifying through the KVPY final examination.

Globally, Olympiads acted as a gateway and opened pathways to studying or researching abroad. You begin to see yourself as part of an international academic community rather than being confined to a single system.

Did mentors or networks from the Olympiad community play a role in helping you navigate these choices?

Absolutely. Mentors, seniors and peers from the Olympiad

ecosystem often provide guidance that is hard to find elsewhere. Sometimes it is as simple as a conversation that introduces you to a new possibility, a research area, a university or even a different way of thinking about your future.

The networks formed through Olympiads often last well beyond the competitions themselves. For instance, one of my current research mates, someone I now share an office with, is a close friend I met during EGMO. She's from Mexico and we first connected there over shared problem-solving experiences. That is when you realise Olympiads are not just about medals or rankings. They create a global academic community. Years later, you are still learning, collaborating and thinking alongside people you first met as teenagers solving Mathematics problems together.

Learning to Think Like a Researcher

It sounds like Olympiads acted as a bridge, not just to competitions, but to higher education and research more broadly as well.

Olympiads do not teach you specific content for university, but they prepare you mentally. They train you to ask questions, to explore ideas deeply and to persist. That transition from school-level curiosity to university-level rigour felt more natural because of my Olympiad background.

You have taught Calculus and Linear Algebra as a lecturer and served as a Graduate Research Assistant. How has your Olympiad training influenced the way you teach?

When I teach, I try to emphasise understanding over procedures.

Olympiad learning taught me that once you truly grasp an idea, techniques follow naturally. I encourage students to ask 'why' questions and to be comfortable making mistakes. That mindset builds confidence and resilience, which are essential not just for Mathematics, but for learning in general.

Looking Beyond Borders

Having experienced both Indian and global academic systems, what differences stand out in how they support young mathematical talent?

One noticeable difference is flexibility. In many global systems, students are encouraged to explore interests early and engage in research as undergraduates. There is institutional support for curiosity-driven learning. In India, while the talent is immense, pathways can feel more rigid. Olympiads are recognised, but their potential as long-term developmental tools is not always fully utilised.

What could India do better to help Olympiad participants translate their experiences into higher education or research opportunities abroad?

Awareness plays a critical role. Many students are unaware of the range of opportunities available to them including international programmes, research internships or funding options. Structured mentorship, outreach beyond major cities and better dissemination of information would go a long way in addressing this gap.

Olympiads should not be seen as isolated achievements. They should be integrated into a broader, long-term ecosystem that continues to guide and support students well beyond the competitions themselves.

Completing the Circle from Learner to Mentor

You journeyed from being an Olympiad medallist to mentoring students yourself. What would you say to students on this path now about the Olympiad experience?

Olympiads are a gateway. Not everyone will win medals and that is completely fine. The real value lies in how Olympiads shape the way you think.

The journey teaches you perseverance, humility and problem-solving mindset. Those lessons stay with you, whether you pursue Mathematics, Science, AI/ML or something entirely different.

I would say focus on learning, not outcomes. Let curiosity guide you. Do not be afraid of problems you cannot solve immediately, they're often the most rewarding. Olympiads can open doors, but what truly carries you forward is the love for thinking deeply and honestly. If you nurture that, opportunities will follow, often in ways you can not predict.

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Pranjal Warade's journey reminds us that talent flourishes when curiosity meets opportunity. Her story is not merely one of medals and institutions, but about opening gateways, especially for more girls, to dream, participate and thrive.

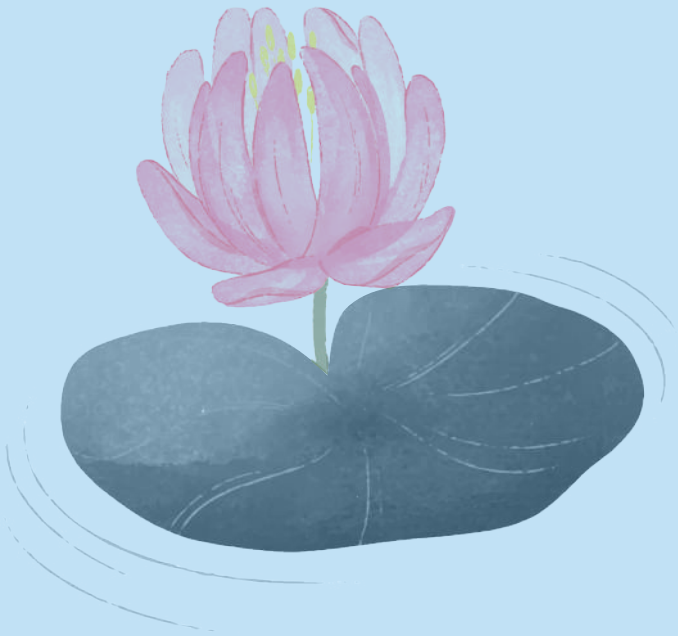
FROM PRANJAL'S CORNER

Q. Let a,b,c be positive real numbers in the interval [0,1] such that a + b ≥ 1, b + c ≥ 1 and c + a ≥ 1. Prove that:

$$1 \leq (1-a)^2 + (1-b)^2 + (1-c)^2 + \frac{2\sqrt{2}abc}{\sqrt{a^2+b^2+c^2}}$$

Solution: p. 205

Talent can come from anywhere





India's mathematical talent does not cluster naturally in metropolitan centres or elite institutions. The country's geography, diversity and vast population mean that exceptional minds emerge in every district, every school system, every kind of family.

The stories in this theme challenge assumptions about where mathematical talent comes from and what conditions allow it to flourish. They show that potential is not confined to particular schools, cities, or backgrounds. Instead, they reveal how talent emerges when curiosity meets opportunity, when someone believes in a student's ability despite unconventional circumstances and when communities create space for different ways of learning and growing. The real question is not whether talent exists everywhere, but how we can recognise it when it appears in places we were not looking.

"Most students just haven't tasted the kind of Math they would love so far. And when they do, remarkable things happen."



When Curiosity Finds its Home: A Conversation with VINAY NAIR

Before Vinay Nair became a mentor who helped shape young problem-solvers across India, he was working in corporate credit control, armed with a training in commerce. Yet today, through the Raising A Mathematician (RAM) Foundation, he has created spaces where students across the country discover their mathematical potential. His journey from asking interesting mathematical questions alongside middle school students, to mentoring several Olympiad medallists shows that the ability to nurture talent requires genuine curiosity, humility and the courage to learn alongside your students.

An Accidental Beginning

Vinay, you come from a commerce background. How did this transformation into Mathematics education happen?

I spent years in corporate roles before getting into teaching. While conducting workshops, I met students who had this deeper thirst for mathematics. They would not let go and kept asking for more content, more problems. After a point, I reached my own limits. So I started connecting them with friends who could offer different perspectives.

All the while, I had been doing residential Mathematics camps since 2010. Back then, to the best of my knowledge, there were no Math-focused camps for school students in India of the kind we were focusing on. One day, our founder chairman said, "Why just your students? Why not do a national-level program for 100 students from across India?" None of us had any idea how to source funds. But we just went all in. That was 2014 and that is how the Raising A Mathematician Foundation was born.

You yourself weren't formally trained in Olympiad Mathematics. How did you bridge that gap as an educator?

I learned everything after I became a teacher. I left serious mathematics back in Grade 10 when I chose commerce. Whatever I am teaching now, I learned because students asked questions that forced me to dig deeper.

For instance, a seventh-grader once asked me, "Is negative one a prime number?" His reasoning was that -1 has two factors: -1 and 1. So, is it a prime number? I had never asked this question in my entire life! That led to discussions in our WhatsApp groups with Math enthusiasts. We explored definitions, conventions,

why we define primes the way we do. A lot of times, questions like these from students led to deeper learning for me.

When Talent Doesn't Follow the Script

You've worked extensively across cities, towns and rural areas. What patterns have you observed about how mathematical talent emerges in the classroom?

One thing I have learnt is that invariably, there is either a parent or a teacher who brings opportunities to the student. Parents in cities are more aware of opportunities like Olympiads. But in towns and villages, where information is not as accessible, when a motivated student does get exposure, they come back saying, 'I need more!'

There's one student interaction that I can never forget. There was a girl in my class who did not enjoy Math much until Grade 8, but when she came to our Grade 9 workshop on discrete Mathematics, something clicked. One day, we were working on a probability problem. The entire class was convinced about the answer except her.

We had a one-hour debate. I tried different approaches, different explanations, but she said, "I am sorry sir, I can see everybody is convinced, but I am just not able to get there." So I said, "Let's pause here. Let's come back tomorrow." The next day, she came and said, "I understood! I went home, thought about it and I got it."

That is the spark I am talking about. Students who genuinely

love reasoning won't step back even if the teacher or the majority thinks differently. That girl later represented India at IMO to win a Bronze in 2021 and was also part of the European Girls' Mathematical Olympiad

Can you share any other stories, which you feel may exemplify different learning journeys one may encounter as a teacher in this sphere?

One of our girls, Swasti Patil… her story is fascinating. She and her elder sister, Saee[2] live in Sangli. They live on a farm and are unschooled. They grow vegetables, build things with their hands and even know what goes into constructing a house! Math and computer science are subjects they love, so they just keep learning with internet access.

Swasti was passionate about both Mathematics and Informatics. After our camps, she found resources, connected with mentors and last year got into the European Girls' Informatics Olympiad team and won a bronze medal for India.

I also had one other student, who was once invited by one of my colleagues to sit in their undergraduate Mathematics classes. By Grade 11 and 12, he was already reading undergraduate-level Mathematics. He then got an opportunity to attend a one-month course at Princeton: fully sponsored. His first flight ever was to Princeton! All of this was made possible just because someone saw his potential and gave him exposure.

[2] Saee Patil's story is also featured as a part of this text. Please refer to the table of contents for the same.

The Classroom as Conversation

Your teaching philosophy seems centered on dialogue rather than lectures. How did you develop this approach?

I was fortunate to observe amazing teachers and see how they engaged with students. When you go to class with the agenda of having a good conversation rather than giving a sermon, everything changes. In our camps, none of the faculty come with pre-decided books. It is a dialogue. The teacher asks questions and students respond. Students ask questions, the teacher responds. Sometimes we get stuck, sometimes they get stuck, but we have good conversations and learning happens automatically through it.

How do you make students comfortable with taking intellectual risks?

You appreciate the process of problem-solving, not just the result. When students see that even wrong answers are met with encouragement, they stop being scared to speak up. Additionally, one has to match their level of enthusiasm. Even if I have seen a proof 100 times, when a student presents it to me having come up with it from scratch, I'll express wonder, as if this is happening for the first time.

That is what my Math teacher, P. P. Raman Sir, did for us. It is only after I started teaching that I realised my teacher was acting the whole time. He was 66 years old and had definitely seen our proofs thousands of times. But he made us feel like we had discovered something revolutionary. That sense of achievement brings students back to class every day. That encouragement is really powerful.

Breaking Through Math Phobia

Interacting so deeply with parents and students over the years, you must have come across the common 'phobia' people have of Math. How does that impact the nurturing of talent?

Math phobia runs incredibly deep. I have had parents tell me that they cannot even flip through their child's Math notebook or help with homework because they had such terrible experiences with the subject in school. Just seeing mathematical terms gives them anxiety.

However, often what looks like mathematical inability is something else entirely. In my first year of teaching, for instance, there was a very sharp student who excelled at some problems but made bizarre mistakes on others. I then met him one-on-one and we read a word problem line by line. Eventually, I realised he did not understand the meaning of the word 'per.' Whenever a question had 'per annum,' 'per cent,' 'per person,' etc., he would make mistakes.

How can we expect a 12-year-old to realise, 'This is what I don't understand'? As teachers, we need to diagnose properly before prescribing treatment. Often the barrier isn't mathematical, but rather related to the language the subject is taught in, or rooted in another specific gap.

How do you address the fear of Mathematics as a subject in your outreach to government schools specifically?

The language of instruction is a crucial concern in government

school settings. When I go to a Marathi medium school, I speak in Marathi even though my Marathi is terrible and the kids laugh. The result is that they end up feeling more comfortable with me.

I remember one government school where a kid explained fractions beautifully. I asked, "How do you compute one-fourth?" He said in Marathi, "You do half of half." He understood division conceptually in a way many Tier-1 city students learning algorithms don't. These students have solid understanding. They just need to feel safe and be assured that someone is genuinely interested in their thinking abilities.

Building Ecosystems for Hidden Talent

What specific practices have you found most effective in helping students from disadvantaged backgrounds feel assured that they belong in problem-solving circles?

First and foremost practice is creating a peer community. Many students who are good at Math feel isolated in their schools. When they come to our camps and meet 100 other passionate students, that changes everything. Second, encouraging dialogue-based learning.

Third, providing exposure to role models. For our All-Girls Math Nurture Camp, for example, we specifically invite women mathematicians. After one of our camps, without exception, every faculty member was thrilled. Many told us, "I wish there was something like this when I was in school." One faculty had shared with me that during her PhD in the US, she was the only

girl in her cohort. On weekends, boys would socialise together. She had nobody to discuss mathematics with. When girls don't have peers who share their interests, a lot of informal learning gets lost. Having women mathematicians as role models shows girls: 'If she can, then I can.'

We've been fortunate to have exemplary faculty like Dr. Sujatha Ramdorai, Dr. Swati Sircar, Dr. Shailaja Sharma, Dr. Reshma Menon and Dr. Kavita Sutar and many others mentor students in our camps.

What resources would you recommend for teachers trying to go beyond routine problems?

One fantastic resource is nrich.maths.org by Cambridge University. Teachers or parents can pick activities by age group and topic. There are open problems where students can submit solutions. So far, students from our programs have had solutions published for more than 30 problems. For kids who may not be 'toppers,' this recognition of their mathematical thinking abilities is powerful.

Another is 'The Infinite Pickle' book — a freely downloadable PDF. P.K. Srinivasan's resource material on Math club activities is excellent. The idea is to move beyond curriculum and provide students with strategy games and puzzles. Such things allow real talent to emerge, even from students who aren't class toppers.

What can institutions and governments do to ensure equal opportunities for students from different contexts in the Olympiad pipeline?

First would certainly be training teachers in non-routine problem-solving. Second, developing partnerships between governments and NGOs. There is immense potential in bringing together government scale with organisations with expertise in talent identification and nurturance. Third, creating awareness

about free resources, especially in regional languages. Fourth, instituting residential camps and Math circles with scholarships for students from smaller towns.

Lastly, we also need to involve parents in their children's journeys. We recently did something different with parents at a residential camp at RAM Foundation. Parents stayed separately and had sessions run by other parents, not by us. It was transformative. They realised their challenges weren't unique and their perspective widened. We need to build parent communities where they can support each other.

The Heart of the Matter

From your years of experience, what message do you want young students to hear?

Thinking ability doesn't depend on your background, your school, or your marks. I came from commerce. I left serious Math in Grade 10. But I could learn and contribute to the field because I stayed curious and was willing to learn from students.

Mathematics belongs to everyone. All you need is curiosity, patience and someone who believes your ideas matter. Don't let anyone tell you that you're not a 'Math person' just because you're not fast at calculations or you come from a small town.

You've mentored both high-performing students and those who struggle. What can you share with fellow educators about talent identification and nurturance?

'Talent' itself is context-dependent. A student struggling in school Math might excel at spatial reasoning or logical puzzles. I always think of my boss at an old corporate job who told me

I was 'methodical' at finding root causes when I think about identifying talent. His observation identified mathematical thinking. It can manifest in figuring out why a client isn't paying, or why a proof doesn't work. So, all of us have that ability. We just need to realise we're good at it.

Watching students find confidence once you nurture their ability is a feeling of immense joy. Many come with doubt, thinking Math isn't for them. But when a student solves a challenging problem, something changes. Their posture changes. Their voice changes. They begin to believe in themselves. That transformation is the most rewarding part.

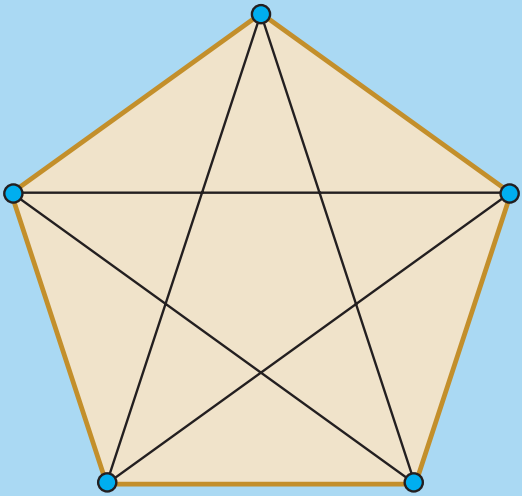
I have witnessed this hundreds of times, from students from every kind of background. Each time, it reminds me: talent resides everywhere. Our job is simply to create the conditions for it to grow.

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Vinay Nair's journey from being a corporate professional to a Mathematics educator embodies his core message: curiosity and commitment are the things that matter for success, not your background. Through the RAM Foundation, he continues creating spaces where students can discover that mathematical thinking belongs to them.

FROM VINAY'S CORNER

Q.



In how many ways can you draw a pentagon with all diagonals if you are not allowed to lift your pen or retrace your steps?

Solution: p. 206

"Just keep doing what you enjoy and have trust that it works out, because it does."



The Girl Who Rejected the Template: A Conversation with SAEE PATIL

Many students discover Mathematics through school lessons or competitive examinations. But for Saee Patil, it started in the quiet contest to win her mother's attention. She, unlike many, grew up unschooled, free from the routines and schedules that shape most children's learning. Her childhood was filled with reading, thinking, asking questions and following her interests wherever they led. When she eventually entered the world of problem solving, she carried a confidence that had nothing to do with marks and everything to do with curiosity. Her journey shows what becomes possible when a child learns outside the template most of us assume is necessary.

Learning in a World Without Classrooms

Saee, your childhood looked very different from what most students experience. How did unschooling begin for you?

It actually started with a family trip to Delhi when I was in Grade 3. My sister and I navigated the entire metro system ourselves, spoke to people in Hindi even though we weren't fluent and our parents just stayed in the background as 'invisible guardians.' We learnt so much just by being there and doing things on our own.

When we came back, we had a chapter about Delhi in one of our classes. One evening I was studying about it and my father asked me, 'We just came back from Delhi, why do you need to study it?' I told him, 'No, no, what is written in textbooks is very different from real life, Baba.' That moment made him wonder whether there might be other ways to learn that felt more connected to real experiences. As days went by, my parents also saw me memorising English essays for my examinations, trying to maximise marks instead of actually learning. That is when my parents felt that perhaps we could explore a different approach to education. So we decided to step out and try something different.

What did unschooling mean for your family and how did you come to develop an interest in Mathematics during this period?

My biggest motivation for getting into Math was actually quite silly. I was jealous of the attention my mother was giving the subject. She's a Math teacher and she would spend hours

reading books and working on Math problems. I wondered what was so interesting that she'd rather do Math than play with me. That is how I got curious about it.

Once you started exploring Mathematics with your mother, how did she encourage that curiosity?

When I was about five, I came up with my own way to add two numbers. My mother's reaction was remarkable. She said, "Oh wow, you came up with your own method! That is great." She did not say, "What are you doing? This is not the way you're supposed to do it." That encouragement to question existing ways and create my own methods stayed with me.

I remember another time I figured out that $a^2 - b^2 = (a+b)(a-b)$. I was so happy. I thought it was literally magic. I later figured out why it works like that. It is not really magic, just logic. That pattern of thinking, observing something that seems magical, then spending time to understand the logic behind it, became very important for me.

Did you eventually feel the need for resources or learning opportunities beyond what you could access at home?

My mother and I reached a saturation point after which we couldn't continue on our own. That is when my mother heard about the Raising a Mathematician (RAM) Foundation through Facebook. When she told me about it, I said, "Oh, Raising a Mathematician, that sounds like somewhere I want to be." Their flagship training programme was for 13 to 15-year-olds and I was only 11. My mother said, "If you want to get in, you have to at least know what a typical 15-year-old knows." So, we completed the entire school syllabus till Grade 10. Then I applied and to my surprise, I got in. I was the youngest at the camp.

What was that first RAM camp like?

I was quite nervous, since I was going to be the youngest. From 6 AM to 11 PM, we were just doing Math and were so happy doing it. At RAM, I felt like I belonged.

It exposed me to a completely different side of Math too. Till then, I had been doing advanced algebra, polynomials, etc. At RAM, I learnt about fractals, Boolean algebra, fun applications in physics and economics. It was a whole new level.

Doors Opening Through Mentorship

RAM continued to open doors for you, did it not?

It certainly did. I remember this one story fondly. One evening at RAM, when I was only 12, Vinay sir, the founder of RAM, told me about a professor, Dr. Rajiv Gandhi, who teaches theoretical computer science. He's a professor of Computer Science at Rutgers University-Camden and also teaches part time at the University of Pennsylvania and he used to come to India once or twice a year to teach classes, mostly for undergraduate students and some high schoolers.

Vinay sir insisted I should attend his lecture. I was in shock. I said, "Are you sure I can handle it?" He said, "Just sit in one class. If you don't like it, it is fine, you go home. I won't force you."

He also had to convince Dr. Gandhi because I was so young. Dr. Gandhi said, "No, I have never taught somebody who's

12." Vinay sir convinced him: "Let her sit for one class. If she doesn't follow, we won't take it further."

I had so much fun. I ended up sticking with it and that is where I got into theoretical computer science. Later, Dr. Gandhi gave me many more opportunities. Most of the undergraduate level classes I audited online were because of him. He'd email me saying, "I have an opportunity for you. I am teaching a class and since it is online, you can just sit in and do all the assignments if you want." My RAM journey wasn't just RAM courses and classes, it was all these other opportunities I got through that connection.

You also attended PROMYS in the United States. What did you learn there?

PROMYS was an unusual experience too. I was 13 when I applied and they only accept students 14 and above. They wouldn't even let me apply. Vinay sir wrote to them and my mother also told them to just consider my application and to look at my problem set before they reject me. I ended up getting accepted. I did not go ahead that year since I had already committed to PACT (Program in Algorithmic and Combinatorial Thinking), an international Math camp for high schoolers and so I ultimately went for PROMYS in the following year.

PROMYS was held online due to COVID the year I attended, but I had a great experience nevertheless. The biggest learning for me was to not give up on any problem. Every student is assigned a counsellor who's an undergraduate student to help with problems. There was one problem I was stuck on for so long and my counsellor just refused to give me any hint whatsoever. I was so annoyed at him. When I eventually solved it on my own, I felt unmatched joy. I was thankful that my counsellor never budged or gave into my incessant demands for hints. That experience really taught me not to give up and keep trying.

When Failure Became Learning

You've mentioned that you also attempted Math Olympiads early on. How did that experience unfold and what impact did it have on you?

After I got out of school, I did some local competitions and did quite well in them. I thought, "Okay, let's try this Math Olympiad also. How hard can it be?"

Then I did it and I failed horribly. I had actually been preparing quite a bit, so this was the first time I had failed so badly. I went into utter shock. I was quite young, maybe 11 or 12 and I had a huge breakdown. I never wanted to attempt Math Olympiads again.

What helped you move forward from that experience?

My mother and I talked about it. She said, "It is fine. You don't want to attempt Olympiads? Nobody's pushing you. Math is something you do because you like it and you shouldn't worry about examinations. That is also a big reason why we took you out of school. We shouldn't be going back to that mindset."

She convinced me that even if I wasn't specifically preparing for Olympiads, I should just keep giving the examinations anyway. She helped me separate my love for Mathematics from the pressure of performance.

Competition Meets Collaboration

Let's discuss your Olympiad achievements. You qualified for IMOTC in 2023. After that early failure, how did it feel to reach that stage?

I was nervous again. I had not been preparing much for Olympiads, I had been doing other things. I thought, "Okay, I have somehow gotten in. It was a fluke. Everybody else is going to be so smart." I really did not feel like going. My mother said, "You should go. You will just have fun, that is what you do Math for. Don't worry about comparing yourself to others."

So I went and I had a lot of fun. What surprised me most was meeting people who had gone to EGMO or IMO and won medals. Before going, I thought they were going to be on another level, like people from another world. When I met them, it felt like, "Oh, they're just like you and me." It felt quite natural. I thought, "This is something I could do as well if I wanted to." That filled me with confidence.

You have participated in the EGMO twice. Tell us more about that experience.

My first EGMO was in Georgia in 2024. One thing that struck me: it is supposed to be a very competitive environment, right? Even at IMOTC, you're competing with 60 other people to be in the top six for the IMO team. At no point did I feel like I was competing with others or that anybody was judging me. It was very collaborative. At EGMO, one or two days before the examination, we were discussing geometry problems with the Taiwan team, the Bangladesh team…

Since STEM spaces are usually male-dominated, was EGMO particularly meaningful for you?

Yes, definitely. There have been many times when I have been one of the few, if not the only girl in the class. For me specifically, the only thing that bothered me was that I had to put in more effort to go and talk to the boys.

When I was at EGMO, surrounded by so many girls across the world who were also into Math, it felt really, really nice. That is when I realised, okay, this is something I had been looking for. Earlier, it did not feel too wrong being the only girl. When I was put into that space with lots of girls, I realised this was something I needed. It helped me feel very at peace. I am not too different in any way.

The feeling of taking your country's flag, going on stage and getting a medal filled me with a lot of pride. It made me feel like I have come some way.

A World of Opportunities

You took 'the road not taken,' but you did have access to cities like Pune with resources like RAM and parents who had your back no matter what. What would you say to students who don't have those advantages?

Firstly, I definitely want to acknowledge the advantages I had, particularly the support from my parents. I want to say though, that there are so many resources available now, no matter where you are. The internet is a big place. You can get any book, watch videos, try problems. There are structured pathways available online.

I have a very close friend from Karad. Just through self-study and some help from student programmes online, he

has a medal from the Asian Pacific Mathematical Olympiad representing India. He's so good that he can close his eyes and solve geometry problems in his head, before I can do it with my notebook and pen.

Most people who've been to IMO haven't been to fancy coaching classes. My friends who've made it to IMO, they just see a problem somewhere, think 'this looks interesting,' and spend hours trying it. If they don't get it, they call up a friend: 'Let's solve it together.' The first point is to know that location is not an obstacle. If you really want something, you can do it.

What other practices would you recommend to students in these contexts?

Find communities. Looking back, community has been the most important part for me. Once you get connected to a community, things become smoother. They tell you about programmes, scholarships, opportunities you wouldn't have known about otherwise. Make good use of online resources.

I won't lie, there'll be obstacles, but they have to be figured out. For example, even for something as seemingly small as registration to appear for the Olympiads, my mother had to do a lot. They wouldn't let homeschoolers apply initially. My mother had to call them up and explain that there is no harm. One year they opened it just for me. The next year, she had to call them all over again. Now they have a separate registration for homeschoolers. When there is a roadblock, you just have to persist.

Do you think your path could be replicated? Should more families consider unschooling?

I think different paths work for different people. Unschooling worked for me because of my parents, my personality and the support we found. I don't think everyone should unschool.

I do think every child deserves what I had: the freedom to be curious, adults who listen to their questions, opportunities to discover their own ways of thinking and communities that welcome them. Those things can happen in school or outside school. The point isn't the specific path. It is that there can be multiple paths. We need to make space for different ways of learning and growing.

What message do you have for a young girl in a village who's determined to do Mathematics but feels uncertain?

I would say: As long as you know that you want to do it, just keep doing what you enjoy. Keep doing what you have fun with, what doesn't feel like pressure or work. Have trust that it works out, because it does.

Also, don't hesitate to reach out to other people. Don't hesitate to ask doubts. Where you come from does not define you. It is what you want to do that matters. The Math community is welcoming. If you enjoy thinking, if you're curious, that is all that matters. You don't need to be fast or know everything or come from a particular background.

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Saee Patil's journey reminds us that mathematical talent doesn't emerge from any single pathway. It grows wherever curiosity meets support, wherever struggle meets encouragement, wherever young minds find the freedom to think in their own ways. Her story is not a prescription. It is a possibility and a reminder that the template we assume is necessary might not be necessary at all.

FROM SAEE'S CORNER

Q. Imagine you have two buckets: a red one that holds 5 litres and a blue one that holds 7 litres. You have an infinite supply of water from a nearby river and a large tank that can contain as much water as needed. Using just these two buckets:

1. Can you fill the tank with exactly 8 litres of water? Exactly 9?
2. What is the smallest number of litres that can be measured?
3. What are some numbers that cannot be measured at all?

Now, consider how the answers to the three questions above change if the bucket capacities are:

- 4 and 6 litres
- 6 and 9 litres
- 12 and 19 litres

What general pattern or mathematical rule do you observe regarding the measurability of a volume V given buckets of size a and b?

Solution: p. 208

"If you train students, they graduate and leave. But if you train mentors, they stay and continue to identify talented students. It has to come from the ground."



The Distance Between a Village and the IMO: A Conversation with PROF. SHANTA LAISHRAM

In Khangabok village, a boy used to finish his entire Mathematics textbook before the school year ended, always hungry for more. His teachers could not help him with higher order Math problems. His parents had no formal education. The nearest city with mathematical resources was days away. Yet a single circular about a competition he had never heard of, a one-week camp with a professor who believed in him and a summer programme that revealed Mathematics could be a career would eventually take him to the Tata Institute of Fundamental Research and decades later, to leading India's team at the International Mathematical Olympiad. Prof. Shanta Laishram's story shows that talent can emerge from anywhere when given even the smallest opening.

A Circular That Changed Everything

Your journey to Mathematics began in a very different setting from most. Could you tell us about those early years and how you first encountered the Mathematical Olympiad?

I am from a village called Khangabok in Thoubal district of Manipur, where I did my primary schooling in Manipuri medium. From childhood, I was interested in Mathematics. I remember in primary school, I used to finish solving the entire textbook before the course was completed. Then I joined the Jawahar Navodaya Vidyalaya in Thoubal District, which is a central government funded residential school. I will say I owe a lot to my Navodaya days for what I am today. One day, a circular came to my school about the Regional Mathematical Olympiad (RMO). Nobody really knew what it was. I wrote the exam and got selected and Professor M.B. Rege from North-Eastern Hill University in Shillong, who was the regional coordinator for the Northeastern region, invited me and another student from Manipur (Dr. Chandrakant, who is also a mathematician now) to write the Indian National Mathematical Olympiad, the INMO, in Shillong.

Were you able to find guidance for Olympiad preparation?

That was the challenge. Regular schooling was different, so my teachers were not able to solve the Olympiad problems. Only one faculty from DM College of Science (Dr. H. Jayanta Kumar Singh), who also taught me in my BSc, was able to give some guidance that time. I used to go to him on Sundays for discussions.

What happened at INMO?

Professor Rege kindly invited us for a one-week problem-solving session in Shillong before INMO. During that week, we practised a lot. I wrote the exam but did not make the top 30. But that experience, that one-week programme with Professor Rege, was quite instrumental in me taking up Mathematics as a career. I was interested in Math anyway, but that helped me push forward.

What Opened the Door

After that initial exposure to the Olympiad programme, how did you discover the possibility of research Mathematics as a career?

After Grade 12, I joined BSc Mathematics Honours at DM College of Science in Imphal. My original plan was to do BSc Mathematics and then go into civil services. But during my BSc, I got to know the Mathematics Training and Talent Search programme, or MTTS. I attended MTTS in 1998 at Indian Institute of Technology Madras, then in 1999 and 2000 at Regional Institute of Education Mysore. That programme changed everything. When I met people from all over the country and faculties from many places, I got to know that one can actually make a career in mathematics.

Did you know about such research institutes before MTTS?

I never heard of the Tata Institute of Fundamental Research (TIFR) or any other places before that. Through MTTS, I got to know about institutes like TIFR, the Institute of Mathematical Sciences, Harish-Chandra Research Institute and the Indian Statistical Institute. My parents are not so educated and even

many of my teachers were not aware of such institutes. I got to know about most programmes like these on my own. After BSc, I joined TIFR directly for my PhD.

Were there mentors who helped shape your path?

Professor Jayanta Kumar Singh, who was also my teacher at DM College of Science, had a great influence on me during my BSc. Then there was Professor Ranjit Singh from Manipur University, who was very encouraging. They really helped me in my journey. And of course, Professor M.B. Rege. That one-week programme with him in Shillong was quite instrumental. Career-wise, MTTS helped me in choosing Mathematics as my career.

What It Takes to Reach Beyond Geography

Based on your experience coming from Manipur, what do you think is the biggest challenge for students from remote areas?

Whenever I go home to Manipur, I try to visit schools and talk about opportunities in mathematics and sciences. From my interactions, almost no one was aware about such career aspects in mathematics. People know about the JEE exams for IITs and medical entrance exams, but nobody knows about careers in mathematics. Many students are interested in Math, but they simply do not have access to information about what pathways exist. Unless they find someone to guide them, they may never discover these opportunities.

Would you say that the real barrier is access to information and mentorship?

Exactly. I find very good students when I visit. Many of them are interested in Mathematics. But sometimes, because of the way school structures work, unless they find someone to mentor them, they don't actually pursue Mathematics further. They just get lost in the nitty-gritty of the school curriculum. Most school teachers are excellent at what they teach, but Olympiad-style problem solving is a very different skill set that requires specialised exposure. The issue is not about the quality of schools or teachers. It is about the lack of a support system for this particular kind of mathematical thinking. Students need mentors who can identify their potential and connect them to the right resources.

You were lucky to find Professor Jayanta Kumar Singh and Professor Rege. What would have happened without them?

I do not know, probably I may not have come so far in Mathematics. I was fortunate that a circular came to my school. I was fortunate that Professor Rege invited us to Shillong for that one week. I was fortunate that Professor Jayanta Kumar Singh could help me on Sundays. But there are many children out there just as talented who never get those chances. That is what troubles me when I visit schools back home. I can see the potential, but I also see how easily it can be lost without the right support at the right time.

You eventually came back to contribute to the Olympiad programme. How did that happen?

After my postdoc abroad, when I joined ISI around 2013-14, I got in touch with the Olympiad programme. I started helping with International Mathematical Olympiad training camps. Just before the pandemic, I became one of the National Board for Higher Mathematics Olympiad fellows who helped propagate these activities. Then I became deputy national coordinator for around a year and now I am part of the National Board for Science and Mathematics Olympiad committee. I have also been team leader for India's IMO team.

You have led India's IMO team. How do our top students compare internationally?

The students who make our top six are well-trained and comparable to the best in the world. But the gap is in the pipeline below them. Last year, three of our IMO contestants came from Delhi Public School Faridabad. Why? Because they have a peer group, they know which books to read, whom to connect with and they work together. There are a lot of resources online. Once you have that ecosystem, students thrive. But this is concentrated in very few places.

In earlier years, there was more diversity in where students came from. What changed?

In earlier times, you had students from Bengaluru, Kolkata, Mumbai, Pune. In Pune, through Bhaskaracharya Pratishthana, they train students from class six onwards. The students who reach the IMO Training Camp now have typically had access to extensive preparation and coaching networks. Though the exam itself is fair, the preparation landscape is uneven. Talent exists everywhere, but access to proper preparation does not. The way forward is to spread mentorship across different regions, so students everywhere can get early exposure before they even know about Olympiads.

The Student Who Could Be Anywhere

How do you identify talented students when you encounter them?

It is subjective. When you talk to them and ask basic questions, the way they think, the way they respond, that is how you know. I give them something to read, then ask them to present it. The way they try to understand and explain things reveals their potential. It is not about asking questions in an exam format. It is through genuine conversation, through watching how they approach problems.

I find talented students everywhere I go. In Manipur, in Haryana, in small towns. The potential is there. What varies is whether they get the chance to develop it.

What message would you give to students from smaller towns who doubt themselves?

If you are in doubt, that is actually good. It means you know you have something to learn. Use the internet to find out more. Reach out to peers, reach out to mentors. Compare information from different sources. Do not trust things blindly from the internet, but check with a few different sites. If you like Mathematics, there are many career options now. Olympiad training helps with problem-solving skills that matter everywhere. In this AI age, your thinking ability is what counts. Routine tasks can be done by AI. But these problem-solving skills, that is something AI still cannot do.

Where you come from does not define what you can become. I came from a village where nobody knew what an Olympiad was. I went to a school where teachers could not solve these

problems. My parents had no formal education. But a single circular, one week with a professor and a summer programme were enough to change my trajectory completely. If it happened for me, it can happen for anyone.

What needs to happen to ensure more students like you get those chances?

We need to reach students earlier and in more places. The talent is already there, distributed across this country. What is not distributed is awareness, mentorship and access to opportunities. If you train students, they graduate and leave. But if you train mentors, they stay and continue to identify talented students year after year. It has to come from the ground up, from every district, every region. Only then will we truly discover how much mathematical talent India has.

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Prof. Shanta Laishram's journey from Khangabok village to IMO Team Leader is not a story of exceptional circumstances creating exceptional talent. It is a story of talent that existed all along, waiting for an opportunity. Today, he works to open those same doors for others, because he knows the truth that his own journey proved: talent can emerge from anywhere. The only question is whether we will be there when it does.

FROM PROF. SHANTA'S CORNER

Q. Find all positive integers $n > 1$ such that $\frac{2^n+1}{n^2}$ is an integer.

Solution: p. 209

"The real task for teachers and parents is to help students discover what they enjoy and then give them the confidence and support to pursue it, whether that leads to an Olympiad medal, an IIT seat or a life in research."



Finding Mathematical Talent Beyond Elite Halls: A Conversation with PROF. AMOL DIGHE

When a shy boy in Thane started spending weekends solving Marathi puzzle books and attending informal 'fun' Mathematics sessions, no one imagined he would become one of India's first International Mathematical Olympiad medallists and later a leading physicist. Professor Amol Dighe's journey, from those community circles to winning a bronze medal at India's debut IMO in Germany and on to a distinguished research career in high-energy physics, shows how talent can surface far from elite institutions when curiosity is nurtured early and gently. Today, as a professor at TIFR and an active mentor in the Physics Olympiad ecosystem, he looks at Olympiads both as a student and as a mentor, trying to keep problem-solving joyful.

Early sparks and first mentors

Prof. Dighe, you often describe your early encounters with problem-solving as 'not even knowing it was problem-solving'. Can you tell us how this interest actually began?

It started with completely non-serious things. Someone in my family gave me puzzle books when I was in Grade 2 or 3. These happened to be in Marathi and were not just mathematical puzzles but all kinds of riddles and logic problems. I had no idea this was 'Mathematics'; it was simply fun to sit with those puzzles and see if I could crack them.

Later, the Maharashtra Government introduced problem-solving examinations like Pradnya and Parangat for Grades 5 and 8 and a group of local Mathematics teachers from different schools decided to prepare students for them. They would run evening and weekend sessions where students from Thane, Dombivli, Kalyan and nearby areas came together, solved problems and made friends. It felt more like a club than a class and that atmosphere took the fear out of Mathematics very early.

Those sessions seem to have been more than just training. What role did the teachers play in building that community?

The teachers were central, the heart of the entire experience. They were school teachers, mostly teaching middle-school Math, but they were incredibly enthusiastic and treated these sessions as an outlet for their own love of Mathematics, creating space to explore the problems and ideas that excited them. Because the numbers were small, they could create a relaxed, friendly environment, just solving and discussing interesting questions that were very different from the textbook exercises.

What made the experience even more distinctive was how the teachers drew parents into this world. Parents who arrived to drop off their children were invited to stay, to sit at the back and work through the same problems. Sometimes you'd see a parent's hand go up 'I solved it!' and that simple moment shifted something fundamental. It changed the dynamics at home. Parents who might have viewed these sessions with skepticism or indifference began to see their child was not just passing time, but engaging with something genuinely stimulating and intellectually rich. The teachers had found a way to make Mathematics visible as a source of joy, not just to students, but to entire families.

Preparing for India's First IMO Team

You were part of India's very first IMO team in 1989. What did Olympiad preparation look like in those pioneering years?

In those days, awareness was minimal. When we wrote the state-level Olympiad around 1987, we did not even know for sure that selected students would go to an international competition because India had never participated before. There were just two stages: state and national and most of us saw these examinations as interesting opportunities rather than as a defined pathway.

The training structure was very different from today's multi-stage IOQM–RMO–INMO–camp pipeline. For our cohort, there were summer camps in Chennai and later at IISc Bengaluru, where the batch ahead of us also came, even though they

eventually 'missed the bus' for the IMO because they became too old by the time India officially joined. Since the numbers were tiny, we got highly personalised training from mentors like Shailesh Shirali, C. R. Pranesachar and Yogananda, who played a huge role in shaping our mathematical thinking.

You have spoken about monthly 'postal' assignments you received from mentors. How did that system work and what did it teach you?

For about a year before the final selection, our mentors would send us notes by post every month, each focussed on a topic that simply did not exist in school syllabi such as graph theory one month, group theory or Ramsey theory the next, number theory and combinatorics very often. Along with the notes came sets of problems; we had to work them out, write detailed solutions by hand and post them back for comments.

Two things were important here. First, many problems were open-ended, that is, there was no guarantee of a neat solution in the back of a book and the instruction from Dr. Shirali was essentially: 'Make as much progress as you can, explain your thinking and send it.' That is very close to research training: you do not always solve the problem, but you learn to attack it from different angles and recognise partial milestones worth reporting.

The Changing Landscape

Compared to that informal, exploratory era, today's Olympiad world looks highly structured and competitive. How do you view this transformation?

The ecosystem is completely different now. At that time there

were no coaching classes specifically for IIT or Olympiads; you mostly studied your subjects well and went for the examination. We prepared for the IMO largely with one serious problem book, 'Yaglom's Problems and Solutions in Mathematics' and whatever material came in those postal notes, with almost no access to past IMO papers.

Today, students may attend multiple specialised coaching classes every week, one for IIT, one for Olympiads, one for something else and there is an entire industry that claims to know the 'code' for these examinations. This has definitely improved performance; India's recent IMO results, with multiple golds and silvers, are far stronger than in the early years. But it has also shifted the motivation: many students now see Olympiads as another high-stakes gateway, not as an enjoyable exploration of Mathematics.

One recent development is IITs offering admission routes for Olympiad medallists. What is your view on this policy?

I feel it is entirely reasonable that institutions recognise Olympiad achievements; students who do well at that level clearly demonstrate a problem-solving mindset and deserve access to strong programmes even if they do not choose the standard JEE pattern. But the only caveat here is that it might increase parental pressure. The spirit of Olympiads should always be, 'My child loves problem-solving and wants to represent India' and not become, 'This is a way into an IIT seat.'

Historically, most students at national Olympiad level were there because they genuinely liked Mathematics; representing India was a dream, but the primary draw was the subject itself. If the route becomes heavily credential-driven, there is a risk that Olympiad training turns into yet another high-pressure coaching track, taking away the very freedom and joy that make deep problem-solving valuable.

Finding and nurturing 'hidden gems'

A key concern today is that many national-level students come from a few cities and schools with strong coaching ecosystems. How can we reach students outside these hubs?

Purely examination-based filters are insufficient because they reward speed, access and test familiarity rather than the way a student thinks. To identify 'hidden gems', students in a small town who could thrive at high-level problem-solving if given a chance, you need more local, personal structures where their thinking can be observed over time.

One approach is to build local bodies: Mathematics clubs or circles at city or district level that are not directly tied to selection. In such settings, mentors can watch how students approach problems, not just whether they get the final answer and slow-burning talent can emerge. This requires many more teachers and mentors, but it is far more equitable than relying only on high-stakes national examinations.

Can you share a bit more on what Math circles should look and feel like?

The goal should be to encourage discussion rather than just ranking. When twenty students sit together and only two 'stars' always answer first, the rest can quickly withdraw and decide they are 'not good at Mathematics'. Instead, in a good club, students are invited to share partial ideas, wrong turns and different approaches and those are valued openly by mentors.

Online forums modelled on platforms like Art of Problem

Solving can help here, especially if they include past Olympiad-style problems, moderated discussions and small rewards like books or mentoring sessions that recognise sustained engagement rather than just speed. But it is crucial that the forum itself is seen as the reward, a place to meet peers and think together and not simply as another selection filter.

Parents, Language and Making Informed Choices

Parents appear repeatedly in your story, from sitting at the back of Thane classes to worrying about IIT versus Olympiads today. How should parents engage with this world?

Parents can make or break a student's journey. In my case, because they literally sat in those early sessions and enjoyed the puzzles themselves, they saw that Mathematics could be fun and were more willing to support trips to camps in places like Chennai even if it meant missing some school tests. That early buy-in reduced the pressure to treat every activity purely as a stepping-stone to an examination.

Today, parents are often very invested, sometimes to the point of chasing achievements for five-year-olds and deeply anxious about the IIT/Olympiad trade-off. The most helpful thing for them is a realistic picture of career trajectories: stories of Indian mathematicians and scientists, not just Ramanujan but contemporary figures who have built satisfying lives in academia and beyond, so that choosing Mathematics or Physics does not feel like jumping into a void.

Language and access can also be barriers. Many students feel 'not good enough' because they are not fluent in English. What can be done about this?

The fact that my first puzzle books were in Marathi is important. It shows that deep problem-solving does not have to begin in English. With current technology, it is possible to create forums where students interact in their own languages, with real-time translation allowing them to access problems, hints and discussions in ways that feel natural.

Designing resources at appropriate levels, for example, structured notes on proof-writing, number theory or combinatorics, openly available and linked to diagnostics that identify strengths and weaknesses, can help students from non-elite backgrounds see a clear learning path. When combined with local circles and occasional offline camps, this can slowly build a culture where a student from any district can reasonably imagine progressing to national and international levels.

Research Careers and Role Models

You moved from being an IMO medallist to doing a PhD in physics and now mentoring Physics Olympiad teams. How did Olympiad training influence your research career?

Olympiad training taught me to be comfortable with not knowing the answer. Many of the monthly problems we received were intentionally unsolved or only partially understood and the instruction was to make progress, not to 'finish the problem'. That mindset is exactly what research demands: you

explore, hit dead ends, reach intermediate results that are still worth sharing and gradually build understanding.

It also broadened my view of what Mathematics could be. Topics like group theory, Ramsey theory and sophisticated number theory appeared long before any formal university course, so by the time I moved into theoretical physics, I already had a sense that there was a rich world of structures beyond school algebra and calculus.

From a policy perspective, many ask whether a mathematically inclined student should prioritise JEE, Olympiads or pure Mathematics. Is there a 'right' path?

There is no universal answer. Different students will be happy and productive in very different futures like research, industry, entrepreneurship or something else entirely. What education systems and mentors can do is help students self-identify what they genuinely enjoy and give them enough information and confidence to choose accordingly, rather than being swept along by a single narrative like 'IIT or nothing'.

Parents also need this perspective. Evidence suggests that people who end up doing what they truly like often do better than those who follow a standard route they do not care about. For that, visible role models matter: contemporary Indian mathematicians and physicists whose careers can be looked up, discussed at home and pointed to as examples beyond the lone figure of Ramanujan.

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A group photo of the first-ever INMO (Indian National Mathematical Olympiad) training camp, organised by Ramanujan Institute, Chennai, in 1987.

In essence, he argued that education systems, families and mentors should work together to open many different doors, so that every student who loves problem solving can find a path that fits both their talent and their happiness.

FROM PROF. DIGHE 'S CORNER

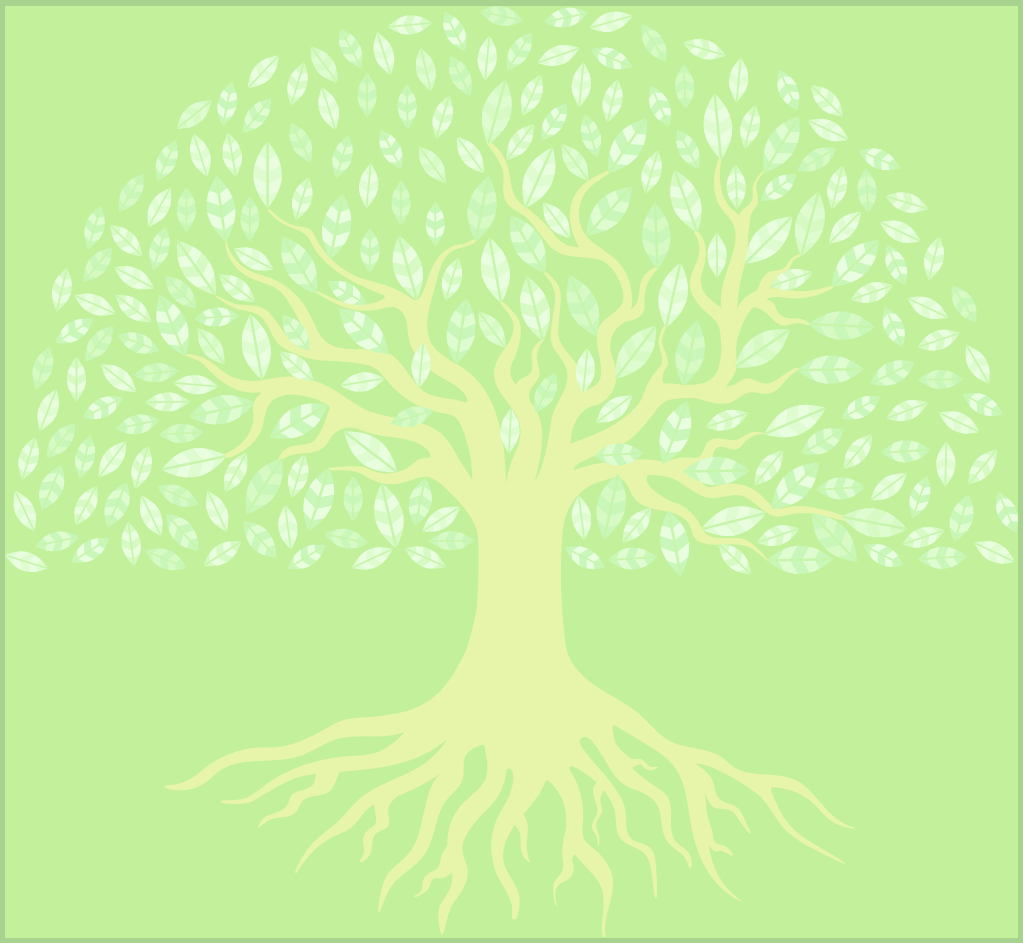
Q. Consider the number 4444^{4444}. Let $f(n)$ be the sum of the digits of n in decimal form. We define a sequence where each term is the sum of the digits of the previous term:

$$n_0 = 4444^{4444},\ n_1 = f(n_0),\ n_2 = f(n_1),\ldots$$

This process continues until a single-digit number is obtained. Find this final one-digit number.

Solution: p. 210

Building the System around Talent



Exceptional mathematical talent is not rare. What is rare is the institutional support to find it, nurture it and help it flourish. Across India, mathematical ability emerges in unexpected places, but without deliberate systems to identify and develop that potential, much of it remains untapped. Brilliance alone is not enough. What transforms individual capability into sustained achievement is the infrastructure built around it: trained mentors, accessible pathways, sustained programmes and institutions willing to invest long-term in uncertain outcomes.

The stories in this theme shift focus from individual achievement to the work of creating supportive ecosystems. They explore what happens when institutions design programmes knowing most participants won't become research mathematicians, when mentors commit to identifying talent in overlooked communities and when systems are built to outlast any single person's involvement. What emerges is an understanding that developing mathematical talent requires more than recognising brilliance. It requires building sustainable structures, training teachers and mentors, creating equitable access and maintaining programmes even when results aren't immediate. The question is not whether talent exists, but whether we will build the systems needed to help it grow.

"If we want excellence at scale, we must stop treating exceptional outcomes as accidents and start designing institutions that make them repeatable."



The Student Who Built the Ladder He Once Climbed: A Conversation with ANANT MUDGAL

Anant's journey is hardly a linear success story, despite his multiple medals at the International Mathematical Olympiad. It is about the growing realisation that individual excellence, while powerful, is ultimately shaped and sustained by institutions. From discovering Olympiads to studying at the Chennai Mathematical Institute and later at Cambridge, from stepping away from a PhD to proposing a problem for the IMO, Anant's path reveals something deeper. For him, Olympiads were never just competitions; they were gateways and over time, he moved from walking through those gateways to helping design them.

Curiosity before curriculum

Anant, before Olympiads and institutions entered the picture, what did Mathematics look like for you as a child?

In the very beginning, it did not feel anything like the conventional, classroom kind of Mathematics. It was more about exploration than memorisation. In Grade 2, my father would give me permutation-combinations and work-time puzzles from Grade 11 and 12 textbooks at the dinner table, not as formal lessons. He refused to teach formulae; he would pose open-ended questions and let me struggle for hours, get things wrong and slowly discover what was going on.

To me, school Mathematics meant multiplication tables and repetitive exercises, whereas these puzzles felt like cartoons or weekend entertainment. That distinction meant I associated difficult problems with play, not with marks or fear and that early framing made curiosity possible long before any syllabus or exam entered the scene.

Was there a moment at school when your way of thinking in Mathematics stood out, even before you knew how to solve complex problems formally?

One moment from Grade 5 remains very vivid. Our school had a local competition called the Aryabhatta exam and there were extra classes to prepare for it; I usually skipped those, but one day I wandered into a session where a teacher was explaining Heron's formula to a group of students much older than me. I understood nothing of the algebra and whilst others tried to manipulate formulae, I was simply watching in confusion.

Then the teacher asked, 'Given a triangle with sides 3, 4 and 7, what is its area?' Everyone began applying the formula, but I just raised my hand and said that this was not a triangle at all, so the question itself was vacuous. The teacher was delighted, because he was actually looking for exactly that kind of conceptual check, not mechanical computation and it was the first time I clearly felt that a system could value logical clarity over rote knowledge.

How did more demanding problems enter your journey with Mathematics and shape your relationship with success and failure?

In Grade 8, during another Aryabhatta cycle, a teacher shared a famous nested radical problem originally proposed by Ramanujan, essentially of the form $\sqrt{1 + 2\sqrt{1+ 3\sqrt{1 + \ldots}}}$ and mentioned in passing that it simplified to a surprisingly clean value. I spent an entire summer vacation thinking about it, noticed patterns and convinced myself the value was 3, but I had no rigorous proof and knew that my argument was incomplete.

The teacher had not expected anyone to get very far with it, yet he noticed the effort and gave me a copy of Mathematical Circles, a classic problem-solving book. I opened the first chapter and could not solve a single problem and that inability felt oddly exciting rather than demoralising, because it showed me there existed a world of questions far beyond my current reach and that failing on such questions was a sign I was pushing my boundaries.

From School Success to National Competition

How did your early encounters with school-level competitive exams shape your ambitions as you progressed through school?

In Grade 8, I first attempted the Regional Mathematical Olympiad (RMO) and missed the cut-off by a small margin, which hurt especially because I was doing exceptionally well in school examinations and had started to equate that success with true capability.

A few months later, I appeared for the Grade 8 Aryabhatta competition again, this time more serious and focused and out of roughly 2,000 students from 200-300 schools I secured first place with a comfortable lead of 79 marks compared with 72 for the second position.

That result made it clear that my performance was not a matter of luck; it signalled that at least within that ecosystem I was at the top. Once you reach the top of one ladder, you naturally begin to ask whether you are even on the right ladder and that led me to explore what lay beyond regional contests: the INMO exam, national camps, team selection tests and eventually the IMO, a progression that was not widely understood in my school at the time.

What was it like when you first entered the national Olympiad ecosystem and experienced how high the bar actually was?

When I qualified for the Indian National Mathematical Olympiad (INMO) camp for the first time, I had only a vague

idea of how the final IMO team of six was chosen; I had not even worked through the obvious fact that some selection had to happen between about sixty students at camp and the final team. At the camp, the practice tests already felt far more difficult than anything I had seen in the earlier Olympiad stages and soon I was facing weekly four-and-a-half-hour selection tests with three IMO-style problems.

Because I did not expect to make the team at all, I went into these weekly tests with curiosity rather than anxiety and simply tried to solve problems. That year, I ended up fifth out of six and joined the Indian team, which genuinely surprised me and recalibrated my sense of what 'hard' means in Mathematics, suggesting that structured exposure to much higher ceilings can be crucial for deep growth.

A Culture of Joy

How did the culture at the IMO compare with what you had experienced in domestic competitions?

Domestically, especially in those years, the environment around Olympiads could feel very rank-driven, with students and parents fixated on cut-offs and lists. When I went to the IMO, the atmosphere was very different: people from many countries gathering not to display superiority but genuinely to enjoy Mathematics together.

Students would discuss problems, exchange ideas and share stories of failure and success with very little ego and the dominant mood was joy rather than fear. That experience convinced me that the highest-performing ecosystems are often the ones that decouple status from learning and cultivate a culture where even elite competition is grounded in collaboration and intellectual delight.

Many past medallists say 'frictionlessness' acts as an invisible enabler when it comes to support from teachers or parents? What are your thoughts on this?

For me, frictionlessness meant that when I wanted to focus heavily on Mathematics, the school did not treat that as rebellion but as something legitimate that might require structural flexibility. If I needed permission to skip a history class in order to train, I would usually receive it and during critical phases I was allowed to spend eight to ten hours a day on Mathematics without constant pressure to distribute equal effort across all subjects.

There was no elaborate bureaucratic process to justify every request; teachers and administrators simply chose not to place obstacles between a genuinely interested student and his work. That decision changes everything, because whilst curiosity cannot be manufactured by policy, it can certainly be suffocated by rigid timetables, compulsory attendance in every class and a culture that treats deviation from the norm as disobedience rather than as a sign of emerging talent.

As your journey progressed, how did advice from peers and adults shape your decisions and what did you learn about navigating it?

One of the most striking patterns I noticed is that most advice people give is wrong not necessarily because of bad intentions but because it is based on their context rather than yours. Many of my classmates in Grade 9 told me to 'stop wasting time' on Olympiads and focus purely on JEE, because that was the path they understood and valued, even though it did not align with my interests.

Teachers were generally more supportive and less prescriptive, but even there, advice can easily be ten years out of date if the adult is not actively engaged with current educational

ecosystems. Over time, I came to believe that students need systems that help them develop discernment about advice: asking who is speaking, what incentives they have and whether their experience maps to the student's reality, rather than systems that push them to obey any single narrative about success.

What Olympiads really build

You have seen very intense parental pressure in both India and abroad. Why do you think pushing children too hard, especially around Olympiads, is such a dangerous strategy?

There are two levels to this. Rationally, it is a terrible bet. Only six students make the Indian IMO team out of roughly 150,000 who start at the first stage, so the probability of getting a direct material benefit from forcing a child into Olympiad training is extremely low compared with the emotional and time cost. If the sole goal is admissions or a foreign university brand, there are easier and less brutal routes.

Emotionally, the damage is deeper. When parents send the message that 'your life depends on what you do at 17', they create long-term insecurity and link love and respect to performance on a very narrow set of metrics. Even when the child succeeds, they often carry a sense of fragility rather than genuine confidence, because they believe their worth is conditional and temporary, which makes it harder to take wise risks or pivot later in life when circumstances change.

What do you see as the most valuable outcomes of an Olympiad journey?

The real value lies in the internal skills you build. Olympiad training forces you to sit with very hard problems for hours

without any guarantee of success and that repeated exposure builds comfort with uncertainty and develops a habit of thinking deeply rather than grabbing quick wins.

Over time, you gain a kind of meta-confidence, the belief that when you enter a new domain, whether pure Mathematics, machine learning, quantitative finance, or teaching, you will be able to orient yourself and solve difficult problems by reasoning carefully. That belief made it much easier for me to move from a PhD programme in pure Mathematics to quantitative trading in Singapore and later to entrepreneurship in education, because each transition felt like another hard problem to solve rather than a catastrophe.

The focus, therefore, should be on training mathematically talented students to develop a strong problem-solving mindset and perseverance; the rest will naturally follow.

Giving back to the ecosystem

Your journey did not end with your own participation at IMO. How did you transition into coaching and contributing to the wider Olympiad ecosystem?

Once my student years ended, it felt natural to continue working with the ecosystem that had nurtured me, partly out of gratitude and partly because there were obvious gaps I could help fill. Over time I became a leading coach for the Indian IMO team, served as an observer and coordinator for the past seven years and also proposed problems for IMO; one of my proposals became Problem 6 at IMO 2019, a slot reserved for one of the hardest problems on the paper, making me, as far as I know, the only Indian whose problem has been selected there.

I have also been involved in problem selection and coordination for the IMO 2025 in Australia, which has given me a vantage point on how different countries structure their training and alumni networks. The strongest teams rely not only on current teachers but on a long chain of former participants who come back as mentors, trainers and problem proposers, creating institutional memory and cultural continuity that keep standards high across generations.

You identified a specific gap in the Indian system around INMO qualifiers and decided to address it yourself. What did you do and what did you learn from that experience?

After being involved for a while, I noticed that students who qualified for INMO, already an impressive achievement, often lacked long-term structured support. They would have short formal camps, but there was not enough sustained engagement to help them internalise the habits required for genuine excellence and many drifted away despite having strong potential.

To help bridge that gap, I started an additional four-week camp for INMO qualifiers, completely voluntary and free. The camp focuses on deep problem-solving habits, mental endurance for long-format problems and exposure to varied thinking styles, often bringing in international trainers, so that students experience an extended period of low-pressure but high-intensity engagement with Mathematics rather than a single high-stakes camp.

Your own school, DPS Faridabad, has since become known for producing strong Olympiad performers. How did that institutional transformation unfold from your perspective?

When I was starting out, DPS Faridabad had some local culture through competitions like Aryabhatta but very little direct experience with the IMO ladder; apart from a rare example

like Vipul Nayak in the wider DPS system, nobody around me really knew what happened after INMO. As I progressed from doing well in Aryabhatta to topping Delhi RMO, ranking in the top five nationally in INMO and then representing India at the IMO, the school's view of what was possible shifted.

Teachers began actively speaking about Olympiad pathways, younger students heard concrete stories and started aiming for higher stages earlier and the administration institutionalised the kind of flexibility that had initially been granted to me. Over the years, this helped DPS Faridabad become a consistent source of strong performers at national and international Mathematics competitions, illustrating how one breakthrough can trigger a culture change that outlasts any individual.

From Contest Problems to Real-World Impact

You have argued that the skills from Olympiad training are under-utilised after school. How do you think systems should connect Olympiad talent to the broader world?

Students who reach high levels in Olympiads develop the ability to handle abstraction, learn new areas quickly and remain calm when facing ambiguous or unfamiliar problems. These attributes are extremely valuable in fields such as artificial intelligence, quantitative finance, complex engineering, data science and policy work, yet there are very few formal pathways that connect Olympiad alumni to these environments early.

Having worked at a quantitative trading firm in Singapore, I have seen first-hand how much value such firms place on

deep problem-solving ability. Creating structured internships, apprenticeships and research attachments for INMO and IMO-level students with cutting-edge laboratories, companies and institutes would help ensure that the public and private investment in identifying talent translates into real-world impact rather than remaining trapped inside a narrow examination circuit.

How does Mathelots reflect what you have learnt about talent, systems and the limitations of traditional education models?

Mathelots grew out of the belief that content, culture and continuity matter more than flashy delivery technology in education. Many platforms focus on high-definition videos and elaborate dashboards, but if the problems are shallow and the pedagogy does not encourage independent thinking, the outcomes remain limited.

Our aim is to create an ecosystem that gives students access to genuinely challenging material, builds a frictionless environment where curious children can go deeper without unnecessary obstacles and links stages of growth, from early curiosity in middle school to contest preparation in secondary years and to broader applications afterwards. Interestingly, many of our early students have come from outside India, from the United States, Europe, Singapore, even though those regions already have strong ecosystems, suggesting that India can be a global leader in mathematical education when it designs explicitly around talent rather than merely copying existing models.

Looking back across your journey, from early puzzles to IMO medals, from research and industry to mentorship and institution-building, what core principle about talent and systems would you like educators and policymakers to remember?

At every stage of my journey, the key was not an exam but an environment that made sustained thinking possible. If there is one principle to remember, it is that excellence survives and multiplies when systems remove unnecessary friction, provide long-term mentorship, preserve institutional memory and create meaningful pathways from contests to real-world problems. Exams may identify talent once, but only well-designed systems can honour it repeatedly and in the long run those systems matter far more than any single medal.

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This story is not about producing medallists. It is about designing environments where thinking is safe, difficulty is meaningful and success is followed by deeper opportunity.

FROM ANANT'S CORNER

Q. Initially, 2026 stones are in a single pile. We maintain a score starting with the initial value of 0. In a given move, you can take any pile of stones with k stones and split it into two piles of a and b stones respectively, such that $a, b \geq 1$ and $a + b = k$. After performing the split, you add the product $a \times b$ to your total score.

You continue these moves in any way you want until no more moves are possible (i.e., all piles have exactly 1 stone).

1. What is the final value of the score?
2. Prove that the final score is independent of the sequence of moves or the sizes of the piles created during the process.

Solution: p. 211

"If you build strong institutions, talent will take care of itself."



The Architect of Quiet Revolutions: A Conversation with PROF. AMITABHA TRIPATHI

Some institutional narratives are built not on dramatic breakthroughs but on steady, thoughtful work. Prof. Amitabha Tripathi's journey is one such story. As Regional Coordinator, Delhi, for the Mathematical Olympiads for 16 years and a long-time contributor to India's Olympiad ecosystem, he has built systems that identify and nurture mathematical talent whilst creating pathways for students who might otherwise be overlooked. His work reveals a fundamental truth: exceptional talent exists everywhere, but without strong institutions to find it, support it and create opportunities for it to flourish, that potential remains untapped.

How Systems Take Shape

How did you first become involved with building India's Olympiad infrastructure and what did you learn about the state of mathematical talent when you began?

I came back to India in 1991 after my PhD. At an international conference-cum-workshop held at Indian Institute of Science Bangalore in 1993 or 1994, senior mathematicians at IMOTC, like C. R. Pranesachar, B. J. Venkatachala and C. S. Yogananda, who were amongst the founders of India's Olympiad programme noticed my interest in elementary problems and invited me to contribute, with an eye on the IMO 1995 that was due to be held in my home city, Delhi. In 2000, I became the Delhi Regional Coordinator, a role I held for 16 years. That position taught me something crucial: individual brilliance matters, but institutional systems matter more. A single inspired teacher can change a few lives. A well-designed system can change thousands.

That said, we were missing most of it. Students lacked exposure. Teachers had limited training. Materials weren't always suitable. Many students who could have done well never even reached the first stage because the system wasn't designed to find them. In Delhi alone, I saw gifted students who had no idea such competitions existed.

How did you approach building stronger processes in the Delhi region and why was that approach significant?

I wanted to start by improving the basics and creating structures that would outlast any individual. Better tests, better evaluation, more teacher involvement and more contact with students. But the key innovation was creating a sustainable mentorship model. I organised three-hour Camps for the RMO at various

schools over the years, inviting around 100 teachers and students from ten schools, choosing different institutions each time. This greatly increased awareness in the RMO in schools in Delhi & NCR. For the top 30 to 35 Delhi Region winners, I followed this up with an intense, week-long training camp. We would meet at Vasant Valley School or IIT Delhi for six hours a day across five or six days. The crucial part was that I would bring in past winners to teach students who had been through the system two or three years earlier. Many of them came to IIT Delhi, so we had a ready pool of trained mentors.

This approach created a self-sustaining cycle more than anything else. Students listen more carefully to people slightly older than them than to people much older than them, like I was. These past winners could communicate well and had something to give back. They understood the struggles because they'd lived them recently. But more importantly, this wasn't dependent on my presence. The system could continue even after I left. That is what institutional thinking means. You don't build something around one person. You build something that continues regardless of Who is in charge.

What were the results of this approach?

Delhi Region consistently sent between three and seven students to the top 30 of India, to the IMOTC. That is not because Delhi students are particularly gifted. It is because of systematic training. When you give students the right guidance, the right materials and a structured pathway from regional to national level, talent emerges. But none of this was about me being a brilliant coordinator. It was about creating consistent practices that worked.

The Cost of Volunteer Systems

You mentioned that sustainability was crucial. What happens when systems depend too heavily on volunteers?

They fail. Or they succeed only sporadically. I tried training teachers across Delhi schools. We would bring in groups from

different schools, give them books and provide training. The idea was that they'd take this back and continue the work in their schools. But every single teacher told me the same thing: they were too busy with the curriculum. They did not have time. I realised then that we were asking too many people who were already overburdened. The training was wasted because the system did not support them to use it.

What would be a more sustainable alternative to this volunteer-based model?

Full-time mentors whose careers are built around talent development, not volunteers squeezing this in around other jobs. People who wake up every day and know their job is to identify and nurture mathematical talent. That requires funding and vision. You need to pay these mentors properly, give them job security and build their roles into the educational infrastructure.

What can India learn from how other countries structure these opportunities and how would that translate to the Indian context?

The United States offers a slightly clearer model. They are not perfect either, but in every community, you find gifted student programmes run by trained educators, often people with degrees in Mathematics Education. My wife is one such person. After doing an MPhil in Functional Analysis, she chose to pursue a PhD in Mathematics Education instead. She is sought after because there is a career pathway for this work. These educators identify talent early, in Grades 4, 5 and 6 and mentor small groups over many years. They're not volunteers. This is their profession.

For India, we would need to adapt it to our context. Start with ten large cities. Establish full-time mentors in each location. Give them the resources to run programmes from class 4

onwards, not starting at Grade 10, when it is already quite late. Create structured pathways so students know that if they show promise, there is a system to support them over years, not just for one competition. Most importantly, make this a viable career. If you tell talented Mathematics graduates, they can earn a decent living nurturing the next generation, you will find people willing to do this work.

How should one address parents' concerns about career security in Mathematics?

A parent will ask, "What's the future in Mathematics?" And currently, we don't have a good answer. What future do students who show promise in competitions have? If we want parents to support their children's mathematical interests, we need to show them career pathways beyond just academia or coaching centres. That means building institutions that employ mathematicians in diverse roles: curriculum design, educational technology, talent programmes, policy work. The opportunities need to be visible and viable.

Building a Broader Ecosystem

How do we create opportunities for students beyond the existing competitive pathways?

That is where real work needs to happen. When I think about creating opportunities, I think about the thousands of students who never make it to competitions, but who could develop genuine mathematical thinking if the teaching were better. A strong ecosystem is wide at the base. You need good school teaching, accessible materials and teachers who enjoy Mathematics. The goal is to make Mathematics less intimidating, more accessible to everyone.

How do we improve that teaching on a scale?

Training and support for teachers is crucial. Good teaching at the school level will shape more students than competitions ever will. But teachers need more than a one-off workshop. They need ongoing support, better materials, reasonable workloads and recognition for their efforts. One of my own teachers, Mr. Pradeep Narain, taught Mathematics at Delhi University for almost 50 years with zero interest in research, by his own admission. His satisfaction came purely from seeing students understand. When I typeset his book on Real Analysis recently, I thought about how we need more people like him, people whose entire career is built around excellence in teaching. We need to value and support that choice.

What Must Be Built

From your experience, what does India need most urgently and how important is early identification in this system?

Funding and vision are central. Strong institutions come from long-term investment. You can't build this on sporadic donations or volunteer goodwill. Mentors must feel secure in their roles. Teachers need support and training. Talented students need visible and viable career pathways. Without those foundations, programmes cannot sustain themselves.

However, identification is essential to the success of these programmes. Class 10 is too late. Many students show promise much earlier, but our system isn't designed to notice it. We need structured programmes that engage students from class 4 or 5 onwards. Not intense competition immediately, but exposure to mathematical thinking, good problems and the joy of discovery. Then, as students' progress, increasingly

sophisticated support. The key is continuity over many years, not sudden intensive preparation at one stage.

Are these achievable given India's scale and diversity?

Yes, but it requires accepting that this is infrastructure, not charity. Just as we invest in physical infrastructure, we need to invest in intellectual infrastructure. Start with major cities. Build models that work. Scale gradually. Train people whose careers are in talent development. Create partnerships between schools, universities and industry. Most importantly, measure success not just by medal counts but by how many students develop genuine mathematical capability and find meaningful careers using it.

The students I have worked with over the years proved the potential is there. What's missing is the institutional support to find that potential systematically, nurture it consistently and create genuine opportunities for all students who show mathematical promise.

What gives you confidence that India can build these systems?

I have seen what's possible even with limited resources. Delhi's results during my coordination came from better systems, not better students. If that is achievable in one region with volunteer effort, imagine what's possible with proper institutional support across the country. Talent exists - the question is whether we'll build the institutions to find it, nurture it and create opportunities for it to contribute. That is not a question of capability - It is a question of commitment.

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Prof. Amitabha Tripathi's 16 years building Delhi's Olympiad infrastructure offers a blueprint for creating opportunities at scale. From structured training camps that turned past winners into mentors, to honest assessments of what volunteer systems can achieve, his work demonstrates that finding and nurturing talent requires more than goodwill. It requires sustained investment, professional mentors, clear career pathways and institutional structures designed to outlast any individual. As India seeks to build a stronger mathematical ecosystem, his experience reminds us that exceptional talent is not rare. What's rare is the institutional support to help it flourish.

FROM PROF. AMITABHA'S CORNER

Q. Let a and b be positive integers such that $ab + 1$ divides $a^2 + b^2$. Show that $\frac{a^2 + b^2}{ab + 1}$ is the square of an integer.

Solution: p. 212

"We emphasise individual contributions a lot in Mathematics, but it is actually community that matters more. The fact that you have people who are supporting you: that makes the difference."



Exceptions to the Rule: A Conversation with PROF. KARTIK PRASANNA

Prof. Kartik Prasanna did not plan to become a mathematician. He was three years into a chemistry degree at IIT Bombay when he realised he had fallen for the wrong subject. What followed required a small army of rule-breakers: an institute that invented a new degree pathway, a professor who rescheduled his class for one student and a group of TIFR mathematicians who had spent years running summer programmes for 30 students. Today, as a professor at the University of Michigan, he is proof that institutional impact is rarely efficient. Sometimes it takes investing in 30 students to produce one mathematician.

From Olympiad Curiosity to Mathematical Community

Prof. Kartik, tell us about your initial exposure to mathematical problem-solving beyond the classroom and what resources were available to students in the early 1990s before the internet transformed access to educational materials?

My mother was a college Math professor. Sometimes, when I was in Grade 9, one of my mother's colleagues gave me a question paper for the Gujarat Regional Math Olympiad. I enjoyed working on those problems and that is how I got introduced to it. I took INMO in Grade 10 and qualified for the IMO camps, which I attended after both Grades 11 and 12.

We had some resources, such as a Russian book with hundreds of geometry problems. Honestly, I was too lazy to do hundreds of problems. But the real constraint wasn't materials; it was time. Most of us were preparing for the IIT exam as well. In my batch, IIT Bombay took in only 300 students. It was incredibly competitive and that consumed most of our preparation time. We would have about a month each year to prepare specifically for the IMO.

Did the Olympiad experience draw you towards Mathematics as a career, or was there something else that shaped that decision?

To be honest, the Olympiad Math itself did not excite me that much in terms of considering a career in Mathematics. It is based only on high school Mathematics, a very small part of what the subject actually is. I did not know what advanced Math was about. It was really what came after the Olympiad that changed everything.

The Programme That Changed Everything

Can you please share more about that moment of change after you attended the Olympiad camps?

Around that time, the mathematicians involved in the Olympiad programme were getting worried. Most students who went to the IMO did not end up doing Mathematics and for them, attracting students to Mathematics was a key goal. Starting with my batch, they created the Nurture Programme. Every summer, we would go to one of the research institutes (for us, it was TIFR) and spend a few weeks there. They taught us more advanced Mathematics and gave us scholarships to study on the side during the year.

What was TIFR like for an undergraduate student and how did this experience influence your decision to pursue Mathematics?

TIFR was magical to visit. It is by the sea, absolutely gorgeous. Staying there for six weeks felt like staying in a five-star hotel. But beyond that, there was this equality amongst people. Professors like Nitin Nitsure and V. Srinivas did not treat you like you were lower in some hierarchy. Everyone was just talking about Math. That culture left a deep impression on me.

You were a chemistry major at IIT Bombay at the time. How did that work?

I was in a five-year MSc chemistry programme. But after going to TIFR and talking to mathematicians there, I knew I wanted to do Mathematics. The problem was there wasn't a good option to switch. But then IIT Bombay came up with an unusual solution: I could finish three years in chemistry, then

do two years of their MSc Mathematics and they would give me a five-year Mathematics degree. They had to change the rules to let me do this.

One Out of Thirty

How many students were in the Nurture Programme with you?

Our IMO camp batch had thirty students, all invited to the Nurture programme. Every year, fewer and fewer would come. In the final year, it was just me and Venkatesan Guruswamy (he's now a well-known theoretical computer scientist at Berkeley). Eventually, I was the only one who moved to Mathematics.

Did the people running the programme see that as worthwhile?

That is what impressed me the most. They spent all this time and effort and for them, it was still worth it. Professor Raghunathan, who headed NBHM, was instrumental. Prof. Nitin Nitsure, Prof. V. Srinivas, Prof. Balwant Singh: all these people wrote letters of recommendation, helped me make the move to Mathematics. They genuinely supported my journey.

You've mentioned Professor Jugal Verma at IIT Bombay as particularly significant in your development. Can you share more about his mentorship?

The first advanced Math class I took at IIT was commutative algebra with him and he was very inspiring. I remember I had a scheduling conflict: his class was in the same slot as something else I had to take. I went and asked him if he could change the slot. And he did it only for me, even though I was just an undergrad and not even in the Math programme. IIT

was flexible in that way; professors could do things like that if they were willing. The professors in the administration at IIT Bombay were also incredibly helpful: Professor Balmohan Limaye (the Math department head), Professor Dipan Ghosh (the Dean of students) and Professor Suhas Sukhatme (the Institute director) all supported my transition to Mathematics and helped make it possible.

What Institutions Can and Cannot Do

Having spent decades in academic institutions in both India and the United States, what observations can you share about how institutions create opportunity and what institutional changes might help India develop more mathematical talent?

The most important thing in Math is mentors and teachers. You can give somebody resources, but what really matters is human connection. We emphasise individual contributions a lot in Mathematics, but it is actually community that matters more. The fact that you have people who are supporting you, willing to help: that makes the difference.

I don't think the government alone can solve this. We need private-public partnerships, private universities that can move faster, hire people from outside the country and pay competitive salaries. Private universities like Ashoka University can put pressure on public ones to step up. And we need to create world-class undergraduate programmes where students come into contact with faculty who are actively doing research.

You've mentioned retirement age at government institutions as a lost opportunity. Can you elaborate on this?

Yes, this matters enormously. In the United States, there is no retirement age: you can work as long as you want. I love teaching and doing Mathematics; I don't plan to retire unless I absolutely need to. In India, government institutions force retirement at 60. It is demoralising and it makes it harder to attract talent. Private universities don't have that constraint and that is a significant advantage.

Making Mathematics Visible

Most students don't even know that research Mathematics exists as a career. How do we change that?

Here is my suggestion. I think that we are not using social media enough. It is the cheapest way to spread the word since students are on their phones all the while.

There is hunger to learn everywhere. Young people especially want to learn new things. But of course a lot of stuff they're seeing on social media is rubbish. There is positive social media, there are YouTube channels that do teach useful things. But are we somehow bringing that in front of young people?

So what you can do is you can create an interesting mix of short-form and long-form content and use advertising to reach young people across the country. And I think that would be a cost-effective way to actually get through to them. I think what's important is not to push this idea of research as much as to just show them what's out there, to show them what's interesting.

It is crucial to focus on creating really interesting content.

Because if you look at YouTube or something like that, it is the content that is really most important and people flock to that. And so to the extent that we can make interesting content that young people will like and then use some kind of advertising to bring it in front of them, we can make a difference.

Everybody has a phone. And if you promote the right channels for these young people, that is a possibility.

Creating Doors for Others

Someone once opened an unexpected door for you. Have you been able to create similar opportunities for others and what have you learnt about the conditions that allow students to seek and receive help?

I try. One thing I have learnt is that students need to know that they can ask for help. I had a student recently who was applying to graduate programmes. When I asked why he had not applied to certain top universities, he said the deadlines were earlier and he did not have money for the application fees. Something that simple. We gave him a monetary award so he could apply wherever he wanted and he got into one of his top choices.

Being a parent helped me understand this. These are still young people, even if they're undergraduates. They need mentoring, they need to feel they can talk to you about their problems. The tricky thing is you can't help someone who doesn't ask. So you try to create a conducive environment: be approachable, be genuinely interested in their welfare. The institutional resources exist; the challenge is making sure students know they can access them.

What message would you give to those working to expand mathematical opportunities in India?

All of modern life depends on Mathematics in ways we take for granted: technology, medicine and communication. If we improve the mathematical training of our population, it will yield tremendous benefits for the country. So I would say: don't focus narrowly on producing research mathematicians. Focus on making Mathematics accessible and interesting to everyone. If you do that, you will automatically find talented students who want to go deeper. The goal should be a more mathematically literate population. Everything else follows from that.

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Prof. Kartik Prasanna's journey, from a chemistry student at IIT Bombay to a number theorist at the University of Michigan, was not inevitable. It required institutions willing to bend their rules, mentors willing to invest years in uncertain outcomes and a programme that considered one mathematician out of thirty a success worth celebrating. His story reminds us that institutional impact is not always about scale. Sometimes it is about the small, stubborn acts of faith: a professor who changes a class slot, a committee that rewrites admission rules, a group of mathematicians who keep teaching summer after summer even as students drift away. These are the doors that don't exist until someone decides to build them.

FROM PROF. KARTIK'S CORNER

Problem: Let n be a positive integer and let $N = (5^n - 1)/2$. Show that for all $n \geq 2$, the integer

$$\binom{N}{0} - \binom{N}{2} + \binom{N}{10} - \binom{N}{12}$$

is divisible by 25.

Solution: p. 213

"You cannot start with the aim of producing medallists or next-generation innovators. You must start by building a robust culture of problem-solving, exploration and problem posing and the rest will follow."



Opening the Circle of Opportunity: A Conversation with DR. SHAILESH SHIRALI

Among the pioneers behind India's first step into the International Mathematical Olympiad in 1989 was Dr. Shailesh Shirali, then a young Mathematics enthusiast working with limited resources, yet guided by a deep conviction that problem-solving and the beauty of Mathematics could transform how children experienced the subject. Over the decades, Dr. Shirali has worn many hats: National Olympiad mentor and problem setter, school principal, author, magazine editor and founder of the Community Mathematics Centre at Rishi Valley. However, through it all, his central concern has remained constant: to build systems that do not merely produce a few star performers, but nurture a culture of curiosity, exploration and collaboration in Mathematics across the country.

The Power of Mathematical Storytelling

Dr. Shirali, what strikes me most is that you were not a typical Olympiad prodigy. Your engagement with Mathematics began relatively late. Could you take us back to those early years?

My mathematical journey was anything but linear or system-supported. As a school student, I loved Mathematics, but that love came from problem-solving rather than competitive examinations. There were no Mathematics clubs, no circles, no coaching. This was long before Olympiads had any presence in India.

I did have a couple of particularly good teachers who showed me that Mathematics could be intellectually alive, not just mechanical. Formally, however, my academic path moved away from Mathematics. I studied physics at university and later even moved out of the sciences. The irony is that my real mathematical growth began only after my PhD, when I started teaching Mathematics and realised how much I did not know.

How did you explore problem-solving in those days?

Very slowly and largely in isolation. I was working in a geographically remote campus in the pre-internet era. Books and journals were hard to obtain and there was almost no peer group with whom I could discuss mathematics. I learnt by collecting whatever material I could find, reading it carefully and then trying to teach it, first to myself, then to students.

That experience shaped my thinking for life. When one has personally felt what it means not to have access to good resource

material, one cannot forget it. Producing good problems and explorations is hard. But without systems that can actually move these resources into classrooms and make them accessible to individuals, even the best materials remain unused and the effort comes to nothing.

Which ideas or people helped you stay connected to Mathematics as something beautiful?

One name stands out: Martin Gardner. His columns in Scientific American and his books showed that Mathematics could be playful, surprising, even whimsical and yet profound. For many of my generation, his writings were a lifeline.

Those pieces were not examination preparation. They were invitations to explore. A simple puzzle, a card trick or a curious paradox could become a doorway into serious Mathematics. The sense of wonder that 'There is a beautiful idea behind every problem; let me uncover it' is what I want every child and teacher to experience.

This influence pushed me towards mathematical writing and editing. Along with colleagues, I helped start Samasya, a small problem-solving magazine. Later, I started the magazine At Right Angles and more recently, The Compass. The intended audience has never been limited to 'elite Olympiad students' but includes schoolteachers, curious students who may never attempt an Olympiad and adults who simply enjoy thinking deeply about Mathematics.

But one obstacle remains constant: distribution. Writing good content is hard, but getting that material into thousands of schools is far more difficult. Without institutional backing from governments, large foundations or school systems, even excellent content remains invisible.

The Birth of the Olympiad Movement

How did India's Olympiad journey actually begin?

In the mid-1980s, India had no real Olympiad pipeline. Around 1987–88, some mathematicians and educators asked, 'Why should not India participate seriously in the IMO?' This was not a government directive; it emerged organically from conversations within the mathematical community. Everything from identifying students to designing training programmes had to be built from scratch.

In 1989, India sent its first team to the IMO in Braunschweig. A small group of mentors like C. R. Pranesachar, B. J. Venkatachala, C. S. Yogananda and myself believed that if we worked with students seriously, results would follow.

Initially, participation was tiny. We did not know how many students were interested. Slowly, we began creating materials, conducting regional tests and gradually building a structure.

The most persistent challenge, even today, is cultural. In most schools, Mathematics is taught as a set of steps for solving standard problems. There is almost no space for exploration. When students first encounter Olympiad problems, they often freeze, waiting for the teacher to give them the method. The idea that they should wrestle with the problem independently feels strange.

This is why I believe strongly in long-term Mathematics circles, not just short-term coaching. A Mathematics circle is a regular gathering where students, teachers and researchers explore problems together. There is no pressure to cover a syllabus. The

focus is on ideas, on thinking aloud, on learning from mistakes. Over time, participants develop a taste for mathematical beauty and a tolerance for ambiguity.

Over three decades, India's IMO performance has improved substantially. We now regularly win medals. What do you make of that progress?

It is encouraging, certainly. But medals alone do not tell the full story. What matters more: Are we creating a culture where mathematical curiosity is valued for its own sake? Are we reaching students beyond metro cities? Are we building pathways for those who want to become mathematicians, not just engineers?

If all we do is produce a few medallists each year without broadening the base, we are missing the larger opportunity.

What would broadening the base look like in practice?

It means several things working together. First, we must start early, at the middle school level, with playful activities: puzzles, games and visual explorations that show Mathematics as a creative endeavour rather than formulas to memorise.

Second, we need infrastructure for access. This means problem sets and solutions available in multiple Indian languages, not just English. It means training a large cadre of mentors who can work in schools and communities, not just expensive coaching centres. It means creating both online and offline spaces where students can share ideas and get feedback.

But perhaps most importantly, it means changing how we measure success. Right now, success is narrowly defined by rank, marks and medals. We need a broader vision that values collaboration over competition, curiosity over rote learning and long-term mathematical growth over short-term performance.

You have mentioned language and examination culture as barriers. Could you elaborate?

Much of the Olympiad ecosystem operates in English. For a student from a Tamil-medium or Hindi-medium school, this can be an invisible but insurmountable barrier. I have heard cases where a student could understand Mathematics but stumbled because they did not know the meaning of a single English word in the problem statement. They might internalise this as 'I am not good at Mathematics' when the real issue is vocabulary, not ability.

The examination system is another barrier. Everything in India is geared towards boards, JEE and other entrance tests, leaving little mental space for exploration. When everything is about high-stakes examinations, teachers and parents naturally ask, 'How will this help with marks?' Anything not examinable gets pushed aside.

This is not the fault of teachers. If we want students to spend time on open-ended problems, then it is our responsibility to correct the situation. Parents need to understand and be convinced that there is value in activities that do not immediately translate into marks. Teachers need support and access to good resources. Finally, schools need flexibility and that requires systemic support.

When Students Surprise the Teacher

You have shared stories of students surprising you with unexpected insights. Could you tell us one?

Yes. One involves a Grade 8 girl in a Mathematics club. We were working on the well-known 3 × 3 magic square using numbers 1 to 9. We know the total sum is 45, so each row, column and diagonal must sum to 15. The question was: what must the centre number be?

Initially, students argued that since 5 is the middle of 1 to 9, it ought to be in the centre. This is pseudo-logic! I coaxed them to justify this more rigorously.

One girl found an argument I had never seen. She said: 'Suppose the central number is 1. Somewhere in the outer ring is a 2. On the line containing 1 and 2 we have 1 + 2 = 3, so the third number would have to be 12 to reach 15, which is impossible as the largest number is 9. Using the same logic, 2, 3, 4, 6, 7, 8, 9 can all be ruled out. The only number that survives is 5.'

It was a perfectly rigorous, elementary proof but completely different from my own. Since then, I have often used her method in talks. It is a constant reminder that when students are given space to think, they can enrich the teacher's Mathematics, not just the other way around.

Another example: a Grade 11 student asked about the iteration for approximating $\sqrt{2}$. Start with a guess x, compute $(x+2)/(x+1)$, repeat. This was an approach I had not seen before. I had to examine the procedure carefully to understand why it worked. These moments teach humility. As a teacher, you might have more experience, but you do not have a monopoly on insight. If you create a space where a student's question is treated as a gift rather than an interruption, the quality of thinking improves for everyone.

What do you see as the core problem in Mathematics teaching?

Most school Mathematics is taught as a set of algorithms. Here

is a problem type. Here is the method. Apply it. Get the answer. Move on. This is efficient for covering syllabi and examinations, but it is mathematically dead. There is no sense of why the method works, where it came from or how it connects to other ideas.

As a result, students see Mathematics as arbitrary. They memorise procedures without understanding them. When they encounter a problem that does not fit a known template, they have no tools to approach it.

Is this a failure of curriculum or teacher training?

Both. The curriculum is often overloaded with topics, leaving no time for depth. And teacher training, if it happens at all, focuses on content knowledge, not on pedagogy or the mathematical thinking process.

I do not blame the teachers. Many are overworked, underpaid and under-supported. The problems lie in our attitudes. If we want better teaching, we need to invest in teachers: proper training, ongoing professional development, lighter workloads and communities of practice where they can learn from each other.

In my teacher workshops, I try to model the kind of teaching I would like to see. We work on problems together. I ask questions, not just give answers. I show that it is okay to be uncertain, to try something and revise it, to learn from mistakes. I emphasise that a teacher should be able to explain a concept in multiple ways: algebraically, geometrically, numerically and through examples. Different students understand in different ways.

And I stress the value of encouraging questions. When a student asks 'why,' that is a sign of engagement. The worst thing a teacher can do is shut down that curiosity with 'because the textbook says so' or 'you will understand later.'

Mathematics Circles and Mentoring

What makes Mathematics circles effective?

A Mathematics circle is not a lecture or coaching class. It is a community. Students come together regularly to explore problems, share ideas and learn from each other. There is no syllabus to cover, no examination to prepare for. The focus is on thinking and enjoying Mathematics.

What makes this powerful is continuity. Over months and years, students develop mathematical maturity. They learn to persevere with hard problems, communicate their ideas clearly and see Mathematics as a collaborative endeavour, not a solitary struggle.

Mentors play a crucial role. A good mentor is not someone who always has the answer. A good mentor listens, asks probing questions, celebrates a student's insight and knows when to step back and let students struggle productively.

What about creating pathways for students to return as mentors?

This creates a virtuous cycle. A student who has benefited from mentoring understands its value. When they return as a mentor, they bring fresh energy and can relate to younger students in ways that older adults cannot.

Moreover, mentoring is itself a learning experience. Explaining a concept to someone else deepens your understanding. If we can normalise the idea that every student who goes through the Olympiad pipeline should, at some point, give

back by mentoring others, we create a sustainable ecosystem that becomes self-renewing rather than dependent on a few individuals.

Teachers and the Courage to Admit 'I Do Not Know'

What is the real bottleneck in building systems around mathematical talent?

The bottleneck is not student ability. It is teacher confidence. India has no shortage of bright children. What we lack are enough adults who feel comfortable handling non-routine problems, open-ended explorations and awkward questions.

To be a good mentor, it is not enough to know more Mathematics than the students. Equally important is a genuine interest in children: how they think, where they get stuck, what excites them. One must be willing to look inside the student's mind and start from there, rather than from the textbook.

And this leads to a delicate point: the ability of the teacher to say, 'I do not know.' At the university level, this is natural. Researchers constantly say, 'I do not know. Let us find out.' But at the school level, we expect the teacher to be infallible and regard an admission of ignorance as a loss of authority. Many teachers instinctively avoid open problems because they cannot risk not having an answer.

How can we change that?

Teacher development must address mindset, not just

content. Universities like CMI, IISERs, NISER and TIFR could systematically train their students in mathematical communication and outreach. Institutions can create a recognised track for mathematically strong graduates who want to work in schools or outreach rather than mainstream academia. Their work should be respected, funded and connected to national programmes.

If we can build a cadre of mentors who themselves enjoy not knowing, who treat a student's surprising idea as a gift rather than a threat, the culture will shift.

Building Inclusive Systems

Suppose a state government or large foundation asks you, 'We want to build systems around mathematical talent. Where should we begin?' What would you tell them?

Building a culture of mathematical thinking means reimagining how children, teachers and institutions relate to Mathematics over many years, not just preparing for competitive examinations.

It must start gently in upper primary and middle school, where students play with puzzles, games and open explorations so that Mathematics feels joyful, surprising and creative rather than a race through the syllabus. As they grow, they can be introduced to non-routine problem-solving, teaching them that struggle is normal and not knowing the answer immediately is part of thinking.

Schools and districts can host Mathematics circles that bring together students, researchers and experienced teachers, creating local communities where deep ideas are explored for pleasure.

For those who show strong interest, structured year-long enrichment programmes with opportunities to return as junior mentors can offer continuity and progression. At the same time, high-potential students from low-resourced backgrounds need low-cost, multilingual booklets, magazines and problem collections pushed through textbooks, government tablets and teacher portals so that rich material actually reaches their classrooms.

Underpinning all this, the state must invest in building a large cadre of teachers who understand what teaching is in its fullness and love teaching, who have strong foundations in Mathematics and the sciences and the languages and who have a deep desire to learn. Without such teachers it is unrealistic to hope for any kind of future for this country. Nor can we hope to nurture leaders, innovators and scientists who have a love of learning.

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In the end, Dr. Shirali's story is a lifelong shift: from solitary curiosity, to mentoring a handful of students, to helping build national infrastructure that others now inhabit and extend.

FROM DR. SHIRALI'S CORNER

Q: Find a way of generating all positive integers n such that

$$n \mid 2^n + 1$$

That is, n divides $2^n + 1$.

Solution: p. 215

Concluding Reflections

What defines a mathematical genius? Is it innate talent, relentless hard work or rare opportunity? Or is it an abstract notion - something that evades simple definition but can be deeply felt? The journeys of India's finest problem-solvers gathered in this book offer something clearer than any single definition could. They reveal a pattern: a story composed of **Constants**, the spirit of excellence that appears remarkably unchanged in almost every account of success and **Variables**, the systemic and circumstantial factors that either amplify or silence the very same talent.

The Constants

Before there is coaching, resources or a location, there are internal constants that remain fixed across almost every story.

Curiosity

It is the child who cannot leave a problem alone or is not satisfied by the explanation provided. It is Supravat with his single book, Kanav wrestling with a geometry problem for months or Saee wondering why her mother preferred Math to play. This spark is the prerequisite; and the fire of curiosity is what makes them search for the avenues to satisfy that thirst for knowledge.

Productive Struggle

Real mathematical thinking is not a sprint, it is the willingness to stay confused and the consistency of looking at the same

problem from a thousand different lenses. Aditi's 13 marks out of 102 or Pallav's last-place finish at his first camp were not verdicts of failure - they were the conditions under which their resilience took root.

The Power of Small Openings

A single YouTube link for Aadish or a circular reaching Prof. Shanta's school in Manipur or a single problem book for Supravat: these ordinary moments create an opportunity for the recognition of their efforts, to meet a mind already looking for something, creating a reaction out of all proportion to the initial spark.

Community

Talent may show itself in solitude, but it does not survive there. Whether it is the late-night sessions at IMOTC or the ISI Kolkata training camps, every student in this book had a moment where they stopped being alone. As seen in the recent success of the Online Math Club (OMC) and Sophie Fellowship, the peers and mentors are not just a backdrop - they are the protagonists of the story.

Joy Outlasting the Medal

For most IMO medallists, the medal is a byproduct; the true constant is the quiet companionship of the problems living in one's head, even after the competition is over. The thrill lies in the 'victory dance' after a lunchtime proof or the realisation that a proof connects nine separate ideas.

The Variables

If the heart of the journey is constant, what changes? The answer is everything else: the variables we must solve for, to ensure talent is not lost to circumstance.

Geography and Access

Geography remains a stubborn variable. While talent is distributed equally from Khangabok to Sangli, the ecosystem is not. We see three IMO contestants in one team from a single school in Faridabad - not because the talent there is greater, but because the 'variables' of mentorship and environment were optimised. Maybe they have been able to crack the code. They have the holy grail that allows for the birth of Mathematical geniuses, so we all stand to learn from it and apply it variably in ways that it suits our conditions the best.

The Language and Resource Barrier

Mathematical talent is independent of English proficiency, yet our system often treats them as one. A student may be gifted mathematically, but stumble over a word problem's phrasing. While the RAM Foundation and others are promoting Math in local languages, the 'vacuum' of regional resources remains a compounding loss. The emergence of Math Clubs at the school level or Math circles at the city level might help us bridge this gap.

The Gender Gap and Safety

The shift from the IOQM to the IMOTC reveals a lopsided boy-to-girl participation ratio. The variable here is often societal; for many parents, sending a daughter to a week-long INMO camp or month-long IMOTC in an unfamiliar city feels like a leap of faith they are not ready to take. The European Girls' Mathematical Olympiad (EGMO) has begun to bridge this by providing to the girls who are mathematically gifted, proving that when the variable of 'space' is provided, the talent is undeniable and nothing would be a barrier to it shining for all to see. Fewer than one in ten students at the national camp is a girl, not because the ability is absent, but because the access is.

Institutional Flexibility

Not every institution 'bends' to accommodate genius. We see

success where the system adapts - like IIT Bombay creating a degree pathway for Prof. Kartik to switch to Math or schools allowing students like Anant to skip classes for training. But this is not always the case. Not every institute or school is willing to accommodate the special care that high performing students need at times.

Communication and reach

The one place where we see things varying the most is how things are being communicated. When India first joined the IMO, students solved problems via postal mail, waiting a month for a single critique. On the other hand, in the current era, information is instantaneous. With AI-driven translations and real-time mentorship from former IMO team members, we are at a cusp of great change. India's 4th place finish at the 2024 IMO proves that our trajectory is uphill.

The Problem Worth Solving

This is not only a book about Mathematics. It is a book about a particular kind of mind and what happens when that mind is found and given the right conditions to grow.

The evidence for what is at stake is not merely intuited; it is measured. Economists Ruchir Agarwal and Patrick Gaule, analysing the careers of over 4,700 IMO participants across two decades, found that an IMO gold medallist is fifty times more likely to win the Fields Medal than a doctoral graduate from a top Mathematics programme. More consequential for India is a second finding: equally talented participants from lower-income countries produce measurably less research than peers from wealthier nations. The IMO scores are identical. The outcomes are not. The entire gap is one of ecosystem, not of ability.

The skills built through Olympiad training including sustained

attention, comfort with abstraction, the discipline of returning methodically to a hard problem, transfer to any domain where rigorous, original thinking matters. Prafulla Dhariwal, a gold medallist at the 2012 IMO from Pune, earned a full scholarship to MIT, joined OpenAI in 2016 and led the development of GPT-4o. Sam Altman said publicly that GPT-4o would not have happened without Dhariwal's vision, talent and conviction. Similarly, Aravind Srinivas, an INMO merit awardee from Chennai, co-founded Perplexity AI. The stories in this book are not isolated cases; they are the most visible points on a longer line running from a child who cannot stop thinking about a problem, through the Olympiad ecosystem and out into every field where the world's hardest questions are being answered.

The question that remains is also the most urgent one. How many such students are we not hearing about? Currently, fewer than one per cent of those eligible participate in the IOQM. Every high-potential student who goes unnoticed is a compounding loss, not just to that child but to the broader intellectual life of this country. The question must shift from 'What are India's best students doing?' to 'What are the best students in every district of this country doing and does anyone know they exist?'

We carry the legacy of Aryabhata, Madhava, Bhaskara and Ramanujan, not as names to invoke but as evidence of something enduring in this country's relationship with abstract thought, a relationship that arrived recognisably intact in the children whose stories fill these pages. Whether we build upon it or merely inherit it is a choice that belongs to us.

The variables, as always, are ours to solve.



About the author

Sagar Shrivastava is a Mathematician and researcher specializing in the intricate worlds of Representation Theory, Number Theory, and Algebraic Combinatorics. He earned his doctorate from Tata Institute of Fundamental Research (TIFR) in Mumbai and currently serves as a Postdoctoral Research Associate at Iowa State University.

Sagar's work is driven by a deep curiosity for patterns, whether they are found in the symmetry of Lie groups or the folding points of paper. Beyond his academic accolades, he is a dedicated science communicator and an avid practitioner of origami. He believes that mathematics is not just a collection of formulas, but a creative language that describes the underlying structure of the universe.

When he is not tackling research problems or teaching, Sagar can often be found exploring the intersection of art and science through paper folding or sharing his passion for math outreach.

Glossary of Abbreviations

Short Form	Full Form & Description
APMO	**Asian Pacific Mathematical Olympiad** A prestigious annual International Mathematics competition for high school students from the Asia-Pacific region.
CMI	**Chennai Mathematical Institute** A premier centre for teaching and research in the mathematical sciences, Chennai. Founded in 1989, it offers undergraduate and postgraduate programmes in Mathematics, Computer Science, and Physics. Students who qualify for International Mathematical Olympiad Training Camp (IMOTC) are granted direct admission.
EGMO	**European Girls' Mathematical Olympiad** An International Mathematics Olympiad exclusively for female students, held annually in Europe. India sends a team of four students to EGMO, providing a platform for talented girl mathematicians to compete at an international level.
HBCSE	**Homi Bhabha Centre for Science Education** A national centre of the Tata Institute of Fundamental Research (TIFR), located in Mumbai. HBCSE is the nodal agency for Science and Mathematics Olympiads in India, and oversees the selection and training of students for international Olympiads.

Short Form	Full Form & Description
IIIT	**Indian Institutes of Information Technology** A group of technical institutes in India established with a focus on information technology and related disciplines. Several IIITs are highly sought-after destinations for students strong in mathematics and computing.
IISc	**Indian Institute of Science** India's premier institute for advanced scientific and technological research and education, located in Bengaluru. It offers undergraduate, postgraduate, and doctoral programmes and is also the host campus for PROMYS India.
IISER	**Indian Institutes of Science Education and Research** A group of autonomous institutes established by the Government of India to promote quality education and research in the basic sciences. IISERs are popular choices for mathematically inclined students, offering integrated BS-MS and PhD programmes.
IIT	**Indian Institute of Technology** India's foremost institutions for engineering and technology education, with campuses across the country. Entry into IIT undergraduate programmes is through the Joint Entrance Examination (JEE). Many Olympiad students pursue Mathematics or related disciplines at the IITs.
IMO	**International Mathematical Olympiad** The world's most prestigious Mathematics competition for pre-university students, held annually in a different host country. Each participating country may send a team of up to six students. India's participation is coordinated by HBCSE.

Short Form	Full Form & Description
IMOTC	**International Mathematical Olympiad Training Camp** An intensive residential training camp organised by HBCSE for students who qualify through the INMO. The camp is the final stage of preparation and selection for the Indian team that represents the country at the IMO.
INMO	**Indian National Mathematics Olympiad** The third stage of the Indian Mathematics Olympiad programme, conducted by HBCSE. Students who qualify through the RMO appear for the INMO, and top performers are invited to the IMOTC.
INMOTC	**Indian National Mathematics Olympiad Training Camp** Five-day long residential training camp organised by Regional Coordinators, INMO for students who qualify through the RMO. The camp supports RMO qualifiers to prepare for INMO.
IOQM (replaced the earlier PRMO)	Indian Olympiad Qualifier in Mathematics The first stage of the Indian Mathematics Olympiad selection process, conducted by the Mathematics Teachers' Association India (MTA). It replaced the earlier Pre-Regional Mathematical Olympiad (PRMO) and serves as the entry point for students aspiring to participate in the IMO.
TST	**Team Selection Test** The final selection test conducted at the IMOTC to choose the six students who will represent India at the International Mathematical Olympiad. Performance in the TST, alongside the IMOTC camp, determines the final team composition.

Short Form	Full Form & Description
JEE	**Joint Entrance Examination** The national-level entrance examination for admission to undergraduate programmes at the Indian Institutes of Technology (IITs) and other centrally funded technical institutions. It is one of the most competitive examinations in India.
MTA	**Mathematics Teachers' Association (India)** A national body founded in 2018 at HBCSE, Mumbai, with the objective of bringing together Mathematics teachers, educators, and mathematicians across India. MTA currently conducts the Indian Olympiad Qualifier in Mathematics (IOQM) and organises conferences and workshops to improve Mathematics education.
NISER	**National Institute of Science Education and Research** An autonomous institution in Bhubaneswar established by the Department of Atomic Energy, Government of India. NISER offers integrated MSc programmes in Sciences and is a sought-after destination for students passionate about Mathematics and the Sciences.
PROMYS	**Program in Mathematics for Young Scientists** A rigorous six-week residential summer programme for mathematically talented secondary school students. PROMYS India is hosted at the Indian Institute of Science (IISc), Bengaluru, and immerses participants in deep mathematical exploration, with a strong focus on number theory and independent mathematical thinking.

Short Form	Full Form & Description
RMO	**Regional Mathematics Olympiad** The second stage of the Indian Mathematics Olympiad programme, conducted region-wise by HBCSE. Students who qualify through the IOQM are eligible to appear for the RMO, and top performers advance to the Indian National Mathematics Olympiad (INMO).
STEMS	**Scholastic Test of Excellence in Mathematical Sciences** An annual open-resource national examination organised by Chennai Mathematical Institute (CMI) as part of its inter-collegiate fest Tessellate. It is conducted in Mathematics, Physics, Probability-Statistics, and Computer Science for students from Class 8 through undergraduates. Top scorers are invited to a fully-funded residential camp at CMI.
TIFR	**Tata Institute of Fundamental Research** One of India's premier research institutions, headquartered in Mumbai, with centres across the country. TIFR is a national centre for research in Mathematics and the Sciences, and the parent institution of HBCSE, which manages India's Olympiad programme.

Solutions

1 Solution to Aadish's Problem

1.1 The Optimal Strategy

The maximum value is achieved when all races are identical[cite: 43, 74]. In this scenario, the student who consistently places at rank k in every race will have an optimal rating of $(n-k)$[cite: 44]. Summing these ratings across all students yields:

$$\text{Max Sum} = (n-1) + (n-2) + \cdots + 1 + 0 = \frac{n(n-1)}{2}$$

[cite: 43, 75]

1.2 Proof via Change of Perspective

The "magical" solution, attributed to Archit Manas, involves fixing the students' rank thresholds (b values) before considering the race outcomes[cite: 51, 56, 61].

Let the students be $A_1, A_2, \ldots, A_n$ with fixed thresholds $b_1, b_2, \ldots, b_n$[cite: 62, 63]. The objective is to maximize:

$$\sum_{i=1}^{n}(a_i - b_i) = \left(\sum_{i=1}^{n} a_i\right) - \left(\sum_{i=1}^{n} b_i\right)$$

[cite: 64]

Since the b_i values are fixed, we only need to maximize $\sum a_i$. We can exchange the order of summation to add by race instead of by student[cite: 67, 68]:

$$\sum a_i = \sum_{\text{race } j} (\text{Number of students } A_i \text{ who placed in the top } b_i \text{ positions in race } j)$$

[cite: 69]

1.3 Conclusion of the Argument

Because the races are independent, the contribution of each race to the total sum is independent of the others[cite: 70].

- If any specific race configuration contributes more to the sum than others, we can simply change all other races to match that configuration to increase the total sum[cite: 72].
- This demonstrates that there is no reason for the races to be different in an optimal setup[cite: 74].
- With identical races, the problem reduces to the simple arithmetic progression sum $\frac{n(n-1)}{2}$[cite: 75].

2 Solution to Aditi's Problem

Suppose we have beads of a different colors. We wish to form a string of p beads.

1. **Total Linear Strings:** There are a^p possible sequences of p beads, as each of the p positions can be any of the a colors.
2. **Removing Monochromatic Strings:** There are exactly a strings where all beads are the same color (e.g., all red, all blue, etc.). We exclude these to focus on strings with at least two colors. The number of such strings is $a^p - a$.
3. **Forming Necklaces:** Now, we join the ends of each remaining string to form a circular necklace.
4. **Rotational Symmetry:** For a prime p, any non-monochromatic string will produce p distinct linear rotations. For example, if $p = 3$ and colors are R, B, the string RRB is distinct from RBR and BRR.
5. **Equivalence Classes:** Since p is prime, these p rotations are all distinct. Thus, the set of $a^p - a$ strings can be partitioned into groups of size p, where each group represents one unique necklace.

Since the strings are partitioned into groups of size p, it follows that p must divide the total number of strings:

$$p \mid (a^p - a)$$

Which is the statement of Fermat's Little Theorem:

$$a^p \equiv a \pmod{p}$$

3 Solution to Kanav's Problem

To prove that we can always pick 51 chests out of 100 to obtain at least half of the total gold and at least half of the total silver, we employ a strategy involving sorting and pairing.

The Strategy

1. **Sorting:** First, sort the 100 boxes in decreasing order of the amount of gold they contain[cite: 6].
2. **Initial Selection:** Pick the first chest (the one with the most gold)[cite: 6].
3. **Pairing:** Group the remaining 99 chests. We set aside the first chest and then group the rest into pairs: the second and third, the fourth and fifth, and so on, until the 100th chest is left[cite: 6].
4. **Selection by Silver:** In each of the 49 pairs, select the chest that contains the larger amount of silver[cite: 6]. Finally, pick the 100th chest as well to reach a total of 51 chests[cite: 6].

Proof of Correctness

- **Silver Content:** By picking the chest with more silver in each of the 49 pairs, we ensure we have at least half of the silver contained in those 98 chests[cite: 6]. Including the first and last chests only adds to this total, guaranteeing at least half of the total silver[cite: 6].
- **Gold Content:** Because the chests were sorted by gold, in each pair, the chest we *did not* pick is guaranteed to have no more gold than the selected chest in the *preceding* group[cite: 6].
- **Final Result:** By picking both chests in the first "group" (or effectively picking the top gold chest and the best silver from the next pair), we ensure that our selected 51 chests contain at least half of the total gold and at least half of the total silver[cite: 6].

4 Solution to Dr. Pallav's Problem

The construction of a line perpendicular to ℓ through a point A not on ℓ, using only the allowed tools, proceeds as follows[cite: 1, 16]:

1. **Construct first rectangle:**
    - Pick an arbitrary point X on line ℓ and join AX[cite: 23, 24, 25].
    - Draw a perpendicular to AX passing through A; let this intersect ℓ at Y[cite: 26].
    - Draw a perpendicular to AX at X and a perpendicular to AY at Y. Let these intersect at B[cite: 27].
    - Thus, $AXBY$ is a rectangle[cite: 28, 29].
2. **Construct second rectangle:**
    - Choose another arbitrary point X' on line ℓ and join BX'[cite: 30, 31].
    - Draw a perpendicular to BX' passing through B; let this intersect ℓ at Y'[cite: 32].
    - Draw a perpendicular to BX' at X' and a perpendicular to BY' at Y'. Let these intersect at A'[cite: 33].
    - Thus, $BX'A'Y'$ is a rectangle[cite: 34].
3. **Establish parallelism:**
    - In rectangle $AXBY$, since XY is a diagonal, the distance of A from ℓ equals the distance of B from ℓ[cite: 35, 36, 37, 38, 39, 40].
    - Similarly, in rectangle $BX'A'Y'$, the distance of A' from ℓ equals the distance of B from ℓ[cite: 41].
    - Therefore, the distance of A from ℓ equals the distance of A' from ℓ, which implies $AA' \parallel \ell$[cite: 42, 43].
4. **Final Perpendicular:**
    - Draw a line ℓ' perpendicular to AA' passing through A[cite: 44, 45].
    - Since $AA' \parallel \ell$ and $\ell' \perp AA'$, it follows that $\ell' \perp \ell$[cite: 46, 47].
    - Thus, ℓ' is the required line[cite: 48].

5 Solution to Supravat's Problem

The problem can be solved by interpreting the variables geometrically:

- **Triangle Side Lengths:** From statement (3), we let v_1, v_2, v_3 be the lengths of the sides of a triangle ABC.
- **Menelaus Theorem:** Statement (1), $x_1x_2x_3 = -y_1y_2y_3$, corresponds to the condition for three points P, Q, R on the sidelines of $\triangle ABC$ to be collinear according to Menelaus' Theorem.
- **Carnot's Theorem:** Statement (2), $x_1^2 + x_2^2 + x_3^2 = y_1^2 + y_2^2 + y_3^2$, is the necessary and sufficient condition for the perpendiculars to the sidelines at P, Q, R to be concurrent, as established by Carnot's Theorem.
- **Acute Triangle:** Statement (4) specifies that v_1^2, v_2^2, v_3^2 satisfy the triangle inequality. This is the algebraic condition that ensures the triangle formed by v_1, v_2, v_3 is an acute triangle.

By combining these geometric interpretations, it can be proven that exactly one of the six values $\{x_1, x_2, x_3, y_1, y_2, y_3\}$ must be negative.

6 Solution to Dr. Vaibhav's Problem

The key realization is that a player saying "NO" provides public information by ruling out certain values.

- **Notation:** Let player A choose integer m and player B choose integer n. The referee writes r and s on the board. Assume without loss of generality that $r < s$. Since $m, n \geq 1$, the true sum $m + n$ must satisfy $m + n > m$ and $m + n > n$.
- **First Moves:**
  - **Player A, Move 1:** A knows (m, r, s). If $r \leq m$, then $m + n$ cannot be r (since $n \geq 1$). Thus, $m + n$ must be s. A would say "YES." If A says "NO," it becomes public knowledge that $m < r$.
  - **Player B, Move 1:** B now knows n and $m < r$. If $s - n \geq r$, then B knows $m + n$ cannot be r, so $m + n = s$. If B says "NO," it implies $s - r < n < r$.
- **The General Pattern:** Let the bounds for m and n at any step be $p < m < q$ and $p' < n < q'$.
  - A says "YES" unless both potential values for n ($r - m$ and $s - m$) fall within (p', q'). Saying "NO" tightens the interval for m.
  - B says "YES" unless both potential values for m fall within (p, q). Saying "NO" tightens the interval for n.
- **Convergence:** Let $d = s - r$. Each cycle of "NO" answers from both players increases the lower bound and decreases the upper bound of the possible integers by d. Specifically, after $2k$ steps, the range for the numbers decreases such that $q' - p' > 2kd$.

  Since the initial range is finite and $d > 0$, this inequality must eventually fail for sufficiently large k (specifically $k \geq \frac{q'-p'}{2d}$). At that point, one player will be able to rule out one of the two numbers on the board and must say **"YES."**

7 Solution to Pranjal's Problem

Simplifying the inequality gives us

$$2 + a^2 + b^2 + c^2 - 2(a + b + c) + \frac{2\sqrt{2}abc}{\sqrt{a^2 + b^2 + c^2}} \geq 0$$

Let's use the substitution $a = x + y, b = y + z, c = z + x$. Then $2x = a + c - b \geq 0$ because $a + c \geq 1 \geq b$. Similarly, $x, y, z \geq 0$. Using this substitution, the above inequality simplifies to:

$$2+(x+y)^2+(y+z)^2+(z+x)^2-4(x+y+z)+\frac{2\sqrt{2}(x+y)(y+z)(z+x)}{\sqrt{2x^2+2y^2+2z^2+2xy+2yz+2zx}} \geq 0$$

$$1+x^2+y^2+z^2+xy+yz+zx-2(x+y+z)+\frac{(x+y)(y+z)(z+x)}{\sqrt{x^2+y^2+z^2+xy+yz+zx}} \geq 0$$

Now observe that

$$\begin{aligned}
&(x+y)^2(y+z)^2(z+x)^2 \\
&= (x^2+xy+yz+xz)(y^2+xy+yz+xz)(z^2+xy+yz+xz) \\
&= (xy+yz+zx)^3+(xy+yz+zx)^2(x^2+y^2+z^2)+(xy+yz+zx)(x^2y^2+y^2z^2+z^2x^2)+x^2y^2z^2 \\
&\geq (xy+yz+zx)^3+(xy+yz+zx)^2(x^2+y^2+z^2) \quad \text{because } x, y, z \geq 0 \\
&= (xy+yz+zx)^2(xy+yz+zx+x^2+y^2+z^2) \\
&\implies \frac{(x+y)(y+z)(z+x)}{\sqrt{x^2+y^2+z^2+xy+yz+zx}} \geq (xy+yz+zx)
\end{aligned}$$

Thus,

$$\begin{aligned}
&1+x^2+y^2+z^2+xy+yz+zx-2(x+y+z)+\frac{(x+y)(y+z)(z+x)}{\sqrt{x^2+y^2+z^2+xy+yz+zx}} \\
&\geq (x+y+z)^2-2(x+y+z)+1=(x+y+z-1)^2 \geq 0
\end{aligned}$$

10 Solution to Vinay's Problem

Drawing a pentagon with all of its diagonals is mathematically equivalent to tracing the edges of a complete graph on 5 vertices, denoted as K_5.

In the graph K_5:

- There are $V = 5$ vertices (the corners of the pentagon).
- There are $E = 10$ edges (5 outer sides and 5 internal diagonals).

Because the problem specifies drawing without lifting the pen or retracing steps, we are looking for the total number of valid **Eulerian circuits** on this graph. An Eulerian circuit is guaranteed to exist because every vertex in K_5 connects to exactly 4 other vertices (an even degree), meaning any continuous drawing of all edges must start and end at the exact same vertex.

Counting the Undirected Eulerian Circuits

To find the total number of ways to draw the shape, we first calculate the number of structural, undirected loops (circuits) using the **Principle of Inclusion-Exclusion**.

Total Edge Pairings

An Eulerian circuit must enter and leave each of the 5 vertices exactly twice. Thus, at each vertex, the 4 connected edges must be grouped into two pairs. For any 4 edges meeting at a vertex, there are exactly 3 distinct ways to group them into two pairs. Since there are 5 vertices, and 3 independent choices at each vertex, there are:

$$3^5 = 243 \text{ total edge pairing configurations.}$$

Subtracting Disconnected Sub-cycles

Not all 243 configurations form a single continuous loop. Some close back on themselves too early, breaking the 10 edges into disconnected sub-cycles. We must subtract these:

- **Two 5-cycles:** There are $\frac{4!}{2} = 12$ possible 5-cycles in K_5. Picking one forces the remaining 5 edges into another 5-cycle. This double-counts each pair, resulting in $12/2 = \mathbf{6}$ configurations made of two 5-cycles.
- **A 4-cycle and a 6-cycle:** There are $\binom{5}{4} \times \frac{3!}{2} = 15$ ways to draw a 4-cycle. This forces the pairings at those 4 vertices, leaving the 5th vertex untouched with 3 options. Total configurations: $15 \times 3 = \mathbf{45}$.
- **A 3-cycle and a 7-cycle:** There are $\binom{5}{3} \times \frac{2!}{2} = 10$ ways to draw a 3-cycle. The remaining 2 vertices are untouched, yielding $3^2 = 9$ options. Total configurations: $10 \times 9 = \mathbf{90}$.

The Double-Count (Inclusion-Exclusion)

If we subtract the disconnected configurations ($243 - 6 - 45 - 90$), we over-subtract a specific overlapping case: configurations consisting of **one 4-cycle and two 3-cycles**.

- These configurations were subtracted once as a "4-cycle" and twice as a "3-cycle" (since there are two distinct 3-cycles in the shape).
- There are 15 distinct 4-cycles, and for each, exactly 1 of the 3 pairing options for the 5th vertex forces the remaining edges into two 3-cycles. Thus, there are exactly $\mathbf{15}$ such configurations.

Since they were subtracted 3 times in total, we must add them back twice to correct the count.

Valid Undirected Configurations

The total number of valid pairings that form a single, unbroken undirected circuit is:

$$\text{Valid Unrooted Shapes} = 243 - 6 - 45 - 90 + (15 \times 2) = \mathbf{132}$$

Calculating the Final "Ways to Draw"

The 132 configurations represent the undirected structural shapes of the loops. To physically draw the shape, we must account for direction and starting position:

1. **Choosing a Starting Point:** You can begin your drawing at any of the 5 vertices.
2. **Choosing the First Stroke:** From the chosen starting vertex, you have 4 available edges to draw first.

Once the starting vertex and the first directed edge are chosen, it anchors the circuit to exactly one of the 132 valid shapes, tracing it in a specific direction.

Multiplying these independent choices gives the final total:

$$\text{Total Ways} = 5 \text{ (start vertices)} \times 4 \text{ (first strokes)} \times 132 \text{ (undirected shapes)}$$

$$\text{Total Ways} = 2,640$$

8 Solution to Saee's Problem

The problem of measuring water using two buckets of capacities a and b is a classic application of **Bézout's Identity**. Any volume V that can be measured must be an integer linear combination of a and b, specifically $V = ax + by$ for some integers x, y.

1. **Case 5 and 7 litres:** Since $\gcd(5, 7) = 1$, any integer volume can be measured.
    - To get 8 litres: $3(7) - 2(5) = 21 - 10 = 11$, or more simply $2(7) - 1(5) = 9$, then $1(7) + 1(\text{measured } 1) = 8$.
    - To get 9 litres: $2(7) - 1(5) = 9$.
2. **Smallest number of litres:** The smallest positive volume that can be measured is always $\gcd(a, b)$. For 5 and 7, this is 1 litre.
3. **Numbers that cannot be measured:** If $\gcd(a, b) = 1$, every positive integer volume can be measured. However, if $\gcd(a, b) = d > 1$, then only multiples of d can be measured. Any number not divisible by d is impossible.

Other Bucket Pairs

- **4 and 6 litres:** $\gcd(4, 6) = 2$. Only even volumes are possible. 8 is possible; 9 is impossible. Smallest is 2.
- **6 and 9 litres:** $\gcd(6, 9) = 3$. Only multiples of 3 are possible. 9 is possible; 8 is impossible. Smallest is 3.
- **12 and 19 litres:** $\gcd(12, 19) = 1$. All integer volumes are possible. Smallest is 1.

General Pattern: A volume V can be measured if and only if V is a multiple of $\gcd(a, b)$.

9 Solution to Prof. Shanta's Problem

Clearly n must be odd. Let $p|n$ be the least prime divisor of n and put $n = pk$. Then $p \geq 3$. Let $d = \text{ord}_p(2)$ be the least positive integer such that $p|(2^d - 1)$. Then from $p|n|(2^n + 1)$, we obtain:

$$2^n \equiv -1 \Rightarrow 2^{2n} \equiv 1 \pmod{p}$$

implying $d|2n$, $d \nmid n$ and also $d|(p-1)$. Thus $d|\gcd(2n, p-1)$. If $q > 2$ is an odd prime divisor of d, then $q|d|2n$ implying $p \leq q \leq d \leq p - 1 < p$, which is a contradiction. Hence $d|2$ implying $d \in \{1, 2\} \Rightarrow d = 2$ as $p \geq 3$ and further from $2^2 \equiv 1 \pmod{p}$, we get $p = 3$ and so $n = 3k$.

Let $\nu_3(n) = \nu$. Then:

$$n^2|(2^n + 1)|(2^{2n} - 1) \Rightarrow \nu_3(2^{2n} - 1) \geq 2\nu_3(n) = 2\nu.$$

By the **Exponent Lifting Lemma**:

$$2\nu \leq \nu_3(2^{2n} - 1) = \nu_3(2^2 - 1) + \nu_3(n) = 1 + \nu$$

giving $\nu = 1$ and hence $n = 3k, 3 \nmid k$. Clearly $n = 3$ is a solution.

Suppose $k > 1$. Let $q|k$ be the least prime divisor of k and put $k = ql$. Here $q > 3$. We have:

$$2^n \equiv -1, 2^{2n} \equiv 1 \Rightarrow 2^{6ql} \equiv 1 \Rightarrow 2^{6l} \equiv 1 \pmod{q}.$$

Let $\text{ord}_q(2) = e$ be the least positive integer such that $q|(2^e - 1)$. Then $e|6l, e \nmid 3l$. If $p|e$ with $p \geq q > 3$, then $q \leq e \leq q - 1 < q$ which is a contradiction again as $e|2n$. Thus $e|6$ since $e|2n = 6l$. From $2^e \equiv 2^6 \equiv 1 \pmod{q}$, we get $q = 7$. If $7|n$, then $7|n|(2^n + 1)$. However $7 \nmid (2^n + 1)$ for any n, which is a contradiction. Thus $n = 3$ is the only solution. □

11 Solution to Prof. Amol's Problem

To find the final one-digit sum of the digits of 4444^{4444}, we utilize the properties of modular arithmetic and digital roots.

- **Step 1: Property of Digital Roots.** The repeated sum of the digits of any decimal number is equal to the remainder when that number is divided by 9 (the digital root)[cite: 7].
- **Step 2: Simplifying the Base.** We note that $(9a + b)^n = 9X + b^n$, where X is an integer[cite: 7]. Since $4444 = 9(493) + 7$, then $4444 \equiv 7 \pmod 9$[cite: 7]. The problem reduces to finding the remainder of 7^{4444} when divided by 9[cite: 7].
- **Step 3: Calculating $7^{4444} \pmod 9$.**
  - Observe that $7^3 = 343 = 9(38) + 1$, so $7^3 \equiv 1 \pmod 9$[cite: 7].
  - We can rewrite the expression as:

    $$7^{4444} = 7 \times 7^{4443} = 7 \times (7^3)^{1481}$$

    [cite: 7]
  - Substituting $7^3 = 9a'' + 1$, we get:

    $$7(9a'' + 1)^{1481} = 7(9X'' + 1^{1481}) = 7(9X'' + 1)$$

    [cite: 7]
  - This simplifies to $9X''' + 7$[cite: 7].

Final Answer: The final one-digit sum is **7**[cite: 7].

12 Solution to Anant's Problem

Local Solution (Mathematical Induction)

We claim that for any $n \geq 1$, the final score is always $\frac{1}{2}n(n-1)$[cite: 17].

Proof. We proceed by induction on n.

- **Base Case:** For $n = 1$, no moves are possible. The formula gives $\frac{1}{2}(1)(0) = 0$, which is correct[cite: 18].
- **Inductive Step:** Suppose the claim holds for all values less than m. For a pile of size m, let the first split result in piles of sizes a and b such that $a + b = m$[cite: 19, 21]. The total score is the sum of the first split and the scores of the two resulting piles:

$$\begin{aligned}\text{Total Score} &= ab + \frac{1}{2}a(a-1) + \frac{1}{2}b(b-1) \\ &= \frac{2ab + a^2 - a + b^2 - b}{2} \\ &= \frac{(a^2 + 2ab + b^2) - (a+b)}{2} \\ &= \frac{(a+b)^2 - (a+b)}{2} \\ &= \frac{m^2 - m}{2} = \frac{1}{2}m(m-1)\end{aligned}$$

This matches our claim[cite: 26]. □

Global Solution (Handshake Invariant)

Imagine each stone is a person. When a pile is split into sizes a and b, we record ab "handshakes," representing every person in pile a shaking hands with every person in pile b[cite: 31, 32].

By the end of the process, every stone ends up in its own pile, meaning every possible pair of stones has shaken hands exactly once[cite: 35]. The total number of handshakes among n stones is the number of ways to choose 2 stones from n:

$$\text{Final Score} = \binom{n}{2} = \frac{n(n-1)}{2}$$

For $n = 2026$, the score is[cite: 15, 36]:

$$\frac{2026 \times 2025}{2} = 1013 \times 2025 = 2,051,325$$

13 Solution to Prof. Amitabha's problem

Let $k = \frac{a^2+b^2}{ab+1}$. We assume that k is an integer and want to show that k is a perfect square. Assume for the sake of contradiction that there exists some k which is not a perfect square.

Let $S = \{(a, b) \in \mathbb{N}^2 : \frac{a^2+b^2}{ab+1} = k\}$. By our assumption, S is non-empty. Let (A, B) be an element in S such that the sum $A+B$ is minimized. Without loss of generality, assume $A \geq B$.

We can rewrite the equation as a quadratic in $A = x$:

$$x^2 - (kB)x + (B^2 - k) = 0$$

One root of this equation is $x_1 = A$. From Vieta's formulas, we know there exists a second root x_2 such that:

$$x_1 + x_2 = kB \quad \text{and} \quad x_1 x_2 = B^2 - k$$

From these, we can find x_2:

$$x_2 = kB - A = \frac{B^2 - k}{A}$$

Now we check the properties of x_2:

1. Since k, B, A are integers, $x_2 = kB - A$ must be an integer.
2. $x_2 \neq 0$ because if $x_2 = 0$, then $B^2 - k = 0$, meaning $k = B^2$, which contradicts our assumption that k is not a perfect square.
3. If $x_2 < 0$, then $x_2^2 - (kB)x_2 + (B^2 - k) = 0$ implies $x_2^2 + B^2 - k = kBx_2 < 0$, but $x_2^2 + B^2 - k$ would be positive if k is small, leading to a contradiction. Specifically, $\frac{x_2^2+B^2}{x_2B+1} = k > 0$. Since $k > 0$ and the numerator is positive, $x_2B + 1$ must be positive, which means $x_2 \geq 0$. Combined with $x_2 \neq 0$, we have $x_2 > 0$.

Finally, we compare x_2 with A:

$$x_2 = \frac{B^2 - k}{A} < \frac{B^2}{A} \leq \frac{A^2}{A} = A$$

Thus, $x_2 < A$. This implies $x_2 + B < A + B$. However, this contradicts our choice of (A, B) as the solution with the minimal sum. Therefore, our initial assumption that k is not a perfect square must be false.

14 Solution to Prof. Kartik's Problem

Let $n \geq 2$ and $N = \frac{5^n - 1}{2}$. We are to show that the sum

$$S = \binom{N}{0} - \binom{N}{2} + \binom{N}{10} - \binom{N}{12}$$

is divisible by 25.

Step 1: Express N modulo 25

For $n \geq 2$, we can write $5^n = 25 \cdot 5^{n-2}$. Since 5^{n-2} is an odd integer, let $5^{n-2} = 2k + 1$ for some integer $k \geq 0$. Substitute this into N:

$$N = \frac{25(2k+1) - 1}{2} = \frac{50k + 24}{2} = 12 + 25k$$

Thus, for all $n \geq 2$, N can be written exactly as $N = 12 + 25k$ for some integer k.

Step 2: Apply Vandermonde's Identity

To evaluate $\binom{N}{r} = \binom{12+25k}{r}$ modulo 25, we expand it using Vandermonde's Convolution:

$$\binom{12 + 25k}{r} = \sum_{j=0}^{r} \binom{12}{r-j} \binom{25k}{j}$$

(where $\binom{n}{m} = 0$ if $m < 0$ or $m > n$).

We need to understand the behavior of $\binom{25k}{j} \pmod{25}$ for $0 \leq j \leq 12$. Notice that we can write:

$$\binom{25k}{j} = \frac{25k}{j} \binom{25k - 1}{j - 1}$$

- **If j is not a multiple of 5:** (i.e., $j \in \{1, 2, 3, 4, 6, 7, 8, 9, 11, 12\}$). The denominator j has no factors of 5. Therefore, the factor of 25 in the numerator remains intact, meaning $\binom{25k}{j} \equiv 0 \pmod{25}$.
- **If j is a multiple of 5:** (i.e., $j \in \{5, 10\}$). The denominator j contains exactly one factor of 5. Therefore, $\binom{25k}{j}$ is guaranteed to be a multiple of 5. We can write $\binom{25k}{5} = 5A$ and $\binom{25k}{10} = 5B$ for some integers A and B.
- **For $j = 0$:** $\binom{25k}{0} = 1$.

Step 3: Evaluate the Sum S modulo 25

Using the properties established above, we expand the four terms of S modulo 25, ignoring any j terms that evaluate to $0 \pmod{25}$:

$$\binom{N}{0} \equiv \binom{12}{0}\binom{25k}{0} \pmod{25}$$
$$\binom{N}{2} \equiv \binom{12}{2}\binom{25k}{0} \pmod{25}$$
$$\binom{N}{10} \equiv \binom{12}{10}\binom{25k}{0} + \binom{12}{5}\binom{25k}{5} + \binom{12}{0}\binom{25k}{10} \pmod{25}$$
$$\binom{N}{12} \equiv \binom{12}{12}\binom{25k}{0} + \binom{12}{7}\binom{25k}{5} + \binom{12}{2}\binom{25k}{10} \pmod{25}$$

Substitute these into $S = \binom{N}{0} - \binom{N}{2} + \binom{N}{10} - \binom{N}{12}$:

$$S \equiv \underbrace{\left[\binom{12}{0} - \binom{12}{2} + \binom{12}{10} - \binom{12}{12}\right]}_{\text{Base terms}} + \underbrace{\binom{25k}{5}\left[\binom{12}{5} - \binom{12}{7}\right]}_{j=5 \text{ terms}} + \underbrace{\binom{25k}{10}\left[\binom{12}{0} - \binom{12}{2}\right]}_{j=10 \text{ terms}} \pmod{25}$$

Step 4: Cancellation of Terms

Now we evaluate the three bracketed segments:

1. **Base terms:** $\binom{12}{0} - \binom{12}{2} + \binom{12}{10} - \binom{12}{12} = 1 - 66 + 66 - 1 = 0$.
2. $j = 5$ **terms:** By the symmetry of Pascal's triangle, $\binom{12}{5} = \binom{12}{7}$, so $\binom{12}{5} - \binom{12}{7} = 0$.
3. $j = 10$ **terms:** We have $\binom{12}{0} - \binom{12}{2} = 1 - 66 = -65$.

Thus, the entire sum reduces to just the $j = 10$ term:

$$S \equiv \binom{25k}{10} \times (-65) \pmod{25}$$

Recall from Step 2 that $\binom{25k}{10} = 5B$. Substituting this yields:

$$S \equiv 5B \times (-65) = -325B \pmod{25}$$

Since $-325 = 25 \times (-13)$, it is clearly a multiple of 25. Therefore:

$$S \equiv 0 \pmod{25}$$

This completes the proof.

15 Solution to Dr. Shirali's Problem

Since $2^n + 1$ is odd, if n divides $2^n + 1$, then n is odd. Let p be the least prime number that divides n. Then p is a divisor of $2^n + 1$. That is,

$$2^n \equiv -1 \pmod{p}$$

Since n is odd, we may write the above as

$$(-2)^n \equiv 1 \pmod{p}$$

We also have, by the Little Fermat Theorem, as p is odd,

$$(-2)^{p-1} \equiv 1 \pmod{p}$$

Since p is the least prime divisor of n, we know that $\gcd(n, p-1) = 1$. Combining this fact with the above two congruences, we get

$$-2 \equiv 1 \pmod{p}$$

i.e., $p|3$. This implies that $p = 3$.

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"One cannot begin with the goal of producing medalists or next-generation innovators. The real starting point is to cultivate a strong culture of problem-solving, exploration, and problem-posing, and the rest will follow."
Dr. Shailesh Shirali, one of the architects of India's first IMO team in 1989

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About half of all Fields Medalists, the highest honour in Mathematics, were once Mathematical Olympiad contestants. Terence Tao, Maryam Mirzakhani, Akshay Venkatesh: the pattern holds across generations and continents. The ability to sit with a hard problem, to return to it, to see it differently each time, turns out to be one of the most transferable capabilities a mind can build.

India has seen this play out in its own way. A student who represented India at IMO 2012 went on to lead the development of GPT-4o at OpenAI. An INMO merit awardee from Chennai co-founded Perplexity AI. These are not coincidences but are the visible end of a line that begins with a child who cannot stop thinking about a problem.

Yet fewer than one per cent of eligible students ever participate in the first qualifying examination. The challenge is not a lack of talent, but a lack of exposure. This book brings together fifteen conversations with India's finest mathematical minds including past IMO medalists and institution-builders and maps what it takes to bridge the space between talent and opportunity.

∞

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