

## An Interview with Professor Po-Shen Loh

by Bishal Deb - Tuesday, May 31, 2016

<http://gonitsora.com/interview-po-shen-loh/>

[Po-Shen Loh](#) is an associate professor of mathematics at the [Carnegie Mellon University](#). He specializes in probabilistic and extremal combinatorics. He is the founder of [Expji](#) which "is a free interactive website, focused on math and science, where students, teachers, tutors, and enthusiasts are encouraged to add their voices and teaching styles to the canon of lessons that are hosted on the site." He is also very actively involved in olympiad activities. In this capacity he was the leader of the US International Mathematical Olympiad team, 2015 which was ranked the number one team.

Po visited the Chennai Mathematical Institute on November 16th, 2015, wherein we had the chance to ask him some questions. The interview team, other than myself, consisted of Varun Ramanathan(interviewer), Anish Sevekari(co-ordinator), Rebhu Johymalyo Josh(camera person) and Pranav V. Chakravarty(technical support).

What follows is a written transcript of the interview.

Varun R. : We have with us Professor Po-Shen Loh from Carnegie Mellon University. Thank you for doing this.

Po-Shen Loh : Thank you.

VR : The talk earlier today was great. It was really inspiring and at the same, very informative. All these ideas, how they connected up. Thank you for that.

PSL : My pleasure.

VR : We congratulate you on behalf of CMI for your success at the IMO this year, your team's success.

PSL : I would pass that to the team definitely.

VR : We all know that you are also part of your team. In that sense, it is the success of the whole team. Congratulations to you and to them also.

PSL : Thank you.

VR : So how did you get interested in math? When did you know it was going to be mathematics?

PSL : Ya that's a good question. I mean, in some sense, I guess, I started looking at mathematics ever since I was very small. My mother would teach interesting ways to do quantitative things like multiply,

some basic algebra. But, I'll say that at that age when I was in elementary school it wasn't really that I thought I was really interested in math. I think it was just that other subjects were more challenging. So in other words, the different subjects that one learns in school like writing, reading like history.

VR : So you thought that other subjects were more challenging!

PSL : Ya ya ya. I always, I guess, happened to find the math less challenging but that's not a good reason to like math. One shouldn't just like things because they are easy. In fact, I'd go on later and say that is that's the exact wrong thing to do. So, actually when I entered middle school, which in America that's roughly age eleven, I was exposed to the first math competition, the first serious math competition called "Mathcounts". And that showed me that there is a lot of math that I don't know. And at that stage, instead of being scared of it, I thought this was actually kind of fun to be suddenly in a situation where the problems are not routine. That's exactly the opposite of memorise this theorem or formula and do it but rather that, 'Oh, boy! How in the world do I ever do this question?' And I thought that creativeness, that thinking out of the box was fun. I got addicted to it. Then I decided that I like this. And by the way at that point, I would say, it's not that I fell in love with math, I would say I fell in love with thinking. And I often like to tell people that we should rebrand mathematics. Everyone is used to saying, 'I don't like math.' Why don't they like math? That's because in many people's minds math is about saying  $2+2$  is four. Why is it four? Because it is four. At the same time,  $a^2+b^2=c^2$ , why? Because Pythagoras said so. Actually no, this is because my teacher said so. But in general, a lot of these things are you memorise a technique and use it. Well if you say that that's math, maybe I can agree with you: that's not as much fun. But if you think what makes all of us like math, it is actually the fact that there is theory. There is thinking. There is actually reasoning and we love the reasoning. So I would like to rebrand and tell that to people: we should not say that it's math. We should say it is thinking. At that point it is very hard for normal people to say "I just don't like thinking. I have never tried thinking." It's not true. Everyone loves thinking. So that's what I would say. Right. I fell in love with thinking and that's what many people call math.

VR : It's probably the logical structure underneath that made you like it.

PSL : Absolutely.

VR : The reasoning and how to solve the problem, the problem solving aspect of it.

PSL : Absolutely. It's to the extent that after the IMO win I happened to have the opportunity to talk to the media and reporters and I used that as a chance to communicate to people that math is much more than what they are used to thinking. I actually gave them a quote. I said well, "I think math is a cross between art and law." And this helps to communicate that is way more than what people usually think. The law is exactly what you just said with the reasoning and the logical arguments. In law you usually prove beyond reasonable doubt. In math you prove beyond all doubt (except for whether you believe or not in the axiom of choice, but that is a different matter, right)? At the same time art is a very important part. And as you saw that before what we talked about in the talk today, I like to think about beautiful questions and I think every mathematician is the same.

VR : So coming to olympiads, could you tell us something about your experiences with olympiads, first as a student and then as a trainer. How it to see people like you from the other side after you became a

trainer. Some good stories about that or what you found interesting.

PSL : I'll say that the first time I saw an olympiad was when I accidentally qualified for the USA math olympiad (USAMO) through the ability to do mathematical computations, and suddenly I got this examination and the morning set, this is an exam like no exam you have taken before, you have to write a proof. I didn't know what a proof was. I see a bunch of questions and one of them was a geometry question and I said, "I know how to do something. I'll write everything as coordinates and multiply everything out." This was basically only thing I knew. And somehow I accidentally qualified that year for the training camp. Because this was a long time ago, this was when it was much easier to qualify for these training camps. That was my first real exposure. I met the national coaches. They were Titu Andreescu that year and several others. Even Zuming Feng, a name many recognize now. That was the first year he was actually an assistant coach of the US team and that all of these people through that. And they showed me that there is actually a lot of interesting theory around proof. They also showed me that I have a lot to learn. In that training camp where I was the first time I was not anywhere close to the top. In fact, I was close to middle of the bottom. And I remember thinking this is an entirely new dimension, an entirely new space I have never touched before. But what I enjoyed the most from that training camp was this combination of interesting problem solving and meeting some other very interesting people. So, I loved the community part of it. And those two things were enough to convince me that I should spend a lot of my free time in the United States, when I was done with homework, studying these various math olympiad problems which I had previously thought were impossible.

VR : Or probably seeing other people solve the same problem in a very different way.

PSL : Oh, yes.

VR : The different ideas used to solve the same problem and how they could be connected.

PSL : So actually, interesting you said that because you don't exactly know my style and in fact, I took particular pleasure in trying to find the most unusual way to solve every problem. In fact, even during the practice tests, I went to the training camp three times. The first time was an accident, second time I worked harder and there was a rule at that time saying that if you do not make the IMO team, you can only go to the training camp twice. So I was quite convinced that I would not make the IMO team because I knew my position and so I said, "Look, I am in the second year of the camp. I am not going to focus on trying to get a good score. I am going to make a challenge to myself, I will try to do all of the questions in exam in the most unusual way possible." And that's like an art. I was like "Can I find the way it was not meant to be solved" and all through the contest to share this new way of solving with other people scored would be very low because, you know, you solved one question in a very unusual way. But I fell in love with that. So I would say that part stuck with me because although I accidentally made it to the team eventually the third time, making the team or not making the team doesn't make you a successful mathematician. Even olympiads or non-olympiads doesn't make you a successful mathematician. I won't even say I am a successful mathematician. But what I will say is the love of doing things in unusual ways especially around math and around theory, I think, is something I value very much. And that's what I took from the olympiads on. So that answers the question of when I was a student of the olympiads.

How do I come back as a trainer? Well again I was convinced that it was accident that I made the IMO team. So I said that I am not going to train these people. They know way more than I do. And I went of in

another direction and did research in computer science as an undergraduate at that time. Then one year, suddenly, the US IMO programme had a lot of extra money and they decided to expand the size of the IMO training by a factor of six. And roughly speaking at that time they sent an email up to everyone and said if you expand the number of students by six, what do you need to do with the number of trainers? Well, presumably also times six. Maybe even more than six, if we think about the way the non-linearity works, which means anyone with any experience, would you like to come back? I said, well, maybe I guess I can try. And it turns out actually history of it I was the last person to decide to try. The training camp was in June, I think it was in April or May that I said, "Okay! Ya, I'll try." And I actually got the last spot available to be back as a coach. I did it because I wanted to give back to the community. I actually do feel very strongly that if you have some sort of talent or achievement, you should pay it back, not necessarily in money but definitely in effort, and in terms of how you steer your life because nobody is entitled to it. Usually tons of people help too. So I wanted to help back. And so I went back as a coach that year, also because I love students and had a lot of fun and whatever reason, I got voted as the best teacher. And so I said, "Maybe I can come back next time. Maybe even though I don't know as much of math, I'll come back."

VR : How did you see students and understand them from the mind of a trainer?

PSL : Ya. So you are asking about when I see students from the mind of a trainer. I guess one useful thing about having been a contestant before is that you know how it feels to be in the same situation. So what I would say is, I guess my main contribution is one of trying to inspire people to keep pushing even when it looks impossible. So for example, from my experience of working as a student, I know that sometimes when you work on a question you can go for fifteen minutes, half an hour, one hour and have no progress. And it is very easy to give up at that point, right? So, what I do sometimes when I teach a class is I go around and I give an individual hint to say, 'No try this,' or I see that they are really going on this wrong track where they just keep going on the track, it will go nowhere forever. And I look at that sort of a thing. So because I remember what it's like to solve these questions, I'll also say that it forms a lot of advice I give because, for example, I get a lot of people who ask me "How do I get better at math competitions or math research or anything?" And they are usually looking for something very specific, "Read this book, do these things." Actually I give a very simple answer which actually covers everything, "Do things that are hard but not impossible." This is a generic advice I give because doing hard but not impossible means always attempt to do tasks where your chance of success is not 80%, not even 70% but less than 50% or even 25% but not 10%. So when you do that you are always engaging yourself and you are always pushing your envelope forward. So when I tell students who are working on some math contest, they are always doing the easy problems correctly and then they run out of time and so they don't attempt the hard ones. What I usually say is, "Don't even start the easy problems. Just do the hard one." And at that point when you focus on these things your chance of success is moderate. So these are all from the experience of being a student, I guess.

VR : What role do olympiads play? What is their purpose and also, what can be done to achieve that purpose? How to bring olympiad level mathematics to schools and to bring that to more people because certainly a lot of mind power is not being used right now. Probably, math is being taught not in a good way and a lot of people who have the potential, who are actually great minds, they are not doing mathematics because of this reason. They may not be involved with olympiads. So what do you think can be done?

PSL : Ya, this is a good question. So first of all I would say, I try to be careful to not criticize the teachers and the teaching methods in the sense that I actually think that most teachers are under-resourced, both in terms of time and in terms of money. So it is difficult to criticize them directly. However, what I should say is that there are things that all of us can do to contribute back. But now let me go back to the first question about what is the role of olympiads. So here's what I think: In a lot of questions that you do for homework and for exams, you are typically expected to figure out the question quickly, in terms of if you don't remember the method to do it, you typically say "I give up, I'll do the next question." Or else your score is too low, right? This means that you are roughly thinking for a minute or two minutes for each question. But in real life if you are trying to solve a real problem, the real problems that are worth solving, actually take a lifetime, or many lifetimes of many people working together. So somehow you have to teach yourself to have more stamina and more patience. So like running a marathon, you cannot run a marathon if the only thing you have trained is how to run 10 second sprints. Now, how do you train for the marathon? You need to certainly have more and more questions where you are expected to spend longer time solving. The olympiad is what I would call the geometric mean between high school math and research. So geometric mean is relevant, because it is like, you know, it's five times, or even maybe ten times as patience is required to go from high school problems to olympiad problems. But actually even within olympiad problems, you go from easy olympiad problems to medium ones to hard ones. There is always a factor, always like some multiplying of the patience you need to solve, until eventually you got these ones where the exam is four and a half hours at the international math olympiad, and if solve one question you are pretty happy. You should be, of course I'll say, people usually aspire to solve more than one question. But anyone who can solve one of those olympiad questions in four and a half hours should be proud of themselves. That's all in a four and a half hour time frame, not one minute, and then eventually of the real world where, you have a life-time, right? So, what I view is that the olympiad helps you stretch the patience and the focus from the typical exam setting to worlds that impact on the real world setting. And without this practice, it's hard to do that. So I feel that the olympiad should be advertised as, actually, something not only to do for math competitions' sake but for building the ability to come up with very creative solutions and do a long patience.

VR : How do you think mathematics should be taught? In India we have this problem being math being too computational. In high school you are supposed to learn a formula and then supposed to apply it. It's too application oriented. Only the application is not very innovative or creative. It's the same old thing again and again and if some people cannot do this computation in a fast enough time, they feel dejected and they think that this is all that there is to mathematics. There is no creativity in that. So, at least in India we have this problem. I don't know about other countries. So how do you think that the subject as a whole should be propagated by the school teachers?

PSL : Ya, so this is a really interesting question actually and again, I'll go back and say that there is a resource issue, in the sense that the teachers do not have as many resources as probably one should devote, in some sense I think that education is one of the biggest investments a country can make in its future and so honestly I think that a huge amount of investment should go to education, at which point teachers would help more help. But I thought about this, I guess after I became the national coach for the United States. I started to think what are the things I can do to try to contribute to that education. Especially mathematics in my country with what I have. And what I have is no real power, no real money. What can you do? The good thing though, is that you can think about it. And so I think that there is actually some theoretical analysis that we can make which is as follows: How many students are there in a typical classroom? Actually, it is a question for you. I don't know. In an Indian mathematics

classroom, if you have one teacher how many students are assigned?

VR : In school, we have 25 to 30 students at least.

PSL : So that is like standard. In the United States, it is also around that.

VR : This is the situation of cities. Even in cities you could have as many as 50 students.

PSL : So, now suppose you have all of these students and take yourself in the point of view of the teacher. What should you do? You have only so much time in front of the students and you have this bell curve of abilities. And I don't want to call it aptitude, in the sense that I don't want to say that the student is destined to be as high IQ or low IQ. I just need to see that what they currently know. And there is this big bell curve, where the majority is here (the center of the curve) and then you have these outliers which are going out to either side. And you have not very much time. So what can you do? The only thing you can do is to try to decide where to focus your energy. Sometimes, teachers are told focus energy on the bottom. Make sure the bottom does not disappear. Sometimes, teachers are supposed to make sure that the middle drives forward as much as possible and maybe there is some help the people to the bottom end. Is it possible for them to really focus so much on the high end? It is difficult. But even then what I want to say is when you are trying to design a curriculum for this, you in some sense need to design a curriculum that will work for most people. What are you gonna do for the one hour you see in the class as well as possible for most people? And then you start to make compromises. You start to say, "Okay, maybe the thing you need to make sure is at least the country should be able to do computation." You have to make up some standards. And this is why I am saying that this is not their fault. In some sense this is an automatic corollary of having to have a situation where one teacher to thirty or fifty students. Their role, I think about now, is it's true you have one teacher but let's go into abstract theoretical. Take the other part. Let's not call him teacher. Let's say you have one computational device for thirty students. What I think is, in the classroom you have one thing which is able to adapt and give a different lesson to what inputs they seek. This is like a program, the teacher is like a program. You have only one execution, one computer and that is why the curriculum which is a program is designed to be as good as you can, you have one computer to these thirty people. Why am I making this computer analogy? It is because it is not true anymore there is only one computer per person. This is a computer (pointing to a laptop), so is this (pointing to cell phones). I appear to have two computers in front of me. So actually, what I think would be very interesting to do would be try to use the technology to start to customise each person's education, not to replace the teacher but to augment the teacher. This is actually what we are trying to do with ExpII, eeh ex peeh ai ai dot com, which is the website, a project I am leading. I am not saying this is the only one. It is just that I am the sort of person who if I see a problem and I see a possible solution called recognise that there are thirty computers with thirty students, it is not necessary that everyone has a phone, but at least at their home they have this ability to automatically adjust. I say I see a possible solution to get the hands dirty and to build something. So what I think would be an interesting solution would be if you can actually use this computational device to start to understand what each person knows and doesn't know through their performance on questions and then to adapt and give them the next step when they are ready. And now this is going to another part which is going to say routine problems. You see, because if we decided that what we need to do is make sure that everyone is in a particular level, may be routine problem is the way to go. But the thing is then, you sort of try to get 100%. What that, kind of, says is that what the biggest mark you can get in the exam is actually 100% and that is a problem. The reason that is a problem is that that prevents you from try to push beyond. In fact,

the value of the olympiad is it's basically impossible to get 100%. Right? But, the idea with the olympiad is that you can then decide where to tail off because a lot of people practice for olympiad on their own. So they challenge themselves with successively harder questions. And they just have to stop not when they have a 100% but when they have gone as far as they think they want to go.

VR : Instead of wanting to cover everything, they want to go into depth.

PSL : Yes, and that is why my vision is that if you can use a computational device, like your phone or your computer, to deliver your questions and to discover, you know, "You can already do these routine questions, great! So what is the next level?" Right? Then suddenly your score is no longer a 100%. Your score is to what level did you proceed. That's not olympiads. What I am trying to say is, this is actually a way to challenge all the way out to the tip of the bell curve because at that point your customisation is detected, you know how to do this, next, next, next and you keep going. At the same time, it is a way to protect the other end of the bell curve because you can adaptively find out, okay, it is not that the person has low IQ. It is just that person did not have that background. So, I give you this now. Go study this thing instead. Again, this is not to replace teachers, it's just that when I look at the situation, I think we are lucky enough to have these computational devices everywhere. And if we can just leverage it, then we can possibly do something on a global scale to really drive education forward with this observation.

VR : About Expii. You are the director and cofounder of Expii. When did you start thinking that you want to build a website like this? What plans do you have for its future?

PSL : Ya, that is a good question. Again this all stemmed largely from when I became the national coach for the USA. In fact, when it happened, when I was appointed the national coach, I remember thinking "This is fun. I did this. I was somehow aspiring to do that some day. Great!" And the next day I said, "Wait! I should do something about this." So, you know, because the IMO training camp is only in June, I was told this thing only in August. So suddenly I thought, "August to June, so much time. What should I do?" So there are different things you can do. I mean, one option was go and identify the top hundred people in the United States and start really training them hard because what are you supposed to do? Win the IMO. Of course, I was not trying to win the IMO. I warned them that we are not gonna win the IMO with me in charge because I am more interested in math and more interested in impact and winning IMO is not the primary focus. I warned everyone when they hired me. But, then I thought, "There is another way you can try to improve the results." And it is a more ambitious project. You are just trying to do something to help everyone in the US and in the world to get access to mathematics. So I had been thinking about this for sometime before that. And, it wasn't that I had the idea for Expii before that. But rather, I had only been thinking about education because in the United States there were several efforts to put massive open online courses, things like Coursera and EdX. Also some of the other professors at Carnegie Mellon University were also considering building one themselves.

VR : Also we have websites like Khan Academy.

PSL : Absolutely! So I had seen all of this. So the thing is I had seen this proliferation of them. In fact, at a certain point I was approached by certain people who were thinking of doing this and they invited certain lecturers. They wanted to start their new thing with certain lecturers who they thought would be appropriate. So they asked me, "Will you be willing to be the one to teach combinatorics?" And I remember how I ended the discussion thinking, you know, I don't know if I really want to put a lot of

effort into making a video that will go onto one website which will not affiliate with the other ones because the idea is to try to make this one product. Is it really worth it to have hundred people all independently investing a lot of resources to make these their own content on separate sites on purpose? Because that is how, I guess, you protect the distribution overlap. I mean, I don't think those are bad by the way; I think that is nice that people have done that and made it for free. But I personally was not interested in trying to just be another one of those. What I said is, "Look! How about we get the million dollar film crew, the million dollar production crew and make the best class ever to end the effort ever to make a class in discrete math." Well of course the responses, you know. (Gives a laugh). Now what I said is if you are going to do this, whenever you do something make it big. So then okay. But of course why not? Why wouldn't anyone do that? Well there is this obvious answer. You never get the money back. You invest a million dollars to make it and you charge nothing. What will happen? So I even advised this to people at that time, "Make the whole thing. Don't attempt to make any money." The people who were talking to me, I said, "Make the best combinatorics video ever and then no one ever will have to do it again." Right? But then that group did not bother do it. But that got me thinking as I said, "Look. If it is actually going to be impossible to get enough money together to make the best thing ever then maybe instead of having lots of groups investing a moderate amount of money to make their own thing, we should have something where everyone in the world can contribute for free and then use crowdsourcing to collectively polish this collective property and to even allow all of them to unite it under one group, so people can compare to see what are the best lessons, what are the best ways to teach any one thing." So that was how the idea was born. It was in response to the notion that it is not possible to get a million dollar budget to make a video worthwhile. So do the exact opposite route and observe that, you know, instead of putting a million dollars from one party down, get the effort together of, I guess, million people who at that point, don't even expect to be compensated one dollar each. It is like I will contribute to certain online free open source projects. It is not like I want one dollar. One dollar is nothing to me. We are like more interested in is having driven things forward and I would be part of this big group, we share the time.

VR : The knowledge that you have now. Also, I think nowadays you don't even need to make it into a video. There are a lot of youtube channels which explains links through animation. And also there are independent channels like Numberphile. You must have heard of Numberphile.

PSL : These are all excellent.

VR : For every episode they take an idea and they explain it. So I guess even that could be done, I mean not in the conventional way of a lecturer presenting to the camera, instead there is a very cute animation and then concept is explained. That could be very powerful.

PSL : Yes! And that is actually another inspiration behind it. That's why on Expii we built it so that you can actually take any video on YouTube and put it into an Expii lesson. But at the same time, you again have scissors. Our site lets you choose any segment of any video. So you can for example say, "Oh! I would really like those 30 seconds of that Khan Academy video." I'll take that. But then I'll ask you a question to be interactive. And now I let the Numberphile explanation of the next part, take 30 more seconds from there and then cap it off with me playing the guitar. I don't know. I am just giving an example, right. But what I am saying is that we wanted to allow everyone unite all of these different creativity aspects together and you exactly mentioned that there are lots of great interesting content on the internet. And our objective with Expii is if you just make a platform that lets everyone unite then you

could potentially create something better than sum of all the parts. And then it is also free, because at that point everyone will build it together. It's almost like if somebody sees a video that they particularly like on Numberphile, they could actually just file that into the spot and Expii will relate it to the topic. And in some sense if more people start to learn about the website, it was secret for a long time because it was under development and we didn't want people to see an early version, or else they might conclude that this is a very not professional, ugly site, which it was. But now we have actually built it to a stage where we want people to know about it simply because people today are searching at the internet to go find a way to learn something and it took all the effort to search but then it is never filed anywhere. The best way they learn this particular topic is such and such. So with Expii what we did is we broke math and science into 9000 microscopic topics which you can surf around them map like Google Maps for math and science with the idea that on each topic that's just crowd sourced. Everyone's work that they have already done and figure out the best way to do it.

VR : And then put it under one umbrella.

PSL : Put it under one umbrella. That's right.

VR : So, who are the cofounders and people who work with you at Expii?

PSL : Sure. So, originally this was actually built in collaboration with another IMO team member. His name is Ray Li. And he and I knew each other because we have worked together for the IMO. He was a student and I was a coach but he is an amazing guy. At the very beginning when you have an idea, you need to get the idea off the ground and there were ideas which were also in collaboration with Ray and with other initial people, which during discussions helped to refine it. But, with Ray's background, because he was both number five in the US in both math and informatics, so he was able to build a lot of technical infrastructure.

VR : Fills the computer science gap as well.

PSL : That's right. So the computer science gap, right. So we were able to start it. In the end he decided to move on to other projects. He is actually not working with Expii at the moment but his contributions were very helpful in getting it to the stage that it is now. Ya, we have actually migrated into a full time team where these are people who now have experience. So for example, the two developers that we have on our team actually both of them previously have cofounded their own tech startups. And also, independent of that, have been employee number one at other tech startups. So this is like four tech startups worth a talent with these two people which is great because they know a lot more about organisation of source code. I am sorry. I shouldn't say it that way. They know more about engineering than we did. So they are driving that side. We also have a full time designer. That is very important because, as we know now, having just the correct technology does not create a good product.

VR : Design is very important.

PSL : Design is extremely important. So that was core task. And then also we have a full time, I'd say, education director who makes sure that what we are creating in terms of these maps of math and science are consistent not only with mathematics and science but also with actual educators so that everyone can work together. Ya, we have a full time operations person as well and we have myself. So it is the six of

us. Yes.

VR : Again coming back to olympiads, they have a lot to do with problem solving. And problems, as you very well know, are beautiful. I mean they are beautiful trains of thought. So do you have a favourite problem that you like to think about even after you solve it, that you keep revisiting?

PSL : This is interesting. So I should say, in some sense, I have always loved the thrill of the hunt, the thrill of the chase. So, actually I had the bad habit of forgetting the question after I finish chasing it down because I want to chase the next big one, actually to the extent that I had to be taught during my PhD that mathematics is more than just chasing. You actually have to remember things. So my PhD advisor was extremely helpful in that regard simply because my style before had always been, "New challenge!" In fact, then I got to some interesting creative way to solve. He said, "No, no no no. For real mathematics you need to actually blend it: both with problem solving and your background knowledge." So for example the question I talked about today in my talk is a good example of that. There was a question where I used some raw ingenuity and then you also plug in into some heavy duty combinatorics where you need to have that background and unite the two and solve. So, that's what I do now as a mathematician. But if you ask me about my favourite problems that I have really solved that is where it is hard to answer it now because if I have already solved it, it is done. I am looking forward to the next challenge. So, I mean the one that I love right now is exactly the question I told you about today which is about these triples of numbers where it is just about a question which looks so tantalizing. Anybody on the street can understand the statement of it. But somehow I cannot solve it and that is another chase I am trying to handle.

VR : So, what problems are you currently working on?

PSL : So this triples problem is actually still open. So, I would say this is one of the questions that I love and I don't know when it will get solved.

VR : Maybe after today's talk, some people can.

PSL : Ya, that will be great.

VR : They will be probably be motivated or inspired to think about it.

PSL : And you see in general, every time anyone adds a new idea, there is a chance that that it will lock into an existing try that I was already thinking about or not just I, maybe other people. And this is a way you can solve it. Ultimately, things are solved by joining unusual ideas which were not obvious, and the more people who are thinking, the more likely you can find more of these ideas. So this is my favourite question right now. But in general there are other long term combinatorial questions. One of them is also around Ramsey theory for finding interesting ways to construct graphs that have certain properties. So, I guess, the questions which I like are the questions which are the most obvious and not done. That would be the best way to describe. My preferences are on the ones where I could explain the question to the a completely ordinary person on the street.

VR : What are your hobbies other than mathematical stuff? What do you like to do?

PSL : So, I would like to summarize all my hobbies in one thing: I like to do things that are supposed to be impossible. That's it. So, I have this certain love for challenge of trying to say, this is something where you really shouldn't be able to do it. Maybe I should be more clear: things which are supposed to be impossible where I guess I have some insight that will make it possible. That's a hobby. It takes a lot of time to find such an opportunity but I would say Expii is actually one example of this and to me it is interesting to try to work on things of that nature because if you do succeed, you generally have done something that will help very many people with some sort of breakthrough. There are other things I am working on too. Another thing I was working on before Expii was trying to help build Carnegie Mellon University to an extremely famous place for people to study mathematics and also to have a great group of very strong students, both undergraduate and graduate, there to work together. It is because I actually think that people flourish when there are other very strong people around them. I can see from this environment, you guys are very lucky to have this right here. And I wanted to make Carnegie Mellon into one of these too. And many people thought that was impossible but I worked together with a colleague of mine, whose name is John Mackey, and he was the director of undergraduate programme for math and the two of us together were involved in, I guess, building up a programme which today attracts an enormous number of great people to come together to Carnegie Mellon to work on math. Actually, one of the alumni of CMI is there right now, Debsoumya. And at undergraduate level there is this competition called the Putnam Math Competition. Just as a statistical measure of what happened, last year if you looked at the number of people ranked in the top five hundred of the Putnam competition from all the top universities Carnegie Mellon had the second most of all universities. Most was MIT, and then Carnegie Mellon and next was Harvard and Stanford but the number at Carnegie Mellon was larger than the number at Harvard and Stanford combined. If you asked six-seven years ago the number at Carnegie Mellon was one-fifth of the number of these other schools. But this is an example of something that people thought was impossible but for me I thought there was a lot of value because at the end of the day, people are looking for a place to join together, to find a community and community building is one of these things where you need to have a catalyst and then it grows. At this stage, that has taken off and everyday I go to Carnegie Mellon, I see this great group of people really enjoying working together on math. That mission is in some sense accomplished. So now I am moving on to other things, not to say that I don't care but that has reached a state which is analogous to the universe if enough mass has accumulated, then gravity forms a planet. So, that is automatically by laws of physics. So the work at Carnegie Mellon has evolved into taking care of the talent in terms of working with them, like I go to lunch with the students for fun because I like to do these sorts of things. You can tell, when I come to India I come visit you at CMI, that's what I do for fun. Ya, that's an example. The next thing was, "Okay! Can you educate the entire world?" That's impossible. Let's try! So this is why I spend enormous amount of time working on that thing.

VR : One of the students wanted me to ask this just before we started. When you are working on a problem do you have a general kind of approach or do you just dive into it and depending on the problem you find other openings to it? What is your general strategy?

PSL : So, I think my first general strategy is to find a question that is fundamentally interesting, one that I would enjoy thinking about, and one which also if I solved other people would care about the result. The second general piece of advice is to work on a problem where you have some hope of solving it in the sense that, I do combinatorics. I probably don't want to do a question which is deep in pure theoretical logic because I just will not be equipped to do it. Right! It is not to say that I only do pure combinatorics questions, some questions I have done have been about probability but I will do a question where I feel I

love the problem, I think I might have the tools to do this and then start playing with it. Sit down in a comfortable chair, play with it for hours and hours and hours and see what observations you make. Sometimes you don't solve it. Sometimes you do. But it is not that I say I have this program where I just use this method to solve it. In general the problems worth solving cannot be done this way because other people have tried the programs.

VR : One last question which is kind of philosophical. I like to ask this to people. Do you believe in God?

PSL : Oh, that's an interesting question.

VR : I will also tell you something interesting that happened. We were following your twitter page and there it was written math educator and evangelist. We did not actually see the evangelist before the comma so I was like math "educator" and "evangelist." So I thought the evangelist in the Christian sense. I was kind of wondering and then I realised that you are a math evangelist, you like to bring maths to the people. But this I like to ask people in general.

PSL : So, first of all I would say, that you are absolutely right but I want to change that state a little bit. It says, "math enthusiast and evangelist."

VR : Ya, I was paraphrasing there.

PSL : No problem. In those you are absolutely. The evangelist is an amendment on the math. So I do spend all my time trying to tell people about math.

VR : It acts on math.

PSL : Acts on math. That's correct. To directly answer your question do I believe in God, yes but that's not to say that I don't need to say this in the sense that I am trying to evangelise the people, I am simply the kind of person that has a particular thought, and I happen to for various reasons but that is not what I usually evangelise on.

VR : But, would you like to share a bit about it, because we all have our version if we do believe that we have a version. Some people believe that there is a creator, some people have more beliefs on that.

PSL : Right. So I will give you a probabilistic analysis, right! What I mean to say is that I happen to be born in a family that was raised Catholic and so I started with a prior on the probability of God existing. It so happened that in my life I thought that I saw a lot of unusual things happen and I don't mean to say unusual things in the sense that I won this, I won that. It is like really unusual things. And rather than going into too many details I will give a different analogy which is that some people say, "Oh! I win the lottery. And so something very unusual has happened." My opinion is that it is not unusual, because there is always someone who wins the lottery. Does this make sense? So what I would say is that this notion of probability which is that I just witnessed a low probability event I won the lottery, somebody who would win the lottery, somebody would say that. But if somebody wins the lottery twice in a row, then that is unusual. I am saying "lottery" because there is nothing to do with skill, does this make sense? If it is something skilled you could draw a correlation.

VR : This is kind of random.

PSL : This is kind of random. If it's the son of the guy who wins the lottery twice in a row, then I might guess that ...

VR : But we are assuming the ideal conditions

PSL : Exactly, ideal conditions. But what I am trying to say is that I thought I witnessed several events, many events which just happened to be not clearly correlated and so if you already have a prior, there is something that orders unordered things, than you are more likely to amplify that probability. That makes sense. I state it this way because, you know, if I wasn't born with a prior that was different, it might not have been this easy to come with this conclusion but I am not trying to say that everyone should but this is how I happen to believe. It was probabilistic.

VR : This will be the last question. To the student of CMI and to college and high school students in India, what would be your message?

PSL : Great! So, I have a message that I try to say to everyone which is to say, "Let's try to do something great for the world." So, this is different from the things I have said before. So, before we were talking about talent and how to motivate talent. But, actually what I believe is that if you have talent and you don't use it to really help the world, you should. So what I want to say is that it would be great if people try to look at the world's problems, the world's challenges and try to think of what is the best that they can do to contribute to it. Not everyone needs to be a scientist to do this. Everyone has their own way of contributing. But I think it would be great if it was part of human nature to try to promote humankind, right! So to students of CMI, since you already happen to be in a situation where you are very talented, you also happen to have access to a lot of mathematics which teaches you to think, then you should definitely try to use this in a way to find something you can do for the society and you will potentially have high impact. And for everyone else who is not at CMI, different people have different talents. Some of them is mathematics, some of them is otherwise. But I really think that if more people attack the problem of the human condition, we will be in a much better place.

VR : So, on that note we would like to end this. Thank you very much for doing this. We sure learned a lot today and got inspired a lot.

PSL : Thank you for having me. It was my pleasure.

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