

INTERVIEWER: It's September 11th, 2015. I'm Chris Boebel, and I'm here with Sanjay Sarma. Sanjay is the Fred Fort Flowers and Daniel Fort Flowers Professor of Mechanical Engineering at MIT, and MIT's first Dean of Digital Learning. Before that, he was director of MIT's collaboration with Singapore, which led to the establishment of the Singapore University of Technology and Design, or SUTD. Sanjay also co-founded the Auto-ID center at MIT, and developed many of the key technologies behind RFID systems that are now in use worldwide.

He is also the founder and CTO of OATSystems. Sanjay received his bachelor's degree from IIT, his master's from Carnegie Mellon, and his PhD from Berkeley. He's the author of academic papers beyond count and the recipient of numerous awards for teaching and research.

So, Sanjay, thank you so much for coming in today. We're looking forward to a fascinating story. And I want to just begin, in a sense, at the beginning. When you were growing up, was engineering, technology, science something that immediately came naturally to you? Was it something you always knew you would pursue, or was there an epiphany?

SARMA: No, the story doesn't involve any sort of romantic epiphany. My great-grandfather was an engineer. My father was a nuclear physicist. Cousins and uncles were engineers. And I was always very 3D. I liked 3D things. I liked to make things. I liked to shape things. I remember when I was six years old, my father and I booby-trapped something that I think may have bothered my mother at some point, using a clock. So no, it was a lifelong interest in making things.

INTERVIEWER: Where did you grow up? And you talk about a lineage of scientists and engineers. Tell me a little bit about your home environment.

SARMA: Sure, yeah, yeah. I grew up, and I had a wonderful childhood. I was the only child of two very intellectual parents. We moved a lot. My father was an honest bureaucrat, which meant he kept getting moved around India as he fought with politicians, or just stood his ground against politicians.

So I lived all over India -- we moved maybe 10 or 15 times when I was a kid. And I had to make new friends. But I always found the kids I wanted to hang out with. Childhood was lovely. We were very science-oriented, history-oriented, intellectual-- a lot of reading.

My grandfather and grandmothers, actually both sides, lived in the south. I'd go hang out there. And there I'd meet cousins who had very similar interests. And one of my grandparents-- my summer vacations would always be near the sea. There's a big shipbuilding industry and we'd build little model ships and we'd fight battles between ships.

India has a festival called Diwali, which is about firecrackers, and we'd use those to build cannons. And the ships would shoot at each other. And it was a very joyful upbringing, with a lot of friends and family, and so on.

INTERVIEWER: Where did you attend high school? Were you moving during that time, or did you at some point settle into an area as a teenager?

SARMA: Yeah. We finally-- when we settled, it was in New Delhi. I went to Delhi Public School, which despite its name, was a private school. And I had a really terrific set of friends there, who were all a little bit nerdy, a little bit wild, but a little bit in a nerdy side. There's no edge to it. It was sort of fun-loving. And so I grew up in Delhi. I love Delhi. But I know India very well, because I lived in different parts of India.

INTERVIEWER: And when you were, say, 13, 14, 15, and really thinking about your life, what did you imagine that you would be? Was it professor of mechanical engineering? Or I know you were interested in technology. Were there other dreams that were part of the mix then?

SARMA: It's interesting. I had a couple of cousins go to IIT. Getting into IIT is not easy. And so I remember when my mother and her sister sat me and my cousin down and said, you know boys, when you grow up, it's a poor country. And there weren't that many opportunities. This was when India was still somewhat socialist. And you know, boys, you need to make the attempt to get into IIT, because there aren't that many options.

And so we studied fairly hard. I was probably not as studious as lot of kids. But we worked pretty hard. But we also had a lot of fun. And I spent a lot of my time either taking these coaching classes or cycling somewhere, or playing badminton or playing tennis with a group of friends.

The Indian system, at that time, was still pretty free. I think what's happened since, I worry, is that things have become more tight, in the sense that a little bit more competitive. And I worry that maybe things aren't-- you don't get as much freedom to mess around and have fun anymore.

INTERVIEWER: Tell me a bit about IIT itself. What was your plan of study when you went there, if you had a plan? Or were you still [INAUDIBLE]?

SARMA: You asked me did I want to be a professor. I didn't completely answer that question. I should say that, honestly, I had no idea. I just wanted to become an engineer.

And at various points, I wanted to do different things. And I was interested in cars and vehicles and robotics. I was very interested in robotics. But how was I going to practice that? I wasn't sure.

Growing up in India, the epicenter is very different. Japan is close by. India was very friendly with Russia at that time-- Soviet Union. So I wasn't sure where I wanted to end up. I did meet a couple people from MIT. I thought, MITs pretty cool. I met someone from Bell Labs, and I was very impressed with Bell Labs. But I don't think I had any specific ambition, per se.

INTERVIEWER: So, arriving at IIT with a general idea of what you wanted to do, but not necessarily a specific plan. Tell me about the environment. Obviously, it's an extraordinarily prestigious school, a difficult school to get into, as you mentioned, and one that's certainly made its mark on the world. What was the environment there at the time you were a student?

SARMA: I have somewhat mixed feelings of IIT. First of all, I was a kid. And frankly, some would call me still a kid. First of all, let me just talk about myself. I was fun-loving. I wasn't very mature. I didn't know what I was doing, really. Perhaps I should have gone to IIT a year later. In India at that time, everyone wanted to go early for some reason.

INTERVIEWER: How old were you?

SARMA: I was 17. Maybe I should have waited until I turned 18. I had just turned 17 when I went to IIT, so I was basically 16. And so that's one part of it. IIT, I was surrounded by just exceptional intellect, these really really, really smart young people, exceptional. Obviously it was still the only undergrad school I've been to, but I don't think I've seen the same level of intellectual intensity.

Having said that, a lot of the kids were like me. They were a little bit immature. So that was one piece of it. I had a great time at IIT. I was sort of the wild kid there. I wasn't the most studious one. But I had a lot of fun. I did a lot of projects. I was into projects. I had great friends, who remain to this day dear friends, who have done well in life. And who when I see them and when they see me, it's like back in the '80s. We're very close.

The pedagogy was sort of interesting. I really liked some professors. They were really great, and they inspired me. But a lot of the pedagogy didn't work for me. And then coupled with the fact that, as I said, I was immature-- and I remain to this day-- it just didn't work. I couldn't sit in classes and take notes, and then stay quiet, and then regurgitate them in an exam. That didn't work for me.

But the project classes were great. So I walked away from IIT questioning myself actually. What did I learn? And what's the best way to learn? And the best thing that happened to me after IIT, was I went to work on an oil rig in Scotland. Actually I didn't go immediately. I made an attempt at going back to grad school. And I said, no, no, no. And I also had some personal issues I had to deal with. And then I went to Schlumberger.

And that was the best thing that happened to me, just because it was when I went to Schlumberger that I realized that all that stuff I'd learned could be applied. And I found myself questioning why I hadn't been told that, or why I hadn't sorted it out myself. And the moment I started seeing the application, the world opened up. Now I knew why controls was important, or why mechanics was important. And why a failed pipe on an oil rig, which can be so deadly, could've been prevented by modeling the strength of steel. Or why a pressure vessel, which we learned the analysis for, was suddenly relevant.

So for me, I sort of take my time in the North Sea as a part of my education, which was as much education for me as IIT, because it did many things. It was sort of a boot camp. It straightened me out. It meant maturation. I matured. And most importantly, it put everything I'd done in perspective.

INTERVIEWER: So how long were you working at Schlumberger? Was it brief?

SARMA: It was brief. I'd hurt my knee before I went to Schlumberger. I had an accident at IIT, playing soccer, actually. And so while I was at Schlumberger, I had a great time. I joined towards the end of 1989. I left in mid 1990, because my knee was unstable. Eventually I had to have surgery and get screws, and my ACL sort of gave up on me. But I was there through the winter of 1989, and I left, I think, in August 1990, to go to grad school.

INTERVIEWER: Winter in the North Sea?

SARMA: I spent the winter in the North Sea.

INTERVIEWER: I see that you're doing a wonderful job of laying the seeds for things we'll talk about later, when it comes to pedagogy.

SARMA: What did Steve Jobs say, you can connect the dots backwards?

INTERVIEWER: Yes, exactly, so congratulations and thank you for making my job so easy. But let's talk about grad school. And the decision to, first of all, to go to grad school, whether that was the moment you said I think an academic career is the career for me. And also pursuing graduate studies in the United States, what your familiarity with the US was, and just what that decision entailed for you?

SARMA: Yeah. I went to grad school partly because of my worries about my knee. Being on an oil rig with a shaky knee is not a good idea, and I didn't realize. Eventually I had to have major surgery, and so on.

But I had friends in grad school, and they were telling me stuff. I remember talking to one of them-- a very dear friend of mine actually, who got me to go to CMU-- in 1990. And he was telling me how much fun he was having, and so on. And I'd applied to Carnegie Mellon and a bunch of other schools, and I got into CMU.

And so he went and talked a professor there into giving me a research assistantship. And I move there. CMU really appealed to me actually, because of robotics. I actually knew America quite well, from a variety of reasons. Not least of which is my father got a degree at Harvard. I was a young man when they came here. I wasn't a child. So I had a pretty sort of interesting insight into what American education was.

Coming to America was seamless for me. It's interesting, growing up in Delhi you'd think it would be a culture shock. But Delhi was, in some ways, closer Pittsburgh than a village in India, growing up in Delhi. It was very strange. Plus, I had all these IIT friends. But I also had a lot of American friends that I made immediately, people I've stayed in touch with over the years, over the decades. So it was a very smooth transition. I had some money from Schlumberger, so I was the guy with the car. So everyone wanted to hang out with me. I think I taught a dozen people how to drive in Pittsburgh. So I loved America instantly. I really enjoyed it.

INTERVIEWER: Did you come with a definitive research or academic plan in mind? You mentioned an interest in robotics continuing. Or was that still a little bit of a work in progress?

SARMA: It was a work in progress. I would be lying if I ever said to you I had a grand plan. I came because I was interested in robotics. I was interested in design. And the professor who wanted me to work in his group was in design, a wonderful man.

So I went to CMU and I worked on a combination of things. And the most profound thing that happened to me was I actually enjoyed learning. I enjoyed it. After going to IIT, after all the troubles of getting into IIT-- in IIT, just me, I said I hadn't grown up, but perhaps circumstances about the way education worked. For some reason after my work experience which put everything in perspective, when I went to CMU-- bam-- everything clicked. I enjoyed every class. I aced every homework. I was so diligent, and there was a completely different person than 18 months previously. And I took a deep interest in a number of topics, beyond robotics and design. It was fascinating, and I couldn't explain it. I can only explain it now, I think. But that time I didn't know what had happened.

INTERVIEWER: So what do you think had happened? Was it you, or was it the way you were being taught, or both?

SARMA: It was both. I really think it was both. And even me, I think different-- you know when you are 17, you're still frankly a teenager. Right? And some teenagers are mature, and some are not. And so we need to understand both things.

People who come in young, the teenage mind is so fertile and so flexible. But also there's so many things happening in there. It's learning so many things. We have to understand how to take advantage of that extraordinary opportunity for a growing person, to guide them.

I was immature, but the system was also sort of brittle. Now when I went to CMU I was older, so I had settled down. But the way learning occurred, which was to focus on less but to learn more. That is 180 degrees, frankly, to how education works to some extent in India, where the focus is on quantities, and not on depth.

Many, many years later, only a few years ago, when my little kid, my child, was in American elementary school, it's sort of interesting. When I was in India, and all over Asia and Europe, it's fashionable to make fun of the American education system. And unfortunately, Americans have fallen into that trap right now. But actually when my child went to school in America, I noticed a pretty fundamental difference, which was the focus on analytical thinking analysis over facts and content.

Facts and content are convenient because you can measure them easily. But analytical thinking is harder to measure, but actually helps you more in life, strangely enough, especially in this day and age with Google and so on. Right? I'm not saying we shouldn't do facts. We should. But there's something very profoundly practical, and in the same time deep, about the way education works in America, which I had only begun to scratch the surface of when I went to CMU.

INTERVIEWER: Was there a point, maybe at CMU or maybe afterwards, where you started to think about teaching itself? Or education itself as a vocation, or a calling that was appealing?

SARMA: You're accusing me of having a grand plan. I don't. I never did. Just kidding.

INTERVIEWER: There must have been a certain point where you said, I can do this.

SARMA: No, I never thought I'd enjoy teaching. I didn't think-- I wanted to go do stuff, make stuff. And that's a good question. It wasn't until I started teaching, quite literally, that I realized that I actually enjoyed it. I'm obviously not very introspective. I enjoyed the research a lot. I really did. I enjoyed the people, my lab mates in a larger academic setting. And I enjoyed the fact that, in a college, you can hear people on the one hand discuss Shakespeare, and on the other hand, discuss engineering, or disagree on politics, or talk about international relations. I really enjoyed that, but I didn't see that as where I would end up. I didn't not see that as where I'd end up. It just never occurred to me. I did think I would go to work at a company and build things.

INTERVIEWER: So you actually went on to Berkeley. Were you teaching while you were in grad school? Was that when you started to have these classroom experiences?

SARMA: So I ended up at Berkeley, strangely enough-- actually, I'd got into both MIT and Berkeley, and I ended up at Berkeley because my wife, who I'd met at IIT, was a grad student at Berkeley. So I moved to Berkeley. I did some TAing there, teaching assistantship. And I wasn't very good. Or I guess I didn't enjoy it. And there was a lesson in there for me as well.

Because when you're a TA, the class is designed right for the curriculum. Everything's laid out, and you're just grading assignments. But I also realized in retrospect, I think one of the reasons I didn't super enjoy it was because I didn't have the opportunity to redo the curriculum in a way that I thought was practical. Maybe I'm a control freak. I don't think it's that. But I was just a spoke in a wheel, a cog in a gear. And again, I was OK. I wasn't great at it. But I enjoyed the research a lot.

But I did enjoy, I have to say, not the actual grading, I did enjoy the one on one interactions with students. For a selfish reason, that it forced me to reorganize my own thinking. I see teaching partly as it's sort of inviting someone to your home. You got to clean up your home. And so I found that strangely clarifying. So but that was entirely selfish. I don't know if the students enjoyed my teaching. I've met a few of them since, by the way, and they've been generous in saying that-- they haven't commented on it. Certainly not negatively, but maybe they were just being generous.

INTERVIEWER: So you mentioned research. As you progressed through grad school at CMU and then at Berkeley, what were the research topics or issues that you found yourself being really drawn to and that you started diving into?

SARMA: At CMU, I was interested in mechanical engineering design, and in particular, I was very interested in a field called it's optimization. And I was interested particularly in taking the information you know about things to make optimization more efficient. So it was sort of a semi-mathematical thing, but I was also partially involved in a number of other projects around robotics and design and so on.

When I went to Berkeley, my research shifted. And I was involved in building machine tools, CAD systems, and something that is calling planning, which is applied both to robotics and to manufacturing. And so it was all about automation, so a form of robotics if you will. But everything from spatial stuff, to controls, to software, it was a very integrative approach.

INTERVIEWER: So tell me about coming to MIT.

SARMA: So when I graduated with my PhD, my PhD adviser said, have you applied? And I said no. He said I didn't do anything. I had applied for a couple of jobs. I was a little blase about it, frankly. And he said, you should go look at MIT. And my PhD adviser was a wonderful man, Paul Wright, who remains a friend and a mentor to this day. So I said, Paul, do you really think this is good for me? And he says, no, you must do it. You should go at look it.

So I interviewed at MIT, and I actually got rejected. But then someone said come back and interview for this other position, actually Professor Alexander Slocum, another dear friend. And I came back and interviewed. And I went back to Boston. And my wife managed to wrangle a ticket to Alaska. It just happened to be November, by the way.

So November, we were in Alaska, hitchhiking and hiking. And one day, I remember calling my answering machine back in Berkeley from a telephone booth in Denali National Park. We could actually literally hear the wolves in the background. And there was a message on the answering machine saying, you need to call. Please call MIT, from them. And I called them, and they went, well, we have an offer for you.

So in December of 1995, I moved to MIT. And there was a massive snowstorm, I remember. And I walked into MIT over the Harvard Bridge in two feet of snow in a suit. And MIT was closed that day.

INTERVIEWER: But MIT never closes.

SARMA: I know. MIT never closes, exactly. It's actually very much more-- we close a lot more now. But at that time we never closed. And so I came to MIT and I started working with a couple of people who remain dear friends, Alex Slocum, Dave Trumper, at the lab for Manufacturing Productivity, where I continue to sit. And my research, I had a very clean idea of what I wanted to do. Rapid prototyping had just started to take off at that time-- Ely Sachs one of the pioneers of that field.

But rapid prototyping is an additive process where they take particles and add up to build things. There is a more traditional process which is very, very powerful, called machining, milling machines, et cetera. And my dream was to create rapid prototyping using machining.

There's a lot of manual intervention that goes in there. And my dream was to be able to take a CAD file-- at that time we still had floppies-- put the floppy in, and then have a finished part come out not by 3D printing, but by machining a hunk of metal. And so I threw myself into it.

And I've always prided myself in being able to bridge across fields. So I computed a design, I built machine tools, and my group and I, we invented a new manufacturing processes. We worked in polymers. We worked in metals. We worked in a whole bunch of things. And that was my research for the first few years.

INTERVIEWER: So at some point you became interested in RFID technology, and all of the promise of that. Which ultimately, not to get ahead of the story, led to this concept of the "internet of things," and so many other things that all of us do now. What was the genesis of that? How did you become involved in RFID? And what did you see as the promise, and then maybe compare that to where things have gone?

SARMA: That's a good question. So in the late '90s, what was happening was we were making improvements in manufacturing by 3%, 5%-- which is huge, by the way. But a company could get a 50% improvement, by moving to Southeast Asia, in economic performance. So these battles that we were fighting were on the front that companies didn't really care about. So we were doing that.

I continued to do research in manufacturing all the way into 2004 or '05. We kept writing and doing some math and good work. But in 1998 a colleague of mine, an MIT man by the name of Dave Brock-- actually, he's the guy who pulled me into RFID. I knew about RFID, and we talked about it. But he said, Sanjay, we should look at it.

And he had this wonderful idea that why do robots try and recognize an object? Why can't the robot just ask the object what it is? So if you imagine a robot and a robot assistant at home-- we were dreaming of it then. And you have a cup. Right? Maybe the cup has an RFID tag, and the robots says hey, how do I pick you up? And the cups says, well, you told me by my handle, and my friction coefficient is this much. And you come in with this approach.

But those are his ideas-- beautiful. And so I started looking at RFID with him. And then we got a couple more people involved. One person, Sunny Siu, another professor of Mechanical Engineering-- he's left since, but he lives in Shanghai. We were very close, still remain in touch.

And we also had a wonderful colleague from Procter & Gamble, Kevin Ashton, come to MIT because he understood-- he was a brand manager at Procter & Gamble. He understood how to place brands in retail. And he brought the whole retail perspective. And Kevin became the Executive Director of the Center. And he was great at helping us frame the vision of where this could go in retail and commerce.

But also, together, we were very good at, frankly, persuading companies like Wal-Mart, Procter & Gamble, and Gillette and standards bodies like the Uniform Code Council. These are the guys who do barcodes, a great organization, to become sponsors. So that's how we got started.

But the real idea, at that time we didn't call it the Auto-ID center. We called it the Distributed Intelligent System Center-- the idea that RFID tags could be fiducials on inanimate objects. And these inanimate objects could suddenly become accessible over the internet. It's like a database, but a physical database. You could see what all was in the room, even without seeing it.

And it was Kevin actually who came up with the term "internet of things." Because we were trying to explain this to people, and people didn't even believe. Very few even knew what the internet was. And if we said the internet would be accessible in a room or a telephone, people would laugh at us. So we decided to turn that into our schtick. And Kevin suggested calling it the "internet of things." That's how that term started.

The reason that we got into RFID, actually, is that we started talking about this. But there was actually an RFID industry already. That saw us as a bit of a threat. I'm not sure why. But as I started looking at RFID personally, I began to realize that the tags are far more expensive than they needed to be. And the protocols, they were old-fashioned. I wasn't a communications guy, but I knew enough. So I started studying it.

The protocols were old-fashioned. The manufacturing processes were old-fashioned. And they weren't using the internet. They were putting all this data on the tag, but you couldn't put it on the internet.

So I said, why don't we make them cheap? And Kevin Ashton, the reason we met and got excited about it was, he said, well, if you make them cheap, the retail industry will definitely adopt them. And I started thinking about how to make a cheap, and how to build a system. And I'm an engineer, so I started piecing things together. So that's how I got into it.

But then we actually tapped a real vein of need and necessity. Necessity is the mother of invention. And that was the fact that, to this day, the supply chain that feeds retail has a lot of uncertainty and a lot of errors in it. And at that time, companies started taking it seriously. And so we tapped right into that, and that's how it got going. And that's how I got sucked into the vortex, and it was a wonderful vortex.

INTERVIEWER: So I think the "internet of things," it's interesting to hear that it's origin is actually some time ago, because it's a term that is only now, I feel, becoming current in popular culture. There was a radio ad I heard the other day making a joke about someone's toaster being online. And I was wondering if you could just think about that sort of revolution, which I mean clearly is happening in fits and starts, but of everyone's stuff being online, not just supply chain, but everyone's stuff.

SARMA: So right in the beginning, actually, Dave Brock and I we were conceiving-- we were thinking of putting things on the internet. You were talking about a toaster? I had a wonderful student, Joe Foley, who now teaches in Reykjavik, in Iceland. Joe managed to purloin his grandmother's old microwave oven. And we put a microwave on the internet in 2000.

And that was our defining vision of where this whole system would go. So here's what we built. We took a packet of food. We put an RFID tag on it. And what we would do is when you put the food inside the microwave oven, it would read the RFID tag, go to the internet, download a recipe for microwaving, cook the food, and the food came out. So that's when it started.

When you start something like that, usually it takes some time for pieces to fall into place. America, one of the great things-- I'm a huge fan of science fiction. And I think science fiction has done tremendous things for American creativity. You know 3D printing, right, in some ways, is the vision that in Star Wars and Star Trek. Right?

So one of things is that when you anticipate these things, you lay a framework. But not all the pieces are there. The internet was slow. It was expensive. Wireless wasn't really there. WiFi hadn't taken off when we did this, right? But once the framework was established, either by sci-fi, or something like our project, I think what happens is it settles in the collective consciousness of the technorati.

So I think it's settled there. And as other pieces fell into place, this sort of unconscious became conscious. And that's we're seeing now.

And we-- as in Dave Brock, and Kevin Ashton, and Sunny Siu, and I-- we stood on the shoulders of others who thought of other things that may not have been the same thing, but created a framework that helped us think this way. So there's sort of a silent meme, a mental framework that sometimes we don't acknowledge or surface, but a lot of engineers share. You know. It's sort of like what literature does for us as well, in my view.

Literature gives us these narratives that take shape over time. And they'll help us build new narratives. So similarly, I think there's a technological narrative that we help frame, and we use other frameworks to build it. And that over time is now becoming actualized, as we speak.

INTERVIEWER: So I want to ask you about another narrative that I think has shaped your interests, entrepreneurship and innovation. And clearly building on some of the research innovations that you've been part of would be one part of that story. But what about just the idea, in general, of being an entrepreneur, being an innovator, being disruptive? Is that something that you felt was always part of you? Or was it again something that you fell into as a narrative that you appealed to you?

SARMA: So I was always a sort of a cocky smart ass, but I'm not sure that I was. Maybe innovative, I was always trying to invent things. But entrepreneurship, I actually consider myself more an admirer of entrepreneurs, or someone who wants to be an entrepreneur.

It was wonderful in America, again, to see people just take that risk, just quit their job, take a loan, and start a business. And be willing to fail. That not being afraid of failure, being able to live on the edge, that's something in India you couldn't really do. Because failure is actually much more stark, there. You starved or something. It's much more-- there weren't that many safety nets. But even then, taking a risk is something that takes gumption.

So I have a great deal of respect for entrepreneurs. And I think that we should. It's become fashionable now, but 15, 20 years ago, I don't think we really gave them the respect they deserved. So in the '90s, because of that respect, because of that awe for their risk-taking ability, it was more me trying to see if I could do it, if I could muster that strength.

In some ways, I've always been at MIT. So I don't consider myself much of a hero. The people that actually quit their jobs, those are the heroes. So I have no idea to ever do that. I took some risks. But not that serious.

But there is something addictive about trying out new ideas. I've always felt that it's important to have opinions you know. They don't have to be crazy. They don't have to be black and white, and you should be willing to give them up if you're wrong. But I always felt that A-- it's good to have opinions, and B-- It's good to question.

Why accept everything for what it is? Why not question? One example I use is, for years, we all have these backpacks. But we always use one strap. Until the kid who invented the one strap bag, right, with only one strap for your back? That was innovative. Right?

So this questioning, the ability to take risks and try and make a business out of it, those are things I've always really respected. So I've tried to bring that into my life, both in our research group, but also in trying to start entrepreneurial activities. And I have never regretted it. In fact, it's informed the way I do everything, pretty much.

The other thing I'll say about entrepreneurship is the ivory tower that we live in is beautiful. It's wonderful. It's also cocoon, and it's a microcosm. So for me as a professor, to go out there and try and make a sale, and to fail, and to walk out of a sale with my ego in tatters-- not fun at that moment, but an extraordinary learning experience. Learning about the real world, I think everyone ought to do it. Or everyone should try it, if they get a chance.

So I think that entrepreneurship is an innovation. And going to become more and more important for society, period. But also, it's been great for me.

INTERVIEWER: So I want to ask you about another narrative that I think has shaped your interests, entrepreneurship and innovation. And clearly building on some of the research innovations that you've been part of would be one part of that story. But what about just the idea in general of being an entrepreneur, being an innovator, being disruptive? Is that something that you felt was always part of you? Or was it was, again, something that you fell into?

SARMA: That's a good question. So the first class I taught was on a topic I hadn't studied in a long time. And that was actually the best thing that happened to me. And so I had to relearn it.

But of course, I'd studied it a long time ago. So it came back much more easily. But I had to question the sequence. How do you explain that? Why is it useful? So I had to rebuild a narrative. The pieces were there, but the connective tissue was missing.

And I was also very fortunate in that some senior colleagues I was teaching with, I was able to watch them. But the most important thing was rebuilding that narrative. And I began to realize that in many cases, the narrative is broken. We just did stuff in a certain sequence, not thinking about how the student is going to construct the understanding in their mind.

So very early in my teaching career, I began to realize that we teach in a way that's convenient for us. We don't teach in a way that a student can accept and assemble a model of the world. It's sort of like if I gave you a bag of proteins, a bag of sugar, and a bag of carbohydrates, and said, eat it. Trust me, it's a Mars Bar. That's how we teach, because it's convenient to do all the proteins in one shot, and all the carbohydrates in one shot, because you can have a protein week and a carb week. That's how we teach, right?

So I began to-- because I was learning myself, I was sort of relearning it. Only much later did I realize that there's actually a scientific basis for this. I began to reverse my teaching, and I was forced to do it by circumstance, and reassemble teaching the components in a way that was friendly to the students' mental model.

I was also able to anticipate. I also learned the importance of anticipating ways in which the students might misunderstand stuff. And, in some cases, letting that happen and then correcting it. And in some cases, heading it off at the pass, when I thought it would be distracting.

So that was actually a wonderful thing, that first class that I taught. That's one. The second thing I realized is when one constructs a lecture or an exam, every one of those things is an opportunity to really shape that mental model.

And finally I just found that our students, and this is at MIT, I'm not sure I would have enjoyed this as much in another school, our students are just wonderful. They're creative. They're thoughtful. They're very decent. They have a great sense of humor. So the principle I came up with was what I call inspire, instill, and anchor.

So the idea is you inspire-- why do you need this? Why is this going to be relevant? And so you create room for the student to sort of absorb it. If you just throw it at them, they don't want to do it. It's just going to bounce off. But you have to inspire it.

Then you instill or install, depending on which word is a more convenient explanation. You want to, at that point, once their guard is down and they're willing to open it, you give them a small morsel of the information that they need. And now they know. It's like they're building a tree for information. They know where that information goes. Right?

And then you anchor it, which is once they have it, you anchor it with something. So for example, by the way, in a consulting gig I did, this showed up in the following way. And that makes it vivid. Right?

And the final thing is our students are actually great fun. So there's absolutely nothing wrong in having fun with them. They have a sense of humor. They play ball. If you make a mistake, they're actually forgiving.

If you confess, say, hey, I made a mistake. Let me go fix it. And what that did was that made it so much fun. And so I got into it. That's really my initiation into learning. The day I did it, I had no idea I'd actually find it fun. But somehow I figured it out, and it worked out for me.

INTERVIEWER: I'm just curious. What was the course that you first taught? And thinking forward, what were some of the courses that you developed, or that you were able to take this process or this approach and apply to that you were really proud of? Or you feel like you made a difference?

SARMA: So that course was a course that doesn't exist, or it's been reformatted. It was called 2.02. It was essentially applied mechanics, solid mechanics, material science. It now sort of exists in the form 2.002. But over the years, I've actually taught maybe more courses than most faculty at MIT.

I've taught mechanics. I've taught dynamics. I've taught design. I've taught manufacturing. I've taught advanced topics in math. I taught a course on finite elements. I've taught a course in RFID. I've taught more professional education. So I've been all over the place.

But in all of them, what I've ended up doing is taking the curriculum and deconstructing it, and reconstructing it in a way that I felt it would be more friendly to students' construction of a mental model. And initially it was unwitting, but over time I've firmed up my understanding of how I teach. It is inspire, instill, and anchor. And keep it loose, have fun.

And each course, when you actually look at the subject matter, the way you do that varies. So for example, if you're teaching manufacturing, the way you do that is very different than if you're teaching mechanics. Very recently in the last few years, through my discussions with a number of colleagues, I began to understand there's actually cognitive science that explains that this may actually not be this bizarre.

It's not a bad idea. This is the way to do it. There's actually a whole field of educational philosophy called task-centered instruction. And I think that pretty much sort of summarizes what I did, but without being told that was what I was doing.

INTERVIEWER: So at some point in your career at MIT, you started thinking about these issues and being involved in these issues, not just at the course level, but at a set of broader level, setting institutional goals, or even goals or concepts beyond MIT. And I was wondering if you could maybe talk about that evolution for you, just as far as your career goes, and how your thinking was shaped as you did that.

SARMA: My life with MIT has been sort of interesting. I did my teaching-- I actually get really good teaching ratings. And I was very fortunate to receive a couple of awards, and so on. And I continue to do my research. And research kept me very busy.

I left MIT for a couple years to start a company, et cetera, et cetera. But because I had these good teaching reviews, I would be asked to redo courses. Which is very stressful, because redoing a course, that's very difficult.

But in the process, it also forced to hone my skill. And I began to form opinions. That's the dangerous thing, to have opinions about how to do it right, and how not to do it. Opinions that, thankfully, later on I found out do line up with what we know from science.

So 2010, the then-provost and now-president asked me to take over and run the establishment of a university in Singapore, Singapore University of Technology and Design. And many of these instincts that I had turned out they lined up with many of the instincts of the faculty who had self-selected to participate in this project. I was the Director.

And I had an amazing two and a half years. Establishing, working with Tom Magnanti, who's the President of SUTD, my former Dean and a wonderful man, shaping the pedagogy of a new institution. The amazing thing was, because it was a new institution, we could throw out all the rules. And we could reconstruct what we thought was right, without any legacy, et cetera, no change management.

And we were able to apply a lot of these things. SUTD, this last couple of weeks, graduated its first cohort. And the students are different. It's amazing. So I did that for two and a half years, and that was extremely, extremely rewarding-- actually, almost three years.

And I also, as I said, my sense of learning science, if you will, sort of firmed up instinctively. I had a much better science and sense of what worked and what didn't, and what students really wanted, and student psyche, and what they lacked, and some of the problems, frankly, in our system at MIT.

And so in 2012, the new President asked me, Rafael, same gentleman, asked me to become the Director of Digital Learning at MIT. And I saw it as a golden opportunity. Not just, of course, to impact the world with MITx and edX, which was an extraordinary thing as someone who grew up in India, far away from all this-- it would have been so amazing if I had MITx. But also, frankly, to reuse some of those tools, to rethink how learning happens on campus.

Meanwhile, edX was going great guns. Anant Agarwal is an amazing guy, and so I was also offered the opportunity to sit on the Board of edX. So these two or three things began to come together.

And so when Ike Chuang and I started setting up MITx and the Office of Digital Learning at MIT, also leveraging the great wealth of resources in OpenCourseWare, also working with OpenCourseWare, to extend that mission, we brought Vijay Kumar's group in. At that time it was called OEIT. So we brought OEIT in, which now it's SEI. And we created a new engineering group. Then we brought AMPS in, DE in.

All these amazing groups of people gave us the tools to actually implement what we'd independently, but also we agree, felt was the right thing to do at MIT. So it's an amazing opportunity here to rethink education. I actually think that the way we educate, less so at MIT than the rest of the world, in large parts of the world I think it's, frankly, outmoded. It needs to change, and we are the cut, the tip of the spear.

INTERVIEWER: So all of this was going on at a very interesting moment in terms of public perception about education. And I tend to think of, with the MOOC explosion, we talked about the "internet of things" suddenly hitting public consciousness. In some ways, in 2012, that's what happened with MOOCs.

Suddenly, digital education became synonymous with MOOCs, but of course, I think it's also much more than that. I was wondering if you'd talk about, first of all, the MOOC explosion and your take on that. But also, clearly, ODL is more than that, how that fits in.

SARMA: So when MOOCs were announced-- clearly, education is such an important thing. But one of the things that really impacted my interest in education was the fact that I had a kid, right? And I watched her learn as you do. Watched her learn and watched what she enjoys.

In America, there's something of a crisis in education. Costs are high. Online education hasn't always been good in America, or it hasn't been successful necessarily. So there's a lot of pent-up interest in this. And when MOOCs landed on the scene, there was a lot of justified and justifiable interest in it.

But also it unleashed some pent-up good and bad feelings. So that caused this up and down cycle about MOOCs. It's an emotional roller coaster.

But you know, students are voting with their feet. And I would say that in every year that I've been involved in this effort, the reality has been this way. Sentiments are going up and down now. But it's just going up. In fact, if anything, it's hockey sticking.

So the MOOC explosion, I wouldn't call it an explosion as much as a front that has moved steadily, and with increasing pace, and with increasing inevitability. Right? Okay. There was a flurry of articles, and there was a flurry of negative articles, but the first articles got it right. This is on its way.

But having said that, the implications on campus may be even greater. Much has been said about, aw, MOOCs will take out universities. No they won't. There's something magical that happens in universities, and professors who worry about MOOCs should find their mojo, frankly. They should stop worrying about it.

Their impact on students is profound. The few professors at IIT who impacted me had a lifelong impact. MOOCs free your hands to do more, free your brain to do more. It's sort of like saying, when books were invented, people thought universities would come to an end. No, they didn't. What happens between two human beings is much more profound.

So that is what we're engaging in now. We're doing both research in learning, and applying those learnings on campus. And there is no better indication of that, or no better proof of that, than the amazing uptake of MOOC-related online technology on campus.

90% percent of our undergrads have already touched our online tools through campus. And this has gone from zero to 90% in the last two and a half years. I don't think we'll get over 100%, though. So we're nearly there.

So I think that the MOOCs give you so many degrees of freedom in how you reformat education. You can take the stuff that you put online, put it online, then create more time to actually talk to students, give them projects, work on issues they don't understand, build their mental model. I think it's an extraordinary opportunity.

INTERVIEWER: So the excuse, if you will, for doing these particular set of oral histories is the 100th anniversary of the construction of our current campus at MIT, the move to Cambridge. And so it's quite interesting to be talking to the Dean of Digital Learning in that context. Looking ahead at the future of MIT as a campus, as an institution, what do you think the impact ultimately is going to be? It's maybe, for people who like the campus, it's a relief to hear you say it's not going away. What do you see as the blend?

SARMA: Oh, I think we'll need more campus. If our EVP Treasurer-- I know he doesn't believe that-- but if anyone thinks that somehow we're going to need less campus because we can go virtual, I would say no way. If anything, we'll need more.

MOOCs make the real magic of MIT even more powerful. And MIT will continue to grow. Our campus will become more and more fascinating and fertile. This is the place where people will use an electron microscope one day and use a 3D printing another. And do an economic analysis to concoct the next amazing thing. So in 100 years, I think we'll be celebrating the positive impact of all these technologies, digital included, in the extraordinary expansion of the impact of MIT on the world. And on its impact on 20139, which is the space we occupy.

INTERVIEWER: I want to ask sort of an abstract question, and I'm not sure if I can get it articulated properly. But one of the things that I've been very interested in observing when working with faculty on online educational--

SARMA: By the way, I said 20139, I meant 02139. I apologize.

INTERVIEWER: Yes, not a date, but a zip code.

The process of creating a MOOC, the process of creating online educational materials, forces or encourages people to think about what they're doing in the classroom in a way that's similar to what you did, or described doing, in that very first experience teaching a class. That's been, for me least, an unexpected benefit or boon.

And it puts an interesting question about pedagogy and what online education might reveal about what works or doesn't work in quote unquote "traditional or classroom settings." So I was wondering if you have any thoughts on that.

SARMA: Yeah. No, it's absolutely-- you know writing is the highest form of thinking? I think MOOCing is the highest form of pedagogy. What MOOCs do is just creating-- putting stuff online forces you to really think through that narrative to the connective tissue. But if you're just going there and doing a live performance, and you've done it 10 times before, you just go by habit. And you don't reexamine. So it's an extraordinary option for you to rethink the way you present stuff.

But it's not just that. It's also that it's impossible in a regular lecture to do a 10 minute lecture. But all the science tells you that 10 minute lectures are more effective. Right? Not because you want to encourage people to defocus after 10 minutes or check their email. But because after 10 minutes, you can do a lecture related activity that encourages long-term retention. Right?

You can do projects. You can anchor better. Everything I talked about-- inspire, instill, anchor, all that stuff, you can do better. But technology's not just a convenience that pushes content out of the classroom so you can do more project work. You can actually do many things more effectively for the brain when you use technologies in some ways. And the things that technology can't do that only the human can do, you can actually open up more time for.

It's an extraordinary opportunity for us to rethink. Right? I can't think of any great analogies, but often change is the time when we improve things. Right? And this is a time of change, and digital is a reason for change. But it's also a tool for change.

But frankly, if five years from now, if a year and a half from now, someone proves that digital actually is horrible, we shouldn't do it. I happen to think it's one tool in our quiver. It's an important tool, and net net learning will improve.

INTERVIEWER: Among other things as the Dean, you're leading this really complex organization with a lot of moving pieces, and a lot of divergent projects and goals on ideas percolating. I was wondering if you would just talk a little bit about- - really, this is two questions. So we can take them in any order.

One-- how do you lead a herd of cats like that? And two-- where would you like to lead that group? What do you see as the future impact of this new organization on MIT, and beyond MIT?

SARMA: If I want all of us to agree to one thing, it is that none of us has the answer. At some level, MIT exists because there's always a question to which we don't have an answer. And an answer that was right yesterday, may be improved upon with a better answer tomorrow. Right?

So in terms of leadership, where how do we lead a group like this, my belief is that we need to inspire folks. And I think they come inspired. It's such a great group, constellation of characters. OpenCourseWare, huge, over 180 million people over the course of 15 years. That's an extraordinary achievement, what OEIT did. The videos AMPS has produced, these are all great groups.

But the key thing is for them to understand the importance of this mission. Human beings are what we are because of learning. If we couldn't learn, if we didn't have memories, if we couldn't plan, if we didn't improve, we'd be animals. Learning is, in fact, what makes us tick.

Learning is what took us out of caves. Learning is what took us out of the hunter-gatherer stage, and helped us design civilization, and manage, and improve. And this organization has the opportunity to pretty fundamentally impact that most important intellectual activity of humankind, right? Outside of feeding ourselves, learning is the next important thing.

So the way I want to lead is to both convince people of that, that they can actually make that difference, but also empower them to make that difference. But also, equally, to be willing on a daily basis to give up ideas, or be willing to open to modify ideas as new evidence accrues.

Where would I like this organization to go? I would like for this organization to be the world leaders in this movement. I would like for our people to be the most coveted, the more successful, the most importantly, the most committed people-- scientifically informed commitment, not dogmatic commitment, to this extraordinary endeavor. And I think we can make that happen.

All else follows, I believe that many of the individuals who are involved in this, and this sounds arrogant, but I truly believe this. So I'll say it. We'll write books about this someday.

For example, how can digital tools impact high schools in India? That's a project we're doing right now. How can digital tools be used to redesign the way we teach computer science, electrical engineering, and robotics? That's happening now, right? And then how can digital tools be combined with in-class tools and hands-on tools? We're doing that right now.

So these are all extraordinary steps. And this family is the family that's doing it. And I think once everyone's convinced of that, because the talent is there, things will just happen.

INTERVIEWER: So we've talked about MOOCs. We've talked about some of these other exciting initiatives that are percolating. Is there anything that's flying under the radar right now that you're particularly excited about? I'm not necessarily asking you to break news.

But is there something that, just as in some ways online education was evolving and then suddenly hit its moment of attention, in some ways over attention, a year or two ago? But it really was, as you describe it, more of a front moving in. Is there a front that excites you that maybe people aren't really thinking about right now?

SARMA:

I think there are two fronts. The first front is our understanding of the brain. In the last year, I've personally immersed myself in understanding what neuroscience and cognitive science and learning science and education science types have studied, and it's extraordinary. And as we understand how the brain works, we will make advances in everything from, of course, medical conditions like Alzheimer's or dementia, but all the way to learning.

How to infants learning, what's the best way to get infants to enjoy what they're learning, and yet retain what they're learning? What should we not teach them, because it's a waste of time because they don't get it, and we're just making things not fun? That is going to be one huge thing.

And I believe that'll play not just a part in K-12, in higher education. Higher education is our sweet spot. K-12 is our feeder. But actually, especially in professional education, because we are moving as a society from employees in large companies, who are cogs in a machine, to we're all going to have to become innovators. And technology is changing fast, and science is changing fast, and economies are changing fast.

And so the professional, in my view, in five years every professional will spend two hours a week just upgrading their skills. And we need to figure out to do that efficiently. And the advances in our understanding of the brain will help on that. So that's one huge front that I see. Maybe it's breaking news. I don't think it is, but I'm predicting. I don't know when this interview will go online, but I think by then this will become more and more apparent.

The other one is credentialing. Today we have a credentialing system that is more than a hundred years old. You get a high school degree, a diploma-- 10 plus 2. Then you can get a four-year degree, or a two-year degree, depending on which career path you take. Then you get a master's, which is two years or one year, depending. Then you get a PhD, if you want. Right?

But is the world ready for that? Is the world ready for something different? I think so.

Let's say you get a bachelor's. Is that it? Or are you going to keep getting one more course every year, or two hours a week, or something like that? And if you do, do you get this different type of degree? We need to start defining these things. May be there are two types of bachelor's, a bachelor's which is you're done, and a bachelor's which is live. Right?

We've got to think about these things. I see the struggles there, and the questioning occurring right now. But I see that taking shape in the next few years. And I'd like MIT to play a key part in this. Not because we're the only people who could do it, but because we have a lot of experience with online, and so on. And so we should certainly be a part of the conversation. We should help guide it.

INTERVIEWER: I want to be cognizant of your time. Is there something that you've been waiting for me to ask you? Or a topic that you've been waiting for me to bring up that I haven't, and you're just dying to address it?

SARMA: You know me too well, Chris. You've asked me pretty much every question that you could have asked me. You didn't ask me about my interest in cricket and tennis and sports, but we can do that some other day.

INTERVIEWER: Well, I want to thank you for coming in. I really appreciate the time you've taken, and I think it's going to be a really interesting and an important part of the record of all of these changes that are going on.

SARMA: Well, thank you. Thank you very much. It was a great pleasure to be here.

INTERVIEWER: Thanks.

SARMA: Thanks, Barry.