SMS 55TH ANNIVERSARY FORUM

EXCERPTS OF SPEECHES BY PROFESSORS TAN ENG CHYE AND LING SAN

As part of the celebration of SMS 55th Anniversary, a forum was organised and conducted on 9 November 2022 from 3 pm to 4.30 pm. The theme of this Forum was 'The Future of Mathematics and Mathematics Education in Singapore. The two speakers at this forum were both former Presidents of the Singapore Mathematical Society - Prof Tan Eng Chye, President of NUS, and Prof Ling San, Provost of NTU). The forum was moderated by Dr Hang Kim Hoo, Vice-President of SMS. The aim of this forum is to gather educators and thought leaders to look at several issue that are pertinent to Mathematics in Singapore.

Excerpt of the speech by Professor Tan Eng Chye

Thank you very much for inviting me to give this talk, and to be part of the panel. I thought the title which I think Kim Hoo insisted on, "The future of mathematics", is really a tall order. I'm going to just provide my five cents' worth of suggestions. We can actually refine our approach.

I've been sort of working in the department, and really fortunate of me to be able to also work with colleagues in the Singapore Mathematical Society, and today I'll just share some of my thoughts on mathematics education. My basic premise is: we are fine, but we can improve. So I hope that's the central message for all of us to take home.

So first I'll just talk about general remarks about mathematics education from P1 to JC2 in Singapore. I would also highlight the changes in the curriculum framework at NUS. We did that over the last two years. It's still in the process of execution. For every big curriculum change, we need actually four years to go through the full curriculum, while we are in the middle of this full curriculum change. My third part is actually to try to relate mathematics to everyday life, and I'll just give a few examples. As we all know, this is mandatory from P1 all the way to JC2. And why do we study mathematics? To many of us, I think it affords us with a structured way of thinking. It's a very structured way of thinking, and that's what I think we want our students to learn. Not so much about … How do you do integration? How do you factorize? And so on and so forth. Those are basically methodologies, or techniques. But it's the structured way of thinking about issues and problems. But we do get also a different perception from people who either are learning mathematics, or who are parents of children who are learning mathematics. The framework…I think it's sound. The MOE framework that looks at mathematical problem solving in terms of skills, concepts, processes, metacognition, and attitudes. I think all of us know; Metacognition is not easy. It's easy to put it down in the curriculum. But how do you get actually students to practice, to reflect, and to make corrections along the way about their thinking. It's not something that you can actually assign as an exercise. "OK, Peter you go think about it." It's less obvious than that, and definitely harder to do in

the class. On attitudes and processes, there is actually a very close interrelationship. Because if you expose students to solving problems, or real life problems hopefully, and they perhaps have a better appreciation of mathematics, and the techniques that they use through mathematics, and therefore the attitude would improve. But addressing one in a singleton is much harder, and I find that the places where we can do more is really how do you actually frame exercises or experience in terms of improving attitudes, metacognition, and processes. We do a lot, and we do very well in skills and concepts. So we did very well in TIMS. That's the measurement of the competency level of our students, and TIMS is typically for Primary 4 kids and for Sec 2 kids. We do very well. PISA, we also do very well. It's actually a random sample from schools, and it shows that our competency level across schools is actually fairly consistent and of high standards.

But then you have PSLE, the Primary School Leaving Exam. It is the level where parents can access. And parents are confronted with problems which they themselves have difficulty in solving. Part of it could be, their knowledge and skills could be a bit rusty, because it has been so many years. Part of it could be that they have not really learned mathematics well enough to understand why we are actually posing this problem. So you have problems like these, which we can do. But sometimes most parents can't do this type of problems, and this is one comment: "Today the PSLE students have done their Maths paper for the second day, and all the students… (well, this is really exaggeration, I think)… are in great distress and wants to kill themselves." I think we can laugh about it, but I think we can also empathise with the perspective of parents, especially whose children are agonised in that particular way. So I think there is a growing perception, that our calibration is not right. Again, I go back to why we study mathematics. As I've said, you need a structured way of thinking, and that's afforded by mathematics.

And if you need students to do science, which is actually very evidence-based, you also need mathematics, because mathematics is also one of the fundamental language of science. The perception of course is that people see that mathematics is just about a set of processes or algorithms. They don't see the connection with real applications, and they find that the problems are just too abstract, and I think that's one important part of my message. As teachers, it is important for us to try to relate what we do with real life. Yes, we need to provide the drilling in. But we need actually to connect students, and that's where I think the mental attitudes and refining of processes and metacognition… these are things that can be reinforced if you provide good examples.

So that's part one. I have more to talk about, but I'll just leave it at that. At NUS, we have undergone actually a big curriculum framework change. This was the biggest change since 1995, and that was more than twenty five years ago. It goes back to importance of enabling our students to learn throughout life. So the capacity to learn, and the mental frame that learning doesn't just stop after you leave the university. And there's also actually a blurring between job and pre-job training, of pre-employment training which is in most cases higher education. And these days we are seeing more students taking gap years. In future, you are likely to have students coming to the university for two years, and then they say, "I'm going to take five years of gap, then come back again to finish my degree." Or maybe they would do one year, and then they go back again after another five years. This can happen. So we have to be prepared that universities may not work in that same current framework, because students actually can be very mobile.

Now, what are the big changes at NUS? One, we have actually moved into a common curriculum system. The common curriculum requires students to go through over three semesters. And the common curriculum is broad. It takes courses from humanities, social sciences, all the way to the STEM. The second thing is that we wanted to infuse more interdisciplinary teaching and learning, and we are starting with the common curriculum. So, many of our modules in the common curriculum are interdisciplinary modules. I trust you understand the difference between multi-disciplinary and interdisciplinary. These basically prepare the student and enable the student to be a lifelong learners, and I'll try to explain why.

So for the big changes, we have created the College of Humanities and Sciences. That, by the way, is not merging Science and Arts and Social Sciences. It's a virtual college. But we have merged the Faculty of Engineering with the School of Design and Environment at NUS, to form the College of Design and Engineering. One of the key reasons is that design and engineering has tremendous intellectual overlap. For YNC and the USP, we have merged them into an honours college, and we call that the NUS College. The common curriculum for School of Computing will be effected this year, for School of Business it is next year. So by next year all seven schools and faculties would come under this common curriculum structure. The only ones that are missing are Medicine, Dentistry and Law. But we are also doing changes to their curriculum; I will not talk about it.

If you look at the spread of common curriculum in Engineering, you'll find actually a very rich tapestry of courses. You have critique and expression which is about communications. You have cultures and connections, which is about humanities. You have project management. You also have design thinking. So it actually has a lot of modules taught in an interdisciplinary way. How do I do that? Actually, I need a lot of practitioners. For instance, the course of Sustainable Futures. I've gotten Khoo Teng Chye, who was formerly from URA and PUB. He became our Practice Professor. He worked with two of our professors to create a course on sustainable futures. In fact, he also created a minor in the cities program in Singapore. Why Khoo Teng Chye? Because he actually has access to a lot of real-life problems which we want him to bring into the classroom. And he's not a teacher, so we have to put him together with professors, in order to curate and deliver the course.

So this interdisciplinary learning is really about taking two or more disciplines and trying to teach them about both disciplines, both approaches, and how you integrate the approaches in two disciplines. And it's not simple. A useful way is to base it on problems. Now, interdisciplinary learning is not just plainly academic learning. We need to actually augment it with experiential training, and this is where internships are very important. The internships should tie in very closely to the courses that they are learning at NUS. So a lot of work in progress. We are aware that it takes about forty courses over four years to get a degree. In the past, you take about twenty to twenty five, even thirty courses in one subject. And then you leave the rest, forty minus that, for the other subject. Now we have confined a major to be only fifteen courses. The common curriculum is fifteen, and we have insisted that we leave a space of ten for students to explore other majors. So we actually want our students to try to do double majors, and if possible in two opposing types of disciplines, like humanities and science, or humanities and engineering, and so on and so forth. But again, the choice is theirs. This just a recommendation. But for someone who is so passionate about physics and wants

to do more physics, they are free to do all the ten courses of unrestricted electives in physics. So there's still the flexibility that they can still be a deep specialist.

Let me just talk about my earlier point that it is important to try to relate our students to everyday experience. So this one is from one of our very, very early Maths programs. We have a team in the 90's. We do a lot of enrichment programs. And our enrichment program is really framed on problem solving. And this is a very structured way of thinking, without the need to go deep into any particular area. But it's just the process of thinking, structured thinking. We typically say, "Oh, okay, there are broadly seven ways that you can approach a problem. There could be more…I think you can do a finer breakdown. But when we teach them we tell them these are seven ways, and you can solve, for instance, a primary four type problem, in this way. We leave the transparency with you, and then you can solve it during your free time. This is a problem that I posed to my kids. I have four children, and initially they get very irritated, because during dinner time I usually ask them puzzles. This is one of the puzzles that I've given them: sharing a cake. How to share a cake the fair way, between two persons, between three persons, between four persons, so that each one of them will perceive that their share is fair. How do you do that?

Now, let me give you an example: statistics versus big data. Statistics has been taught as a subject. I don't know whether now, in the pre-university, or in Sec 3 Sec 4 whether statistics, or some aspects of statistics, has been taught. But I think that statistics is important. Statistics is actually about quantification. And quantification actually provides a very, very strong way to think about, say, numbers, objects. Numbers do sort of mean something. But sometimes numbers can be misleading. And one of the challenge that we have now nowadays is with social media. A lot of people, even with good training, will be easily misled by so-called quantification like this (slide). That is one aspect that if you are well-trained in statistics, then you are sharp enough to be able to say that "Aha! This is wrong." Now this is our contemporary view of statistics. But what happens when you have big data? When you have big data, you don't talk about a sample. A lot of statistics is about looking at a big population. You want to infer some characteristics of the population, and the best way is that you take a sample. You analyze the sample, and then you infer the characteristics of the population from the sample. So that's a basis of statistical inference.

If you have big data, the paradigm is very different, because with big data all the data is available to you. So you don't need a sample. Does it mean that the statistics is not useful? The answer is no, but statistics needs to be applied in a very more delicate way. So this is one example where, it is one of the important sort of techniques, important capability that all of us need. I think mathematicians, you are safe, because a lot of this you already know it. And so at NUS, you understand why, now that I make every staff actually go through the data literacy program. Every admin stuff, so that's about four thousand of them. These are admin stuff. They have to do data literacy, and they have to also attend an AI competency program, and another program that they need to attend will be design thinking. My premise is that it is an important skill. And, in fact, my second example is on digital technologies. If you look at digital technologies, data analytics (I've just given you, and I relate it to statistics that all of us learned very early on in our pre-university education), artificial intelligence, blockchains, fintech. All these are mathematics.

[Let me] grab some slides from a talk that I gave on blockchain a couple of years ago. In fact I was teaching this to Sec 2 kids. I was teaching them about the RSA encryption system, about public keys, about private keys. This is the public key system. I did not illustrate this then, because there then wasn't an application where you can actually embed a signature, you can accompany a blockchain, a part of the blockchain. But all these are actually fairly simple mathematics, which I think can be illustrated to students, so that they can connect, and there are many, many more examples.

A last example. This occurred to my daughter. I have two daughters; one of them is an opera singer. She is often used as an example. She did her degree at NUS in the Yong Siew Toh Conservatory of Music. She graduated in opera. Then she went over to Hanover to do her masters, also in opera. After that she told me "I can't find a job in Singapore, because Singapore only has one lyric opera that only has one performance a year." So she said she wants to look for jobs in Germany. In Germany, if you go to an opera house, you start as a trainee. The starting pay is one thousand euro a month. One thousand euro a month is barely subsistence level. And as a foreigner, she doesn't get their benefits. They'll probably only pay her five hundred dollars a month. So in the end she said, opera house is out for her, too. She said, okay, she is going to look for another job. Then she found a job in Rohde and Schwarz, which is a electronics company. She actually depended on her fluency in German. As an opera singer, she needs to know German, French, and Italian. Most of the operas are in those three languages, and she is pretty good at languages, so she's pretty fluent in German. So she got herself in as a project manager. Now, as a project manager in an electronics company, she has to learn engineering. Two months ago, she came to me, "Dad, can you teach me quantum computing?" Because a company is interested in quantum computing, and she needs to have a quick knowledge of quantum computing. She said that, okay, she's thinking of changing jobs. Now she wants to be a consultant, and then she has to practice for all these interviews. As you go through the interviews for consultancy firm, there's always one or a few interviews on case interviews, so they'll present you with cases. And she showed me some of the cases. She said, it's actually fairly easy, because these cases look for a structured way of approach to the issue or the problem. They want to hear about how you structure your approach. I'll let you read this one form Bain & Company. Usually they will give it to you. Your study for ten, fifteen minutes, and then you answer. This is another example. Now, the nice thing that my daughter said is that she went through primary school in Singapore, secondary school in Singapore, JC in Singapore. Her maths and logical thinking are pretty good, even though she's trained as an opera singer. She has the foundations and she was able to adapt quite easily. And I will just end with this example to just say that our system is actually good. I think there are very few educational systems in the world that is as good as Singapore. But I think there's increasingly a need for us to try to connect to real life. I think you have an excellent framework, but there are parts where you need now more attention on the part on metacognition, on attitudes, and on refining the processes. Those three are actually fairly well interconnected. You need to expose students to those three areas so as to reinforce. Giving them actually more and more examples like this to deal with, I think, will help them actually appreciate mathematics better, and mathematics is actually extremely powerful. Thank you.

Excerpt of the speech by Professor Ling San

Eng Chye has actually said everything I want to say. So I can skip to the last slide. But I guess in order to earn my keeps, let me just start at practically where he left off. You know, he ended his excellent talk with some real life examples and the message that it is important to connect to mathematics with real life. Well, so I'm just going to very quickly skim through a few very recent examples. During the pandemic, a lot of mathematicians came into life, most visibly in the space of modeling. It was very important, because nobody understood how the disease was spreading. And modeling was one way to help us get some handle on it. Sometimes you get it right. Sometimes you get it wrong. But nonetheless there was an attempt. In fact, modeling went beyond just the epidemiology of it.

So this slide just gives us a very quick glimpse into the various real-life areas, applications, where mathematics actually features very prominently. Epidemics, we just saw. Even in the study of human growth, prediction, modeling and differential equations come in. Imaging, tomography and MRI… image processing is full of mathematics, and there are some excellent people working in image processing right here in NUS. Surgery… modeling and differential equations. Genomics is all about data, and that's really big data. So these are just some modern day examples where I would stress that even though these are all life science areas, they are not dominated only by biomedically trained individuals. In fact, mathematicians play a very key role in some of these. Well, Eng Chye talked about cryptography. I don't need to belabour that. But computer graphics, for example, is so rich in underlying mathematics as well. Speech recognition, again, it's about statistical modeling, artificial intelligence, data compression… your name it, you have it. Search engines: the famous Google algorithm really was founded on mathematics. And again, one does not need to be a computer scientist or a communication engineer or whatever to be in these domains. With strong mathematical foundation, whether you are studying mathematics as your degree major, or some other STEM areas, so long as there is a very heavy component of mathematical thinking, chances are one will be quite fit for a number of these areas.

Well, beyond digital economy, beyond biomedical sciences, this [slide] is more about sustainability, about our planet Earth, prediction of weather. Now, this is another big data thing, and it is so complex. Glacial melting…that's global warming. This one is my favorite. Coral reef growth: the underlying mathematics is hyperbolic geometry, because that is the best way to model coral reef growth. So just in case you think that oh goodness, they're all like statistics, and you know, so-called applied mathematics. Now this is as pure as you can get.

The others are like monitoring of volcanoes and wildfire. Again, a lot of fluid dynamics and all kinds of interesting applied mathematics there. Well, here are some other everyday examples. Finance: it started actually more than two decades ago. It was probably like three decades ago, when Wall Street was already getting very interested in it. And there have been proven success stories. Beyond that, a lot of challenges that we are still facing today, like supply chains, operations research, optimisation. All these are directly linked with a lot of facets of our life, and that's where any training in those areas will become extremely relevant. Okay, so enough said about these. I call these just theory examples.

I will show you a few faces. So the first guy, Sergey Brin, founder of Google. He did undergrad in mathematics and computer science, his claim to fame is Google, and Google became so successful because of the algorithm: the search algorithm. Needless to see, he's one of the richest men on Earth today. Jim Simons spends I think more than a decade as a mathematics professor in topology, in geometry, in string theory. And then he founded a quantitative hedge fund. Renaissance Technologies, using mathematical tools to manage hedge fund. Immensely successful, amongst the top hundred richest individuals on this planet Earth. And he is still passionate about mathematics, and he's still supporting mathematics. Tom Leighton, from MIT, a professor of computer science and applied mathematics. He is one of the co-founders of Akamai Technologies. It's in everything that's IT-related: web and Internet security, cybersecurity, cloud computing, distributed platforms, content delivery network, and so on, and so forth. Again, immensely successful, and he's on leave from MIT. He has been the CEO of Akamai for I think, at least the past 10 or 15 years. Closer to home, Ning Chen David, he was one of my colleagues. Very sadly, I lost him. So his original research area was computational game theory, very exciting stuff. And then one day he discovered that actually it was quite interesting to apply it to real life. So he started his first company called Matchimi. It was like an online matchmaker between companies which are looking for part-timers and individuals who are looking for part-time jobs. So that was what he started. He found that the real world was really quite interesting, so he decided to take a leave of absence. He set up Nestia, which is a live stock platform. It has a whole lot of things, on top of mobile payments. You can also do property transactions…really a whole suite. Those younger ones amongst us might recognise this one. It's Atome. In a simplistic way you can call it an online shopping platform. It's a buy-now-pay-later kind of concept. Quite successful. In fact, it led to the formation of this one: Advanced Intelligence Group, which he started, together with a few others. Amongst other things, they are doing fintech. It's just so great that he's gone, you know, from academia. He's fully in the real world. And of course, colleagues from NUS would know Alex Thiery. He set up a company Abyss Processing that's doing 3D AI solutions to glaucoma. Again Ai and machine learning, big data, kind of thing. So these are some real-life examples of what mathematics has been used to impact mankind.

Now let me take one step back and look at all those things that I've shown you. What principles can we abstract from there? I would argue that if you think about all those past few slides, and try to glean some common themes, in terms of skills, the mathematical ones: modeling and simulation, was quite prominent. Underlying that, computation, some kind of computation. Data analysis was another. Okay, you call it big data, you call it stat, or whatever. Broadly, I will call it data analysis. And then, of course, underlying all these whole suite of skills, such as stats, discrete math, and so on and so forth. So these are the mathematical skills. Well, which then suggests to me that perhaps these will need to take priority over certain other topics, if we want to ensure that students who study mathematics are as useful as they can. But mathematical skills alone would not be enough. Eng Chye has alluded to that already. In fact, in all these applications, the application is always in another domain. And in order for us to make ourselves useful in a different domain, we need to be able to communicate with the people in those domains. First of all, the communication goes both ways. We must have the ability to understand what that problem is. Then we can bring back to our own professionals to process it. But after we have solved the problem, we need to be able to communicate back our ideas, our solution. So not only do we need to understand a field. We need to be able to

communicate. And that calls into question, whether we have enough interdisciplinary collaboration, the kind of skills we have. I would also argue that while programming, fundamental idea of programming will be very useful, even more useful is actually that frame of mind. Of understanding how you can translate a problem into a code. It's the computational thinking behind, but having the actual skill to translate it into a program, that's even more useful. So I would argue that these are the skills that will be quite fundamental if we want to realise the full power of mathematics.

But we should not forget some of the inherent gems in mathematics. These I call the evergreen usefulness of mathematics. To me the most beautiful part of mathematics is really the power of abstraction, the kind of training that would give us the ability to go back to the first principles and try to suss out the underlying principles. In my own experience, I find that generally mathematicians do it best, because the thinking is very, very clear. But after you have been able to abstract a situation into a problem, into principles, you need to be able to model it. You need to cast that problem in a mathematical language, in mathematical framework. It's a process of translation, distilling it, distilling the idea, and then now framing it in the right way. But here comes the key, rigorous, logical thinking. So I was meeting with a very successful businessman just last weekend. And I was trying to explain to him mathematics. The moment he heard I was a mathematician, he got very excited. He said, “I like mathematics, you know, but I only studied to O level. But tell me more. Actually he is very intelligent. So I was trying to explain to him mathematics to me is a very unforgiving discipline, because in terms of logical thinking, the demand is very, very strict. An argument, a reasoning, is either right or wrong. There's no such thing as, your view is also okay, my view is also okay. I mean, there's no such thing as it all depends on which perspective you come from, it's either right or wrong. I mean, there may not be one right argument to get an answer, but every argument you come up with is either right or wrong. So that kind of rigor actually is invaluable because it actually provides a very tight framework for us to think. And from there, with all the information we have with all the tools we have before, we are able to draw inference. Sometimes the inference can be astonishing. Even in mathematical theorem, sometimes you know the conclusion really astonishes us. And real like the same thing. If only we allow the combination of abstraction modeling and logical thinking to guide us. And of course all these lead to effective problem solving. So I would argue that these are actually the best selling points for mathematics that we should never throw out, and that's also where Eng Chye was alluding to, that we have done very well in our curriculum. Let's not throw these things out.

But coming back to the skills that I mentioned earlier. I think, in view of the understanding of the skills needed, we would then have to relook at our curriculum, both at the University level as well as before University, to see whether there can be room for improvement. I'm starting from downstream and slowly going upstream. At the University level, I would argue that we will have to rethink core mathematical skills. What do I mean by that? For example, traditionally, the mathematics undergraduate curriculum… the cornerstones are often, you know, mathematical analysis, linear algebra. But in some cases, statistics is not even in there. Discrete mathematics is not in there. And even if they’re in there, they might actually be less prominent than linear algebra and analysis. So do we need to do some rebalancing? Do we need to, for example, weave in programming? when we set up the Division of Mathematical Sciences, we made programming compulsory for the math major.

The first few years, when students came to check out the program, there was always a question, which was "Professor, I want to study mathematics. I don't want to do computing." That was the kind of mindset, but we believe very strongly that that is basic skill, that was why we weaved it into the curriculum. And I think today, it has become much more widely accepted that, you know, it is part and parcel of a maths training. So beyond that, breath beyond mathematics. And that's all about connection with other disciplines. That's all about this interdisciplinarity that Eng Chye was talking about. There will be always these exceptions, who only want to become a number theorist. But by and large the whole system should not be just tailored to that. So by and large, I would argue that, you know, beyond mathematics, that's important.

Interdisciplinary learning…well, NUS has introduced its interdisciplinary learning, at NTU we also introduce an interdisciplinary collaborative core since last year. We approach it slightly differently. All the five to six thousand undergraduates from different programs attend the same core. And in fact, starting next year, the medical students are also coming on board. Each of these courses has been co-curated by a team of professors from different disciplines: the philosopher with the mathematician, with the life scientist, with the electrical engineer, coming together to co-curate that course, and then they co-deliver. The students come from different disciplines, sitting in the same classroom, in the same team, doing the same project. So that's our way to expose them to interdisciplinary learning, in a very interdisciplinary manner. Transferrable skills such as communication, computational thinking, and so on, again, have become very very critical. All these would mean that we need to re-imagine our curriculum design. We cannot just add on things more and more. Something has to go in order to make room for some other more current skills needed. So the question is, what?

Well, let me go upstream. So I call it pre-university, I don't mean JC. I mean anything that's before university. Eng Chye talked about this as well. Connection to other disciplines and connection to the real world. We need to make our mathematics quite relevant. So one of the challenges I find, I don't have an answer. One of the challenges we have found is, for example, because of our A level curriculum, students do tend to specialise quite early. In particular, the contrasting subject, and all that. So every student will have to do a contrasting subject at A level. You never find, or at least it's very rare to find, a student, for example, who does physics and biology together. Every student does math, then they might do biology. But even then, amongst these students, somehow, at that stage in their life, they have already sort of decided that math and biology don't quite exist together. But then, if you want data-driven bioscientists, which one do you choose? Do you choose mathematics, or do you choose biology? You know that segregation of mindset is a little bit too early. If there are ways for us to sort of encourage this broader mindset earlier on, keeping the minds open, that will probably keep their options open later on. And that's what I mean by, you know, if we can weave in connection with other disciplines, weave into connection with the real world, that will actually help them keep their options open. And weaving in the connections to real world, is precisely what Eng Chye was mentioning. Really draw problems from real life and making them part and parcel of the learning, rather than some very artificially crafted, oversimplified problems. And that leads me to the third point: open-ended problem solving.

We are quite trained to think that every question has a model answer, has a correct answer. Well, yes, many problems do have a correct answer. But really I think we all agree in this room that in the study of mathematics, the emphasis is not on the answer. It is that thinking process, that logical thinking process. So by having open-ended problems, the beauty is because there is no single right answer, you have no choice but to focus on the process and that will help settle the next part. And then the last one I've already talked about, computational thinking of coding, so I'm not going to belabour that. So I'll just give you some examples of interdisciplinary majors at NTU, since Eng Chye sold some "koyok", right? So these are just the mathematical ones. For example, mathematics is paired up with economics, with computer science, with physics. These are quite obvious choices. Quite a few years back they teamed up with computer science and offered a data science and artificial intelligence undergraduate program. I think they are contributing half the curriculum. So I'm very, very pleased that actually Forbes listed it as one of the top ten undergraduate AI and data science programs in the world. Again, even recently, business started to work with them. And so accountancy and data science is also part of it. So mathematics, I'm pleased to say, is everywhere.