Jacqui Ramagge – 'What's Maths Got To Do With It?'

Moderator: Welcome to the podcast series of *Raising the Bar Sydney*. Raising the Bar in 2016 saw 20 University of Sydney academics take their research out of the lecture theatre and into 20 bars across Sydney, all on one night. In this podcast, you will hear Jacqui Ramagge's talk, *What's Maths Got To Do With It?* Enjoy the talk.

Jacqui Ramagge: Thank you, Carmen. Hi, I'm Jacqui and I'm a mathematician. It's been seven days since I've solved an equation. Actually I'm lying cause it's only been about five hours. You should know that you are all really, really special, because whenever I go to parties and they ask me what I do, I lie. I lie like the best of them. They say, "Oh, what do you do?" I think about it, I look a bit like a rabbit caught in headlights and I say, "I'm a chicken sexer!" Then I have to learn all about chicken sexing in order to defend that comment because you see, if I say I'm a mathematician, people stop talking to me because they don't know what to say and they don't know mathematicians do, and they just got no closer … the easiest thing to do is just stop talking to you, so the easiest thing to do is to lie.

There are some mathematicians in the audience and I see them smiling, so I see that I'm not the only one who has this issue. Anyhow, before I actually start talking for real, I'd just like to make a couple of comments. Should anything happen and we all need to evacuate the building pretty quickly, the stairs are there and you can just follow me because I'll be walking straight out the door. I appreciate the need for this access to this area over here, which provides us with sustenance. We're pretty full, I am so happy to see you all and somewhat dumbstruck, I must say, that you've all come to listen to this talk and so we're pretty full so feel free to wander around and if you need to come down here and through here, I won't object at all so long as you bring me a drink and put it over here, that'll be great, thank you very much.

Mathematics, where should I start? Part of the problem is that people don't know what mathematicians do. It's like we don't have the word "mathematician" tattooed on our forehead once we graduate. You rarely see people employed as mathematicians because they get employed as analysts or IT people or all sorts of other areas and so people don't see that value necessarily of mathematician in the community, and that's a real challenge for us, because somehow if I say "scientist," I suspect you've all got an image in your mind and it probably involves a grey-haired male in a white coat of some sort, right?

But when I say "mathematician," there's nothing that really comes to mind except perhaps your maths teacher and I've had lots and lots of students come to me say, "Why would I do mathematics, I don't want to be a maths teacher." In fact, the big problem is, we don't have enough students going into mathematics, going into teaching because all of our maths graduates end up being head-hunted by other people into other jobs. It's a real issue, and trying to get out this concept, this message that mathematicians are highly employable and highly sought after and when I say mathematicians, I include statisticians as well. Yeah, not in any ... somebody laughed there as if it's something strange to say. But no, I mean mathematics and statistics, I mean ... the difference between mathematics and statistics is blurred, it's a line that's very blurred, but roughly speaking, mathematics you can think of broadly speaking about things that are determined so that a run by formulae of various sorts, whereas statistics tends to be more probabilistic.

For example, you could have a system for which you have a mathematical model and that model, if you start off in the same place, twice, will have the same evolution however many times you started at that same place. Whereas a statistical model will have more probabilistic nature so that even starting at the same place could lead to a different outcome eventually.

Now, that's not to say that there's uncertainty only in statistical models because you can have mathematical models where even though it's all driven by a formula, if you start at two close points, the evolution of the system can be completely different in the long term. In fact, you have systems which are chaotic in the sense that they show a very sensitive dependence on those initial conditions where if you say you want the two systems to be arbitrarily ... say you want them to be three million miles apart in terms of their outcome, whatever our units are, and you insist that I look only at a difference of .00001 in the inputs, I will be able to find an initial condition which is within ... that close, that eventually gets that far apart.

So there are all sorts of things we can do with mathematics and statistics and sometimes we can do things which are quite unexpected. So, let's see. Can you put your hand up if you like horror movies? Just put your hand up if you like horror movies. Oh, very few look at that, that's very interesting. Okay, put your hand down. Because one of the things that happen when people go to bars is they're actually looking for friends, whether short-term friends or long-term friends, yes and so if you're looking for a long-term friend and you had your hand up, you should look only at those other people who had their hands up.

So basically ... so where does this come from? Well this comes from three mathematicians who graduated from MIT and started a dating agency called *Go Cupid*. What they did was they got people to fill out a form with all sorts of questions, answering all sorts of questions. When those people eventually matched up in long-term relationships and withdrew from this online dating that they had been participating in, the *Go Cupid* management said to them, if you had paired up with somebody else on our database, please let us know and so then they took all of that data and they analysed it. They looked to see which questions that they ask were the best predictors of long-term relationships. The number one best predictor on their database of a long-term relationship was, "Do you like horror movies?"

There you go right. So this is a situation ... and if you think about it ... so you have to be careful when you're interpreting such data, but if you think about it, what is it saying about us but it's also ... well it's saying …

Audience: It's very sad.

Jacqui Ramagge: It's very sad, absolutely. Audience participation is encouraged. I don't know that it is very sad because I think one of the things that's possibly indicating is that in order to maintain a long-term relationship, you want to socialise with your partner to some extent, and if you're going to go to the cinema and one of you wants to go and see a horror movie and the other doesn't, then it's a problem. I guess horror movies are quite polarising; you either love them or you hate them. There's kind of very little indifference to them.

Also, it's also biased in the sense that it was a dating thing, right, so those people were dating, and when you're dating you tend to go out. Who knows what would have happened if they'd asked other questions. We don't know if there is another question that is a better indicator of a long-term relationship. It's just that of all the questions that they ask, that was the best indicator of a long-term relationship.

The interesting thing from a mathematical point of view is that this is a situation where you just take data, you have no preconceived opinion other than the fact that that was a question you put on the questionnaire in the first place, but you have no preconceived opinion of which of these things is going to be the best indicator and the answer just comes up from the data, so the data speaks to you in some sense without you imposing any preconceived opinion on that data and that's really, really important.

Out of interest, the second or the next two ... I think there was a bit of daylight between the first one and the other two ... but the next two questions were, "Have you ever travelled in a foreign country on your own?" That also had a high correlation. Also, "Does the idea of sailing off into the sunset with just your loved one on a boat appeal to you?"

You know, you can sit and analyse why this must be or why this might be, but that's not the point. The point is it is and we don't necessarily know why. It just is. There are all sorts of ways in which we analyse data and I could say quite a few things, but anyhow. Well, later maybe. That's about the data just speaking to you in the context of matchmaking, but you can do this sort of thing and it's really, really powerful in the context of clinical medicine as well. It's really, really hard to do when you've got millions of variables floating around, when you've got really big data and really complex data to deal with.

We do such things and so I have a colleague in the school of maths and stats at the University of Sydney who's a statistician who works with the Charles Perkins Centre on melanoma, so they were looking at prognosis. When somebody's diagnosed with melanoma, they want to know what their likely prognosis is going to be. How many years I'm going to live, what do I have? They have genetic information and they have information about treatment and they have historical information about survival rates. What they found when they analysed the data that was available was that if you are diagnosed with melanoma and you've had no treatment, your prognosis is entirely determined by your genetic component, right? So your genetics will say how likely you are to survive ten years and so on. But the moment that you have any treatment whatsoever, the prognosis is overwhelmingly determined by the treatment that you've had, and that's really good news because it means that we're getting the treatments right. It means that we can compensate to a great extent for all of the genetic predispositions that people may have.

So knowing that sort of stuff is really, really important and is a great value to the community and to society. I'm hoping that those of you who were coming to learn about melanoma and those who were coming to learn about matchmaking now are happy and I can talk about all sorts of other things. The thing about what we do is in terms of applications of mathematics and statistics, that aim is to take information, data typically, and try and build a model that explains it so that we can then predict what happens. Then the big goal at the end of that is to be able to control what happens.

Let me give you an example. A student who had done maths and engineering was headhunted by a health group who were doing data on pregnancy. They had a whole heap of information, data, about hormones released by the mother, the placenta, and the foetus during pregnancy, and they knew that these interacted but they didn't know how. They knew that sometimes, inappropriate balances or certain balances triggered premature labour, but they didn't know how and what they wanted him to do was build a mathematical model to try and model to predict what's happening, because then you have a hope of controlling the events and so then, you could have a pregnant woman presenting and you could take a hormonal test and you can say, well, "You're fine," or "The model is telling us that at this point in time, you're at high risk of premature labour, but if we give you this particular hormone supplement, then we can bring you down into the safe zone," and that's clearly better for everybody. Those sorts of things are bread and butter.

Of course, there are all the great, changing the world-type applications, which involve just making money but I hate to tell you, but all of these companies that are getting all of this information from you and trying to sell you stuff, they've all got teams of mathematicians and statisticians working on these things and finding out how best to actually monetise you. There is no nice way of putting this, is it, they're monetising you.

I'll give you an example and there's an example from the US. It's the Weather Channel. The Weather Channel used to be a TV channel where you would check into the channel and it would cycle through the weather at all sorts of places, telling you what the weather was like. You'd have to sit there and wait through all these cycles until you got the weather at your city and then you'd change channel and do whatever you wanted. So they knew they had you for an expected value of around half a cycle, so adverts that they would give in that half a cycle while you were watching as an expected value would be things that they could charge for on the expectation that you'd see about half of the ad words that they were putting on.

Well now, we go to iPhones and phones ... not wishing to make any free commentary here, but anyway we've got phones of all sorts and the Weather Channel has gone online. Now, there's absolutely no reason why you shouldn't be able to find out the weather where you are immediately. There's no reason to sit through a cycle. They have absolutely no justification in making you wait to see the weather. How on earth are they going to make any money out of this? Because they used to make money out of all these advertisers. Similar thing is happening journalism and so what is the one piece of information you have to give them, even if you are really security conscious and ... your location, that's right. You have to give them your location. It's meaningless, right, it's going to be impossible for them to give you the weather unless you give them your location and so what they do is they take your location together with the weather at your location and they give you just one ad. But that ad is targeted depending on where you are and what the weather is like where you are.

Now ... right, you're laughing, right? You're laughing now ... here's the thing. Here's a really bizarre fact; people buy different shampoos depending on the weather. I don't know ... you know, look at me, I mean make-up, really, but the make-up industry is seasonal. I don't know if you've noticed this.

Those of you who might wear make-up might notice that the make-up industry is totally seasonal because in the heat, you might want different make-up, to when it's humid, to when it's cold, and the same thing goes with hair and in particular if you've got slightly curly hair or even frizzy hair, humidity makes it go more curly. So you want more conditioner in your shampoo if it is humid. So this is the way that the Weather Channel is taking all of the data that they have at their disposal and using it against you. Unfortunately, mathematicians are completely complicit in that because it's their job. Anyhow, so we can use it for great good. We can also use it for more pragmatic purposes, let's say. I have quite a few students who have ended up working in finance and in particular working in micro-trading ... have I dropped out? No, no? Okay ... working in micro-trading and so what they do, they're quants basically, so they develop mathematical and statistical models to try and make money out of the stock market.

The interesting thing is that they make money irrespective of whether the stock market is high or low, because they make money on volatility. Anytime that things are going up and down, their worst case scenario is when things are steady. When things are steady, it's hard for them to make money. But anytime there's any movement, whether it's movement way up here or whether it's movement way down here, they're making money and so how does one do that? The interesting thing of course is that it happens in exactly the same way as we model the health data, as we model all the other data, and there is a certain amount of scientific method to it. You've got a whole pile of data that you're trying to build a model for and you had no clue what this model is going to look like in the first instance. There's no predisposition as to what it should look like and you're going to try various things, but you want to be able to test it once you've built the model.

What you do is you separate your data into two halves. You take one half of the data and you use that to inform a model, to build a model. It may be a mathematical model, it may be a statistical model, it may be a combination of both. Then once you've got that model, well, you could test it on the data that you used to build it, but you know, you wouldn't have built a very good model if it couldn't actually predict the data that you used to build it, right? That would be like, yeah, nobody's going to get a high distinction on that assignment. So the thing is, you want to test that model on data that has not been used to build. Here's where the other half of the data comes in. You take the other half of the data and you test your model on the other half of the data and if your model can correctly predict, backwards predict, if you like, would have been a good predictor of that other half of the data, then you'd know you've got something that might be worth trying. Then and only then can you go on and try and use it to predict the future, which is totally unknown.

This is the way we do those things, irrespective of whether we're doing them for health or whether we're doing them for finance or whether we're doing them for marketing. That's the right way to build a mathematical and statistical model.

So we do all sorts of things and so ... one example of ... one of my colleagues, Peter Kim at the University of Sydney. He is an applied mathematician who worked, still works, with anthropologists. I don't know, has anybody here heard of the Grandmother Hypothesis? No, just, yeah you would, Susan. You don't count, no you don't count.

Great, because that means that you will learn something new today. The Grandmother Hypothesis, so what happened was that Peter was just at a social at his university then, which he was in Utah at the time, and he happened to get chatting with this anthropologist and this anthropologist was telling him that there was this really interesting question in anthropology that humans are one very, very few animals where the female significantly outlives her fertility. In almost all other animals in the animal kingdom, once the female ceases to be fertile, shortly thereafter, she dies away.

This is true of our nearest cousins. You know, chimps and such like. They die shortly after they cease to be fertile. This is a real conundrum, why are females in the humans outliving their fertility by so long? She's cracking up now. Is it ... oh yeah? Do you have a question? Sorry? There is much more to a female than fertility, but remember that we're talking to an anthropologist, so she is thinking about millions of years ago. From a biological point of view, this is a very interesting question and so he did some modelling, and working only on the female line, not on the male line. Working only on the female line, he was able to build a mathematical model, which basically says that if the older generations subsidised the younger generations by helping to look after grandchildren, all of a sudden, if you simulate that over many, many generations, evolution starts to favour that subsidising.

What does this mean? This means that when you have hunter-gatherer societies, if people live long enough so that they can help their grandchildren survive, and so that they can look after children who have been weaned but who are not yet independent, that's the key difference in the human species. Then evolution just does the rest because it's an evolutionary advantage. If you're living longer and you're subsidising those kids, that means that humans can technically have four times as many children per childbearing year than a chimp and that gives you an evolutionary advantage.

The interesting thing is of course, it triggers longevity in the mean and as a system, as an evolutionary system, it does all sorts of things which are quite amazing and there was a great talk on the Grandmother Hypothesis at one of our Sydney ideas at the university and I think it's still online. If you're interested in hearing more about that particular model, it's absolutely fascinating.

So that's another sort of aspect, so anthropologists, biologists ... of course, one of the things ... so mathematicians and statisticians have always been doing this. One of the things that I find interesting is people talk about the laws of physics. Laws. Nah. They're mathematical models; they're all mathematical models. All mathematical models are wrong, some are useful and the ones that have stood the test of time are particularly useful, but even if you think about Newtonian mechanics, that's a special case of Einstein's Relativity. So now nobody would say that Newtonian mechanics was not useful. It's completely useful, but it's wrong. It's wrong in a way that we can totally tolerate for day-to-day things, but it's a special case of general relativity. Mathematics is just trying to model stuff and we get it as right as we can, and that's really important. Now many hundreds of years ago, their biggest contribution would have been to physics, basically, and astronomy, big time. If you're thinking about the Mesopotamians, Babylonians, they were really into astronomy.

Actually, here's a question; hands up if you know why there are 360 degrees in a circle? Oh, well I'll leave that one til later. We've got question time at the end, because that was ... anyhow.

So but you may also have heard of Kepler, as in Kepler's Laws of Motion, planetary motion, right? How many of you have heard of Tycho de Brahe? Whoa, two, three or four? Four? Couple of die hards. But many more have heard of Kepler than have heard of Tycho de Brahe. Now Tycho de Brahe was a guy who spent 40 years taking meticulous measurements of the planets as they move through the sky. Actually the most interesting thing about him was that he had a copper nose because he had lost it in a duel. He'd had a duel, with a sword fight, and his nose had been swiped off in this duel, so he made himself a nose out of copper, which I guess gave him an excuse for it all being green, but anyhow, that's probably the most interesting thing about him.

He spent 40 years taking these meticulous measurements, and he had no clue why the stars and the planets in particular moved the way they did. He couldn't model them. Then along came Kepler, who persuaded Tycho to let him have a look at the data. Because Tycho was keeping it all to himself, it's really valuable. If you spent 40 years taking meticulous measurements, this is really valuable to you. But Kepler persuaded him to let him take a look at the data, and sure enough, he basically said, "No, you've been looking for circles; actually they're ellipses." That was it. Suddenly, you've got Kepler's Laws of Planetary Motion, and it's that insight into what is happening, whether it's geometrically, algebraically, or analytically, that really gives that power and what's happening at the moment is that mathematician or statisticians are doing that same transformative effort in the biological sciences. That's where the biggest growth is.

Of course, that's not why we do it all. I mean, I don't get up every morning and say, "Oh, I'm going to help the biological sciences." No, I get up every morning and I say, "I'm going to have fun," because that's what I want to do, I just want to have fun all the time, it's brilliant. I am employed to do what I love and we do it because we love it.

So here's the thing, there are many, many things that if crazy mathematician hadn't thought about those things, would never have happened. Imaginary numbers, who would have thought about the square root of minus one? When that happened, those mathematicians were called crazy, literally. They were crazy people for thinking about this completely imaginary stuff.

The engineers use J for some reason because they use I for current. I think this is a big difference between mathematician and engineers. We use I for imaginary, but anyhow, that's another story. That's a completely other story. The fact is, you wouldn't have the tools to model electrical circuitry if some crazy mathematicians several hundred years ago hadn't been thinking about imaginary numbers and so, mathematics and statistics, why not? Well, because you wouldn't necessarily have gone back to think about that as what you needed. There are things that appear through curiosity that don't necessarily appear through deadlines and such like.

Audience: What do imaginary numbers got to do with circuits?

Jacqui Ramagge: Oh, complex impedance.

Audience: Anything that has an AC current (29:46) …

Jacqui Ramagge: You can say that louder for everybody.

Audience: Anything that has an AC current is based on imaginary numbers.

Jacqui Ramagge: There you go. I'm not lying. Thank you very much. What's your name?

Audience: I'm Jay.

Jacqui Ramagge: Jay, Jay's going to give the talk next year. It really is. You need it in order ... so they disappear. You don't get any imaginary numbers in the solutions, but ... complex numbers, yeah ... I'm trying to keep it as simple as possible ... but you need to use them as a tool during the calculations. This is the amazing thing. There's all sorts of things that appear just because these crazy mathematician were just looking.

So mathematics and statistics are immensely powerful tools, and our job is to keep the tools in the toolkit as sharp and as up to date as possible. It's a bit like the ... there's a thing in economics called the Pareto Principle; 80% of your outcomes come from 20% of your effort, but you just don't know ahead of time which 20% it's going to be. So you do everything and hope that some of it is going to be useful, but our job is to keep those tools sharp and new for when they do eventually need to be used. We don't know which bits of it will need to be used or when.

Okay, on that happy note, I think I have to wrap up, and it's question time. Thank you very much.

Moderator: Thank you for listening to the podcast series of *Raising the Bar Sydney*. If you want to hear more Raising the Bar talks, head to racingthebarsydney.com.au.

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