INTERVIEW WITH THE AUTHORS: A Cultural Challenge – Teaching Mathematics to Non-mathematicians

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Fig. 1. Left to right: Judy-anne Osborn, Veselin Jungic, Andrijana Burazin, and Miroslav Lovic

An interview with the authors of “A Cultural Challenge: Teaching Mathematics to Non-mathematicians”, *Maple Trans.* 1, 1, Article 14144 (July 2021). This interview was conducted by Dr Judy-anne Osborn, with authors Andie Burazin, Veselin Jungic and Miroslav Lovric, on Thursday 8th July Australian Eastern Standard Time via Zoom.

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1 Culture

Judy-anne: Your paper is very much in the line of what the journal wants to do, which is change the world a little bit. And really provide a space that can promote conversations. Your paper is called “A cultural challenge – teaching mathematics to non-mathematicians”: what is the nature of the cultural challenge?

Veso: One of the arguments that we are trying to make is that each discipline has its own culture. If you compare mathematics with something else: the language that we use, the level of proof that we need to establish some evidence, the way how we think, the history that we follow, is specific for our trade; and it is different for some other scientific disciplines. That is one of the issues that we are trying to communicate. When we teach these so-called “service courses”, we are witnessing a cross-cultural experience.

Judy-anne: Mmm: for instance?

Veso: Conventions are different, say in Physics with derivatives. Or, on the lighter side: something that I find both upsetting and funny: Engineers – they use “ j ” for the imaginary unit – but in my culture it’s always “ i ”.

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Judy-anne: So, there's these small signifiers of culture like the *i-j* thing, that can throw us into a bit of dissonance, but some deeper things as well? A quote on your first page from Leone Burton is:

"It is a major irony that, while the mathematicians learn in an enquiry style, they revert to traditional teaching practices with their students. But this means they carry with them into their classrooms some of the worst features of the mathematical culture, in particular the reification of hierarchies in learning, competitive practices and isolation."

It is a very strong quote, and provocative, and you're using it to situate your whole paper. I want to do a bit of provoking back in the opposite direction: what do you mean by "traditional teaching"? There are a lot of traditions, for instance the Moore Method, and that consists *entirely* of an enquiry style.

2 Traditional Teaching and Enquiry

Andie: What is traditional teaching? Sometimes people allude to that lecture style with an instructor at the front professing about a concept or enriching student's lives with what *they* know. But yes, Moore method is a strong tradition as is *enquiry-based learning*. For the context of our paper, to have a student in a Moore method in a service course would possibly not work. To benefit from that style, the student would have to be very strong in that discipline, and very engaged and curious.

Miro: You see, in my view, "traditional teaching" is a term that was coined by math education researchers to construct this binary thing between good and bad. Traditional is cast as *bad*: teacher-centred, sage-on-the-stage, and other things; contrasted with methods proclaimed to be *good*.

Judy-anne: Uh-huh.

Miro: It comes from this will to separate good teaching from bad teaching. There is an idea that traditional teaching promotes "surface learning", and that enquiry promotes "deep learning". Most of this is not true. Good teaching is good teaching, no matter how you do it. Bad teaching is bad teaching, no matter how you do it. In good teaching, students will learn. If you bring yourself, your energy, your enthusiasm into a classroom, things will work. I really don't agree with that separation into traditional and non-traditional mathematics teaching – for me it's a kind of nonsense.

Judy-anne: So, there's this dichotomy, that may not be productive?

Miro: Something that could be a little bit controversial, because we are very happy about "enquiry", but there are some serious problems about it. The concern we sometimes discuss is that students are not learning enough through "enquiry" – they can think about simple problems, but when it comes to complex problems, they cannot solve them because they do not know enough.

Judy-anne: I think that there is this constant seesaw issue about a certain amount of Mathematical content in a certain amount of time, versus issues like motivation and depth of retention and things like that.

Andie: If we go back to what it is, enquiry, or Moore method, it doesn't have to be just for Math students: it could be Chemistry or Physics. You know you start off with these foundational pieces and slowly scaffold and build the student's knowledge so that they come up with these discoveries, some of which are known, but they would actually be like a Scientist, coming up with these ideas that have already been well-established, without having a textbook and showing solutions.

Miro: We also know that Moore had the luxury of having fewer than 20 students, who were mature and able to do the work he assigned them. By the way, Moore was a racist and I think his method may be renamed sometime soon.

Andie: The student would actually have to be like a Mathematician doing research or a Physicist doing research. It's not just "oh, the student has to be a Mathematician". No! The student just has to have these tools. Students in service courses are an eclectic bunch in first year. Not everyone is on the same page. To use an enquiry method in say a 1000-plus student course, to get them all on the same page, to have the weaker students catch up and the stronger students not fall-off because it wasn't interesting enough, would be really hard.

Judy-anne: Hmm.

Andie: It's just that the students need to have that core; and push that core with their instructor. And their instructor has to slowly guide them, with that particular method. And sometimes that's very challenging with an eclectic bunch. Some are really weak, and some are really strong, and the students might not be motivated in Math and maybe they don't know why they're going to University. Sometimes I feel that an enquiry-based method might not be the most ideal for a service course until the student becomes a bit more mature and understands a little bit of mathematics a bit better after going through a semester or two of mathematics at University.

Veso: Andie used this word "maturity". Really, when you teach service courses your main goal is to increase the students' Mathematical maturity, academic maturity, intellectual maturity. And if we do this, without doing any additional harm to students, I think our job is done.

Judy-anne: Teaching is something from the heart.

Veso: Yes, and students do mature! Some years ago, I happened to teach Calculus I, II and III in sequence to some students. The students who completed my Calculus I course took Calculus II. Those who completed my Calculus II took my Calculus III. It was really impressive to see the change in those academic novices in a relatively short period of time. That is also our contribution to our students' lives. I would like to mention that our job in teaching these service courses is bigger than teaching mathematical techniques: we are helping our students increase the level of their maturity.

Judy-anne: So, I've got a question. We seem to be thinking that students need to be all terribly mature and have a very solid base of knowledge before they can do enquiry. But if you look at school, primary school is arguably more enquiry-based than secondary school. Little kids seem to do enquiry, and do it naturally: what's going on there?

Andie: It's because, when you're a kid, right, you'll try anything. You're curious, you're imaginative and creative. You're not scared to fail.

Miro: You play – it's play!

Andie: Yes. But as we get older, we are under certain rules, and as we progress in elementary school these rules come in, bit by bit. When you start do math, you use your fingers and you colour in shapes and what-not, but then algebra kicks in and you have to follow the rules, or you don't get the right answer. And then if you don't get the right correct answer then you are stunned, and you're scared to try again because you don't want that failure.

3 Failure and Struggle

Judy-anne: It's a really interesting trajectory that you're talking about with little kids. Suddenly at some point they become afraid of failing. But they don't start out afraid of failing, because no-one would learn to walk.

Miro: You see, one thing, I don't remember how I learned to walk. So, all the failures, all the bloody knees, it did not create any trauma in my life. The point is that all of these failures are integral part of our learning. They do not traumatise us – they make us stronger and they make us learn.

Veso: I want to go back to Leone Burton's quote. My reading of her quote was that the way how we present mathematics, is this polished way, it's a polished mathematics, it is not mathematics of failure, it is not mathematics of sleepless nights, it is not mathematics, that is hard and difficult and that promotes the joy of overcoming those things. When I teach my Calculus, it is a polished version, and it is a watered-down version: it is one thing coming smoothly after another. No wonder with the way how this is presented, that students sometimes feel "oh I am stupid, I am the only one who doesn't understand this".

Judy-anne: Hmm.

Veso: You know, in my *MathCatcher* program I went to many classrooms from kindergarten to grade 12. Something happens in grade 6. Those kids start taking school seriously, and they forget about playing! I think we should take part of the blame, we Mathematicians and Math teachers. Because we are not presenting Mathematics as it is, it is: messy, hard, with dark places that we need to find and to explore. We present this polished version and if you don't understand you're stupid.

Andie: What occurs to me, now that we're teaching online, these students are isolated, so they don't see their peers studying and struggling. They become depressed that they can't do this math, because they don't see their peers working and struggling.

Judy-anne: It's interesting how we could set up social situations online so that students can see each other struggling and benefit from that.

Andie: Yes, when the students don't see their peers struggling, they become less engaged in the course. They get frustrated and they think they're the problem. I think it's really important that when we teach we actually show that, yes, we're human and we're going to make mistakes. And that math doesn't come naturally – a professor does a question in class and it takes 2 minutes and students think "Why can't I do it?" and they don't see the many years it took us to get to a point where we can do the question in 2 minutes.

Judy-anne: Yes.

Andie: I like that human component when I teach, showing that I do make mistakes. Some students might be of the mindset, "Oh, she doesn't know what she's doing – if the professor can't do it how does she expect us to know?" No, I want you to see that I'm human too and I make mistakes and it's okay, as long as we learn from it.

Miro: One other thing I wanted to say is this: in our discussions, we talk a lot about teaching, but we don't talk that much about students. One thing we have to admit is that many students are in universities these days because they have to be, and not because they like it. They have to be there because, at least in North America, if you do not have a college or a University degree, you can kiss middle-class life goodbye. Unless you start your own business and sell it to Amazon or whatever, and most young people will not be able to do that, basically they have no way of this, you know, promotion of upward mobility.

Judy-anne: Hmm

Miro: So, we have many, many, students who just dread coming to our classes, who just want to pass and get the hell out of there. Or, the thing is, they come to class and they sit there and now they expect me to motivate them?! On top of teaching! And where the hell are they?

Judy-anne: Hmm

Miro: If they come to my class, and they don't want to participate in breakout rooms, and I see a black square where their face is supposed to be, and they don't give a damn about interacting with me online, what can I do?

Judy-anne: Hmm, mmm

4 Teaching and Motivation

Miro: The big question, really, is what is the role of us as teachers? And by the way, if we have to really motivate, is it even possible to motivate somebody?

Veso: Yes it is, I think it is.

Miro: Yes but it takes a lot of time and a lot of energy.

Veso: Part of our job is to be role models, and we are.

Miro: Here's what I'm trying to say. I'm teaching a course for life sciences and if I present a model of development of a cell and show mathematically that the reason why it has a large surface area is because it can take more nutrients, is that going to motivate them? I don't think so. I tried: it didn't work. So, yes, I think to a point we can motivate, but I think also motivation has to be intrinsic – it has to come from you.

Judy-anne: I posit that when you learn something, when anyone learns something, and I mean genuinely learns something as opposed to becomes capable of parroting a simulacrum of it, but actually learns something, that that is fundamentally fun. That there's a little pleasure hit that you get when you understand something, no matter who you are.

Miro: Yes.

Judy-anne: So there's this sort of cycle: if you can get into a situation where students are learning, then I think they will be motivated and will be more inclined to learn, and more inclined to be motivated, and so on. I did practicum in a fantastically interesting school run by a maths teacher, and he said to me, "They've got it all wrong. They say you have to get order in the classroom so that you can teach. But it is the other way around! You have to teach, so that you can get order."

Miro: Yeah

Judy-anne: Our own motivation and our students' motivation are linked, I think. That sense of being able to make a difference in someone's life is special, and conversely it's incredibly disheartening, to be trying and trying to make a difference, and not making a difference, or at least apparently not making a difference. And this is this challenge we have to grapple with: we've got students whose main degree is not maths – something else – so we don't necessarily have that point of contact, and then as you say whose baseline or at least introductory attitude may be one of fear or disinterest or lack of interest or just really don't want to be there.

Miro: Yes.

5 Cross-cultural collaboration

Judy-anne: In your paper you suggest this collaboration between the researchers and teachers from the other discipline, whoever that is, and the Mathematicians. How can this help? How does it solve these problems?

Veso: Maybe not to solve, but at least to address them, at least to talk about them.

Judy-anne: Mathematics is often presented as something very clean, like a diamond, sharp edges: something is in or it is out – no fuzziness. And then we've got this fuzzy world. Modelling the actual fuzzy world is difficult. How does that interplay work? How does the potential collaboration with the Mathematician from this "diamond culture" work with the Chemist or the Nurse or the Engineer or the Architect or the Businessperson or who-ever?

Veso: This world around us is messy: one way how to deal with that messiness is Mathematics. We have a responsibility to prepare the future professionals to deal with that Mathematical side of the world around us.

Judy-anne: Mmm

Veso: And with all the data that we are collecting and various applications of Mathematics, future Engineers, Doctors, Businesspeople, are going to face more and more mathematics.

Miro: Going back to your initial question about culture, when Veso and me and to a large extent Andie were educated, it was: when you do Mathematics you do Mathematics, right? You don't really do applications. So, there is a big cultural change that when you teach Mathematics it's Mathematics, when you teach some other discipline it is their discipline. Even back home in the courses, where you have Mathematics for Biologists, you teach Mathematics and power series and all that stuff without ever mentioning the word "Biology".

Judy-anne: This is terribly interesting when you think about brains and learning and how different situations will trigger different parts of knowledge that you have and whether that knowledge is connected or not, and whether students and practitioners will apply that knowledge or not, even if they happen to have that knowledge – whether it is connected enough to their context that it rises up in that situation where it is really critical.

Miro: I know a case where there was an experiment to see how students react under caffeine. And they were computing a dose and they used a standard formula which all the researchers knew, and they typed it into the phone and ended up with a 100-fold error. Instead of giving the equivalent of 3 cups of coffee, they gave the equivalent of 300 cups. And when major questions were asked, they said, "Well the problem you see is that the decimal point found itself in the wrong place."

Judy-anne: That's a serious problem.

Miro: Nobody noticed because they believed the formula and the calculator. Wouldn't you think something is wrong? Wouldn't you think about volume? There is a critical reasoning there, mathematical reasoning, that goes beyond just using a formula. For instance, there is evidence from Neonatal Emergency units in the US. So, there is a problem – a kid is born but they have a problem so they go into an Emergency Unit. They say that 12% of errors made by miscalculations by nurses of doses are of the order of magnitude of 10. So, it means they administer either 10 times more medication than is needed or 10 times less. So, these are the situations we are taking about. Formulas are there, procedures are there, but there has to be something more than that. Mathematics teaches you to think, to check every step, like in a proof, to make sure that you have evidence that everything follows.

Andie: The problem is cookie-cutter recipes. A mathematician can expand and show different constructions, so that math could actually be this beautiful tool to solve various situations that the nurse comes into.

Judy-anne: I really wonder whether we believe this as an article of faith?

Miro: It is quite controversial – we are happy with that.

Veso: Back to this idea about culture. We are dealing also about cross cultural experiences. Academia as we know it now is really all in their silos in their different departments. The word ‘department’ doesn’t come here by accident. And people are territorial. One example we mention in our article is Mathematics and Computing Science. If you think about theoretical Computing Science, that’s graph theory with different terms. Many years ago I tried to put a seminar together across these groups and there was so much resistance.

6 Closing remarks and Open questions

Judy-anne: Do you have any closing advice or words?

Veso: My advice is actually my personal feeling of responsibility to help these young people that are in my classes – to help them explore their talents and develop their skills. I think that is our joint responsibility, actually. And one of the reasons I should talk to my colleagues from the School of Engineering or the School of Economics, and why they need to talk to me, is that it is our joint responsibility, really, to prepare these young people for the world that is out there. And I still think that mathematics is the best tool that humans have to describe that world that is around us.

Miro: My closing line goes like this. Many of us, really, are behaving like schizophrenics. We have romantic attitudes about teaching and what Veso said is an example of that. So, for me, I am teaching a course in the Fall and I am extremely motivated and I’m thinking about what I am going to do and it is extremely positive: I mean I have so many ideas about so many things I want to do. But then there’s the other side and there’s the reality that hits you. For instance, after one week, even before students get a taste of my course, half of them will no longer be there. Or you get an email from a student about something that is in the second line of the course outline.

Judy-anne: Yes, it is common.

Miro: You get in situations where you are so frustrated because the students are not where you want them to be. You want them to learn, you want them to be engaged, and not worry about the bloody extra point on a test. There are these two polar opposites between which we oscillate all the time, and we should talk more about that.

Judy-anne: Yes, it could be important to talk about things that we don’t always talk about. There’s a quote in a wonderful book by John Holt called “How Children Fail”. It says something like, “If a person is lost in the woods and you want to help them out you first have to go to where they are.” If we are to help each other, I think we first need to find each other, and talk about things that we might not normally talk about, like interplay between our students’ motivation and our own.

Andie: I feel that sometimes when we think about our courses and what we want to do in our courses and what we want to teach we forget who our students are. It’s like “hit these notes” or do applications or show magnificent mathematics or whatever. But what’s the point if your student is down here and you’re up there? Sometimes we have to lower our expectations a little bit and help our students get to a certain point, so we can bring them up to where we want them to be.

Judy-anne: Hmm

Andie: And the other thing that would be great for service courses is to move away from a laundry list of things that you need to be taught. Sometimes that just sucks the energy out of the course for the student because it’s just a shopping list. And it sucks for the instructor because every year every term it’s the same thing over and over again: how many times do we teach L’Hopital’s rule in our teaching career? Or the Chain Rule or Integration by Parts – it’s just so frustrating because we do have computers and we can tell a computer to solve an integral so why do we have to know

the nitty gritty details and these tricks and what not? So, it would be really nice to revamp some of these service courses and kick out that laundry list and maybe have some of these applications and reach out to other disciplines and experts to show us some nifty application that we can introduce into our service courses so that we can engage our students a bit better and show them why the math that we are teaching is really important in their discipline.

Judy-anne: Thank you all. What you have opened up is at least another hour or year or maybe a lifetime's conversation. We have to close it for now, but I hope that people will read the transcript of this interview and think "I disagree with that", or "I agree with that, but they didn't really justify it"; and get in and write something.