Mark Royce (00:01):

Hi, Anita.

Anita Schuchardt (00:02):

Hi, Mark.

Mark Royce (00:04):

How's it going?

Anita Schuchardt (00:05):

Pretty good. Thank you for inviting me to your program.

Mark Royce (00:09):

Oh, it's great. I'm glad you're here. I'm wondering ... In Minnesota, what's the weather like?

Anita Schuchardt (00:16):

There's no snow on the grass. That's a plus. It's a little windy today though.

Mark Royce (00:25):

You said something in our conversations, in our, in our communications about being excited that it's almost kayaking season.

Anita Schuchardt (00:34):

Yes. I like to go kayaking on the lakes. And so, I look forward to the weather getting warm enough for me to be able to do that. I live right by several different lakes and so I can go kayaking whenever I want on the weekends or during the week.

Mark Royce (00:55):

That's awesome. That's neat to have handy. Let's see. You're at Minnesota University, correct?

Anita Schuchardt (01:05):

University of Minnesota Twin Cities

Mark Royce (01:08):

And tell our listeners exactly what your role is there.

Anita Schuchardt (01:12):

I'm an assistant professor in biology education research.

Mark Royce (01:18):

And so you teach what kind of classes?

Anita Schuchardt (01:20):

So I teach biology. Introductory biology for majors, and I advise graduate students in doing biology education research.

Mark Royce (01:32):

And I know that you've been heavily influenced by modeling instruction methodologies in the past. And you've been involved with the development. Am I correct? You've been involved in the development of some of the modeling instruction curriculum for biology?

Anita Schuchardt (01:50):

Yes, that's that's right. The first iteration of the biology modeling instruction curriculum came out of Shadyside Academy. And so myself and my colleague Bill Diehl, worked on that during the summer and then implemented it and refined it. And then we ran workshops on it. And then when Kathy Malone moved to Ohio State University, she got a grant to do revisions on it formally. And I was a consultant on that grant and participated in the revisions of that curriculum.

Mark Royce (02:26):

What years were these? When did you start?

Anita Schuchardt (02:29):

Summer of 2005 was when I took my first modeling instruction in physics. Then in the 2005- 2006, I taught modeling instruction in physics and the summer of 2006, we started working on the biology modeling instruction curriculum. And we did that because our students were doing modeling instruction and physics, then modeling instruction in chemistry. And we didn't feel right that they didn't have a modeling instruction in biology to follow that.

Mark Royce (03:05):

Gotcha.

Anita Schuchardt (03:06):

And so we started teaching that in the academic year, 2008, approximately.

Mark Royce (03:14):

Okay. So that was at Shadyside academy. Am I right?

Anita Schuchardt (03:19):

That's right. It's a small independent school in Pittsburgh, Pennsylvania.

Mark Royce (03:24):

Okay. Now, the curriculum that you helped develop for that has been disseminated through the workshops with AMTA. Am I right there?

Anita Schuchardt (03:36):

Yes. So we've run some workshops. Yeah.

Mark Royce (03:39):

So the modeling in the biology classroom has kind of grown since you guys started that, right?

Anita Schuchardt (03:46):

Yeah. It's been really nice to see it grow. So there have been people in some of my first workshops, modeling instruction in biology, who became modeling instruction workshop leaders themselves. And they then disseminate that more. And, you know, it's been really nice to see that progression in that development.

Mark Royce (04:15):

Tell me about now, I guess 2005 was when, when you took your first workshop with modeling?

Anita Schuchardt (04:22):

Yes, I believe so. Yes.

Mark Royce (04:25):

Okay. And was that your first introduction to it? That's how you got introduced.

Anita Schuchardt (04:29):

That was how I got introduced to it and it was physics. And it was preparing to teach physics to freshman. And I had not taken physics since I was a long time ago an undergraduate in college. And I did physics algorithmically. I did, I saw physics problems, you know, as if they were algorithms, okay. Show me the formula and I'll apply it. And the modeling instruction in physics workshop was the first time where I understood physics conceptually. And I was so impressed with the curriculum, with the teaching method. And I was like, well, we can do this in biology. We have models in biology and we can totally do this.

Mark Royce (05:17):

That's interesting. I'm not a scientist and I'm not a teacher. So me doing this podcast, it's always been really fun to discover things, you know, but how did you --talk to me a little bit about how you see the models in biology for those who are listening, you know, but most of the modelers I've encountered are physics or chemistry. And I've not talked with a lot of biology modelers, but so talk to us a little bit about that.

Anita Schuchardt (05:51):

So, there's several different models in biology and it depends on the way that you like to think of them. So, one of the big ones is evolution. You really cannot have biology without having a model of evolution and how that works and then applying that to all different kinds of contexts. Then another one would be-- you could either call it information flow or inheritance, but how are traits passed down from one organism to the next organism? And that could be sexually or asexually. You have energy flow. Energy flow is a really big one, just like it is in physics and chemistry. The idea that, for us, we focus a little bit more on how energy flows through an ecosystem. That also comes with matter transformations. Trying to think what our other...there are others that we have that I'm blanking on right now. But those are three of the biggest ones.

Mark Royce (07:02):

Now I know that from reading about you a bit that you apply a mathematical approach in your modeling curriculum. Talk to us about how you came to that and how you employ it.

Anita Schuchardt (07:19):

Okay. So, in the physics and chemistry modeling curriculum, the mathematics is there. It's explicit, it's, it's implicit, but it's also implicitly part of the curriculum. It's an integral part of the curriculum. Much of biology is taught without reference to the mathematics, but it's such a strong representation. If you can model something, your ideas mathematically, you have to distill the concepts down to their essence because you have to decide what is going to be included in your mathematical model. And you can't include everything. You have to include the key features. And so having students mathematically model means that they have to discuss among themselves and by mathematically model, I mean, construct a mathematical representation of their ideas about whatever phenomenon they're studying based on data, based on their observations of the phenomenon. And, they have to discuss among themselves, which of the features I need to pay attention to, which are the ones that are important, how are they going to be incorporated?

Anita Schuchardt (08:29):

How does that, how are they related? Are they added or are they subtracted or, you know, and what does that mean? And the reason that I incorporated that is because when we first did the first pass at the biology, modeling curriculum, the mathematics was a little weak. We didn't have time to develop all the representations equally. And the mathematics was a little weak. We definitely had it in inheritance, because you need that to be able to predict outcomes. And, the students were still having a hard time with it, even though we have them base it on data. And so when I did my doctoral research in learning sciences, the group I went with was working with mathematics and biology and so that was my focus. And I said, well, you know, and they wanted to use this specific approach. And I said, well, I know that doesn't work. It doesn't work with my high school students. So let's try something different. And my advisor gave me the freedom to try something new. And so we did an equation, got students to develop an equation, which related egg and sperm joining and the probability of an outcome. And it doesn't use --for the bioligists out there-- the punnet square, which is the traditional representation. And I can speak a little more. Can I just say one more thing?

Mark Royce (10:04):

Sure. Yeah.

Anita Schuchardt (10:04):

Sorry. I could go on forever about this. So, one of the really neat things that you see, I'll give an example. One of the reasons why I think it's so powerful. So, we have students who are modeling, the population growth equation, and they're doing a basic one with bacteria and just, you know, describing how they grow. Like how does that, how do you get more and more bacteria using a mathematical equation? And in biology when a bacteria splits in two, that's called dividing, however, that dividing is contradictory to the multiplying that is occurring with the population. And so we've got recordings of students saying, well, that's dividing, but that's, it's not dividing in the equation. It's multiplying, wait, what do we mean? And they discuss both what dividing means, conceptually in the biology and then what they have to do in the equation, how they represent that and how that actually is represented as an exponent, which is multiple multiplications. And hearing them kind of tease apart those concepts is why I do mathematical modeling in biology.

Mark Royce (11:24):

Wow. That's pretty fascinating. So you also use, I know, you look at the effect of mathematical modeling curriculum on how students problem-solve and how they develop their conceptual understandings of statistics and genetics.

Anita Schuchardt (11:48):

Yes.

Mark Royce (11:49):

Talk to me about that.

Anita Schuchardt (11:51):

Okay. So let's split that up just a little. So for the genetics-- this was when I, for my dissertation work largely, but not fully. I've added onto it since then, but for my dissertation work, what we looked at was, we had developed high school curriculum for high school students to be able to, represent Egg and sperm, joining in a single gene cross, and then modified that equation to apply to crosses where there were multiple genes matings where there, where there were more than one gene. And then we used a multiple choice test to assess students understanding of biology concepts, and also students' ability to solve problems that involve more than one gene or to apply the principles they've learned to, to a slightly different application of the problem. So instead of predicting offspring outcome, predicting outcome of gammetes or sperm, and eggs, and we compared the results for students who had experienced the model-based curriculum and students who had not, and students who experienced model-based curriculum, not only did better on the more complex problems mathematically and solving them for the probability, but they also did better on showed better understanding of their biology concepts.

Anita Schuchardt (13:24):

And I think that has to do with what I talked about before was they have to discuss these ideas in order to mathematically model them. So they did better than students who hadn't experienced the curriculum. And when we look at students who have experienced a model-based curriculum, when we've done this at both the high school and the college level, students who experienced the model-based curriculum use more approaches to trying to solve genetics problems. They use both biology-based approaches and mathematical approaches. And as part of my dissertation research has showed that they switched approaches either when they got stuck, to check their answer as they were proceeding through the problem, and then to check their answer when they got to the end of the problem. And so that's probably what accounts for them being more successful at it.

Anita Schuchardt (14:21):

For the college level we've also done implementing in inheritance, and we've extended that slightly to talk gene regulations. So we have students mathematically model, whether different activators or repressors and the different proteins that are involved in transcribing a gene to make a protein, whether they're bound to the promoter and then they mathematically model that. And then they can make predictions about whether or not a gene will be turned on or turned off. And it is very reminiscent of like, almost like a computer instruction, cuz it's very like multiplying. Yes, it's on. No it's off. And you multiply them all together to get it. So it helps to form the connection in their heads that, oh, mathematics forms the basis of computer programs that simulate what's going to happen and make predictions. And then the statistics...

Anita Schuchardt (15:32):

So people, not just students, but people in general struggle with statistics. So the research shows it doesn't matter whether you're an undergraduate student, a graduate student, medical professional, principal investigator, people use statistics incorrectly. They talk about statistics incorrectly. And we hypothesize that part of the reason for that is they don't connect statistics to this idea of biological variations. Statistics is really important in biology because everything varies. Nothing's the same. It's not like in physics where it's like, okay, your variation is very small. In biology, individual organisms vary for lots of different reasons. And the only way to take that into account is by doing statistical tests. So we developed a curriculum to have students actually, mathematically model that variation. They came up with a formula, which expressed how far their data points were on average from the mean, and that's related to standard deviation, which is in most statistical formulas. And then they saw how that related to the T test and how that related to sample size. And when we developed this curriculum, we trained TAs to implement it. And we compared students who had the curriculum with students who had not, and students who had the curriculum did much better on an assessment that measured their understanding of statistics. And not only did they do much better right after the curriculum, but that persisted into the next semester. So that was rewarding in a lot of ways.

Mark Royce (17:32):

Yeah. So there's a buzzword that I've heard. And I don't know if it's a buzzword or it's a real focus for a lot of people in the modeling community right now where they're investigating computational modeling. And employing that in the classroom. What's your understanding of that? And are you using that at all in your classrooms?

Anita Schuchardt (17:56):

So the closest we get is with the mathematical modeling and gene regulations. So we... Because students, once they're done constructing the mathematical formula, they enter it into an Excel document, which is basically programming the Excel to multiply the cells that they should multiply and come out with an output and when they do that, they get an output. And so it's baby steps. It's small and it's very focused. The reasons for that, that's where I kind of wanna go next is like, okay, let's explore, they're doing this small step. Where do we take it next? And how do we connect it up to this more, this idea of actually incorporating in a computer program and doing that? I think that one of the things that I need to be aware of as an instructor is that I need to figure out where I'm focusing my student's attention.

Anita Schuchardt (19:03):

So while it's very important that they learn to code, they do do that a lot in their lab courses and it's very structured coding, but they do do that. And if they're trying to learn to do the mathematical modeling, pay attention to the biology concepts, and figure out what code to put in, I may be asking them to do too much. So I need to figure out how to break it down so that they focus on one piece at a time. I think that that type of modeling --and I have a colleague who in the college space works on this much more than I do-- And one of the powerful aspects of that kind of computational modeling is that it is super powerful for getting students to pay attention to the hidden pieces, the things they cannot see, because you can model those on a computer. You can have students figure out how to represent that in code, see whether that's going to have the effect that they predict it will have and those kinds of things. And it's just figuring out the best place to use it.

Mark Royce (20:13):

Yeah. You teach in the university setting. In some very large classrooms.

Anita Schuchardt (20:19):

Yeah. 150 students, plus.

Mark Royce (20:23):

It's kind of hard to employ all the methodologies of modeling that most of our high school teachers use in that kind of setting. For example, to do a whiteboard session would be ridiculous, I think with 150 people,

Anita Schuchardt (20:41):

We do a modification of it. Yeah.

Mark Royce (20:44):

Oh, you do. Yeah. That, see that's my question is how, does the concepts of modeling instruction influence your teaching in the classroom at your university level?

Anita Schuchardt (20:58):

Yeah, so we do modify the whiteboard sessions, between 150 to 180 students. Students are in groups of nine, which is not ideal, but I sometimes subdivide them into groups of three within those groups of nine. They have whiteboards that are available to them around the room. But it's very difficult to share those whiteboards. And I was using a kind of video capture, like, so I could have a student capture it, and then I could project what that student was saying about their whiteboard around this screen. But we've discovered a new method, thanks to COVID. So Google slides are great whiteboards.

Mark Royce (21:47):

Ah.

Anita Schuchardt (21:48):

And so we have students put their representations on Google slides, one slide for each team, that way, when we come back together as a group, whichever group is showing is speaking. I can show their Google slide. And then we project that up on the projectors in the classroom and they can talk about that. Everybody can see it, or they can look at it on their computers and then we can have a discussion about that. We don't necessarily always get to every group. And so I have some ways to address that. One of the things that we do, and I think this is an advantage because they're college students, but might work with upper level high school students too, is that I have them provide feedback on each other's presentations or ask questions. And so, that's one way. And so I'll do it in different ways. Sometimes if it's a picture that they've drawn on the whiteboard, I'll have each group move around one and put post-it notes and things like that onto the whiteboard, and then have a discussion. I also structure Google docs where they can provide feedback on the Google docs, and then we can look through them and discuss interesting ones.

Mark Royce (23:15):

I wanna ask you about this other part of the modeling approach is, you know, Socratic dialogue and drawing the students' knowledge out from them rather than feeding it to them. Do you employ that kind of thing in your classroom as well?

Anita Schuchardt (23:34):

Oh, yeah. A lot.

Mark Royce (23:37):

So share how that works in the large classroom like that.

Anita Schuchardt (23:42):

So when they're working in their groups, I get round to as many as I can. And I ask them questions, like, tell me what you're thinking. Why did you decide to do that? And how you going to, you know, what have you thought about this? And I really try and get them to refine their knowledge in that space. It's another power of Google slides because I can go and see in the slides where each group is at, before I go around to the group and then I can get to them and I can target my questioning for where they're at to help with the board. And then when they present their work, I ask them questions. I ask them, you know, how do you know that? That's one of my favorites, right? How do you know? Can you provide the evidence?

Anita Schuchardt (24:33):

I encourage the students, the other students, I ask them, do you have any questions, comments, or thoughts about what your peer has said? And it takes a little while in the classroom. It's very different than a normal college classroom, right. To get students to do this. And it takes a while, but by about mid-semester, they're very comfortable speaking up. And I think partly because I ask for comments and reflections and questions, so they don't necessarily have to put the other team on the spot. And then the other approach that I use, which is not, is kind of modeling instruction, but kind of not, is that I'll often have every group say one thing about something. Something they've learned. Right. And then I'll ask them, oh, what's your ever evidence for that? Or why do you think that? And so as we go around, we build up all our evidence for it. But if they get stuck anywhere they can do --you can call a friend which means call on another team, or you can--we have one designated speaker that rotates every week in the teams. And so that person speaks. And if that person gets stuck, they're allowed to call out any of their teammates to speak up and help them.

Mark Royce (25:54):

Yeah, that's really cool. Are there other ways that your teaching has been influenced by modeling instruction? I'm just curious about you personally.

Anita Schuchardt (26:06):

Yeah, the use of multiple representations. So I focus on the mathematical representations as a way to get students to build their ideas and to represent their ideas. But I also make heavy use of pictorial representations. And when students are developing their mathematical representation, I ask them to draw out what they're doing, to represent that. And we work a lot with doing different types of representations, talking about why they're important, how it helps them. And I get a lot of students saying, wow, I realize that, if I get stuck somewhere, I can draw a picture of it. And that helps me. Or, oh, you know, I could actually use mathematics in my other classes because that helps me. And I try to give them lots of different tools and lots of different representations and lots of different ways to access the material.

Anita Schuchardt (27:09):

And I think the other way is, and we can't do the same kind of paradigm labs that you can do in high school classrooms, because the way the college, at least our college, biology is set up, the labs are run very separately from the lecture, so instead of doing that, what we do is I provide them with data. And give them a rundown of the experiment and provide them with the data and ask them to, for the population growth, for example, represent this pictorially and then do your mathematical expression that represents the ideas that you represented in the picture, and then present out their work. And that works pretty well, actually,

Mark Royce (27:58):

One of the questions I had was, and you just touched on, it was with a class that large, how do you handle the labs and the coordination between your instruction time and the connection with your students and their lab work?

Anita Schuchardt (28:14):

We don't get a lot of a chance, unfortunately, to do that. That's run very independently. That's common on a lot of college campuses. Not all of them. I have some ideas of some of the things that are going on because I actually work, as I said, we implemented a curriculum in one of the lab courses. I kind of keep my hand in both places, so to speak. But I don't do curriculum development, like the lab curriculum development. And so, but I also, my graduate students TA in the lab courses. So I also get to talk to them and I find out what's being taught when, so when we're talking about PCR I'm at least able to reference it to say, oh, like you saw, but we cannot do the same kind of coordination that you can do at the high school level where often, the labs in the classroom can be tightly intertwined.

Mark Royce (29:08):

Right.

Anita Schuchardt (29:08):

I do know in other settings in college, it is possible to do that where that happens. We're a large institution and that would be very difficult to manage.

Mark Royce (29:21):

Yeah. Yeah. That makes sense. So earlier in our conversation, you referenced several statistics that have come out of research and into your area of expertise. Now I know that you have a thing called the Schuchardt Research Group.

Anita Schuchardt (29:42):

Yes.

Mark Royce ([29:43]()):

I was looking you up and I found this website. So is that the source of some of your discoveries in research? I guess basically my question is what is the Schuchardt Research Group?

Anita Schuchardt ([29:59]()):

What is it and what do we, we do, right?

Mark Royce ([30:03]()):

And how does it, how does it connect to your university position?

Anita Schuchardt ([30:07]()):

Exactly. So like many sciences, right. Have what they call a lab. So if you're a biology, you have a biology lab if you're a professor and you have graduate students and postdocs and undergraduate students who work with you and they do research under your guidance. And so, it's kind of weird to call an educational research setting a lab. So instead we call it a research group. And so my Schuchardt research group research group is composed of the members. Well, and now past members, who have worked at some point with me on doing educational research. And they're the ones, if they're graduate students and postdocs, they're spearheading a lot of this research. I might come up with some ideas and I guide them and stuff. And I'll give you a few examples of some of their work and some of the undergrads' work too, because they've done some pretty amazing stuff as well.

Anita Schuchardt ([31:08]()):

So, um, and that's related mostly to the mathematics stuff. So one of my former graduate students, she's now an assistant professor in China, she reviewed all the literature that was talking about mathematics and science in physics, chemistry, biology in high school, college, wherever it was. And she came up with this framework of mathematics and science sense-making in mathematics and science. And so what types of sense making are going on, which is basically, are students making, or people, making connections between the math and the science, and also, what types of connections, what are they connecting? Are they talking about math procedure? Are they talking about mathematics concepts, are they talking about the scientific mechanism or are they talking about the scientific labels of the variables? And that framework has been very productive for our research group. So we looked at what biology instructors were doing, and we found that they provide their students with access to lots of different, what we call sense-making opportunities of mathematics and science and

Mark Royce ([32:32]()):

Sense-making?

Anita Schuchardt ([32:33]()):

Sense-making. So that means that they're getting the opportunity to make sense of that mathematics equation in that science context. And the one thing though, is that very few instructors provide students with the opportunity to connect the mathematics sense-making of that equation with the science sense-making of that equation, what we call blended sense-making. Instead, what you see most often is, okay, here's the science ideas, here's the mathematics ideas and repeat. And so the reason that's so important is because it's been shown that when students do connect science ideas with mathematics ideas, that's when they're better able to solve problems. That's when they're better able to like, apply their mathematics knowledge, not just to what they were taught in the classrooms, but to problems that are a little bit more complex or to transfer to a slightly different context. So that's fun.

Anita Schuchardt (33:40):

And then, I have a graduate student right now who is looking at students' discussions as they are mathematically modeling, as they are constructing their mathematical models. And she found that there is a lot of sense-making of the science of trying to make sense of the science concepts when they're constructing these mathematical equations, even though it's a mathematical task. And she's found that they're talking about the mechanism of science, how, what the processes are that allow for this phenomenon to occur. And she's gonna be presenting at that at a conference next week. So I'm very proud of her. She's done a lot of work on that. I have undergraduates who are also doing work. One of them is looking, I think I referenced before about how students are solving problems after model-based instruction and before it, and he was, he's the one who found out that they're doing lots of different strategies after instruction, more strategies after instruction and that's associated with success. So,

Mark Royce (34:58):

Yeah, well, we will put a link for your website, the Schuchardt Research Group website on our webpage. So when people, you know,

Anita Schuchardt (35:13):

That would be good. We're working on updating it, it's a little out of date, but we're working on it.

Mark Royce (35:18):

Well, it's, I imagine it's hard to keep it up to date with what we've been dealing with with the pandemic and all that kind of stuff, you know, so, yeah, that's cool.

Anita Schuchardt (35:29):

I was just talking to a group of undergraduate students today. And they had met with me as part of our--we do a orientation kind of program for our first-year students. And they met with me to talk about what I do. And so many of them said, I didn't know that there was anything I could do with biology, besides medicine and research. And I didn't find out about biology education research until, you know, I got a PhD in another topic, taught in the high school. And then I found out that there was this thing called biology education research. So I encouraged like high school teachers. I wish I knew more about this stuff when I was a high school teacher too, like the biology education research. So I encourage, you know, to tell students that there's so many more things they can do. Open up the world. And I know it's really tough cuz you know, as a high school teacher, I struggled with that as well, but there's a lot out there.

Mark Royce (36:33):

Well, talk about that. Talk a little bit about what kinds of other options there are.

Anita Schuchardt (36:39):

So the other options are like, like I said, you can do, you can teach, obviously, but you can also do education research in biology. I do a certain type of research, but I have colleagues who are researching into culture, into diversity, equity and inclusion, and social justice issues in biology, both in the biology discipline itself and in biology teaching. And there are so many different avenues. I have a student who is a former undergraduate who is looking to do biology, archeology, slash anthropology. We need, there's a desperate need for journalists who understand biology, who go do biology and do that, biology illustrators and people who can illustrate and provide those illustrations and creative. But know some biology and there is another huge need that is for-- this is gonna sound --lawyers who know biology. Yeah. Because there are so many, you wouldn't think that, right? So it's like, there are so many different things you can do with a biology degree that, it's a lot more than we think, I think, when we go into it and yeah.

Mark Royce (38:10):

Yeah. Wow. Several of those things you just mentioned, I had never thought of as, you know, a career path or, you know, something to invest your time in, around biology or having a degree. That's really very cool. You know, it's been really fun talking with you, and you have shared a lot of interesting information that I wasn't aware of and I know that our listeners are gonna really get a lot out of this conversation. So thank you very much for taking the time to do this with us.

Anita Schuchardt (38:47):

And thank you, Mark, for inviting me. I really enjoyed talking to you and getting a chance to express some of these ideas.

Mark Royce (38:53):

Yeah. It's really great, Anita. Best of luck to you as you continue at the university. And we'll probably cross paths at some time in the future.

Anita Schuchardt (39:05):

I am sure we will. I'm hoping to eventually get back to an AMTA conference. So.

Mark Royce (39:10):

Awesome.

Anita Schuchardt (39:11):

Well, good when I can do that. Okay. Thank you so much, Mark.

Mark Royce (39:14):

Thank you.