Science Modeling Talks

Episode 65 - "Models are the functional unit of scientific thought"

Guest: Cynthia Passmore

Mark Royce (01:16):

Well, hi, Cindy. How are you doing?

Cynthia Passmore (01:19):

I'm great. How are you doing today?

Mark Royce (01:21):

I'm doing well, thank you. Looking forward to our conversation today. You have an interesting background compared to a lot of the people that I've interviewed for this show, and I wanted to talk to you first a little bit about that. I'm very familiar with the American Modeling Teachers Association (the AMTA), their practices in using models came out of the work that David Hestenes did at ASU. And I know that your work has grown out of your collaborations at UC Davis, and I'd love for you to share ways that the work of those two groups are similar and maybe as well as any distinctions between the approach at Davis and the ASU approach to modeling and the AMTA.

Cynthia Passmore (02:19):

Yeah, that's a good question. I have read Hestenes work and, you know, cited it my whole career, and met him. And things like that. But, for whatever reason, I never got very involved in the American Modeling Teachers Association. I guess because we had kind of our own thing going here. I think I used to think there were more differences than there are, if that makes sense. I focus on modeling in biology. And of course, the AMTA started in physics, but has expanded it to those other content areas. So that's a distinction that doesn't really exist anymore. I think the biggest thing maybe, is really the focus on representation and how representations are used. I think in my work, we tend to, I don't know what the word is, downplay the representation in favor of the cognitive model, the thinking, the ideas that we have as learners. But I don't know, it feels like a distinction without a difference to me these days. But earlier in my career, I felt like it was a bigger difference.

Mark Royce (03:34):

Well, I

Cynthia Passmore (03:35):

Way more in common than, than different.

Mark Royce (03:37):

Yeah. And I kinda wonder as both of the approaches have matured over time, they probably have become more similar.

Cynthia Passmore (03:45):

Definitely. Yes.

Mark Royce (03:46):

As each group begins to learn more and more about -- and perfecting and developing the concepts, they probably become more and more alike

Cynthia Passmore (03:57):

Yeah, I think that's right. There's been more cross fertilization, and I think the inclusion of modeling as a practice in the next generation Science standards has also brought a lot more people to the work of modeling than used to be the case.

Mark Royce (04:12):

Yeah. So why is the use of models so important, from what you've learned?

Cynthia Passmore (04:22):

Yeah. I mean, so a lot of my-- the basis of my work is both in my own experience as a teacher and a science educator, but also in a lot of careful reading of the philosophy of science, history and philosophy of science. And one of the phrases that always has stuck out to me from that work is that models are the functional unit of scientific thought. So to think about that a little bit more concretely, we don't really do anything in science without having a model. We may not express it and have it be an artifact that we're using publicly, but we've got it in our heads, or we wouldn't be able to function. And in that sense, a model is just a set of ideas about how something in the world works. And we can formalize that.

Cynthia Passmore (05:12):

We can externalize that we can make it an object of our inquiry and our conversation, which is what we've tried to do in the classroom. I think it's important because if we don't bring it to the fore as the tool that we're using to reason with in the classroom, then it's hard to know what people are thinking about how things work. It's hard to get on the same page and hear other people's ideas and compare them to your own if you're not, you know, bringing that, that model that you have out into the public space. And so, and that's what scientists do when they share their ideas, and they do that in things that they call models, and they do that in things that we call something else a theory of, or you know, sometimes, there's fancy diagrams or equations or whatever --they're shared, but underneath them is a mechanistic view of how whatever the phenomenon is under study is how it works.

Mark Royce (06:13):

Yeah. So, you kind of just alluded to this a little bit. Tell us what your thoughts are are on the distinction between the phrases, "models of" versus "models for."

Cynthia Passmore (06:31):

Yeah. This is a sort of a heuristic or shorthand that my colleagues and I have been using for a while. Julia Govea, who's at Tufts now and I worked on a paper to try and kind of bring this out into a more useful space. And really the idea is to prioritize the purpose that you're putting the model to. So what are you modeling for? What are you trying to answer? What's the question you're trying to answer? What's the phenomenon you're trying to explain? Rather than what often happens with modeling, and I mentioned this briefly a moment ago, is the focus is really on how we're showing our ideas. So the representational aspect, and in many ways, the representational aspect and what's in your head are indistinguishable in some ways, but in other ways, if we overly focus on the drawing or the diagram or the three dimensional object, we sort of lose some of the detail of what's going on, mechanistically in our thinking.

Cynthia Passmore (07:46):

And so we use this distinction "models of/models for," to be sure. I force myself to say it, whenever I'm creating curriculum or working with pre-service teachers on a unit in one of their classes, if I can't complete the sentence, the model is for understanding where the matter in the tree comes from. If I complete that sentence with some scientific word, then I'm cheating. The model is for, the model is for photosynthesis. No. The model is for understanding how a tree grows or why a tree doesn't need to eat, or where the matter in the tree comes from. So those are the things in the world we're trying to explain, versus if we just say a model of photosynthesis, then we're, we're really focused on the representation of that, usually as an equation in this case. We like to use the example of DNA because we all have that iconic image of the object that Watson and Crick built in their lab and the picture of them standing next to it.

Cynthia Passmore (08:53):

But the building of that thing helped them communicate their ideas. But the ideas are what matter and what have lasted and persisted and transformed the field of genetics. The depiction is important. I'm not trying to say it's not, but if all we're doing is asking kids to reproduce representations and depictions of things, then we're losing the modeling practice, in my view. And so we think this distinction of a model of a model of DNA versus a model for understanding how a molecule could act as a code for inheritance is that's really the, the kind of trick that is a little hard one to pull off sometimes in the classroom.

Mark Royce (09:39):

Yeah. Yeah. I read in, I think it was the book that you were involved in helping students make sense of the work using next generation science practices. I think it was there where I read you said that there's a difference between learning science as sets of facts versus learning science as models that can be used to understand and explain our world. This is kind of what you were saying just a moment ago. Do you wanna expand on that at all?

Cynthia Passmore (10:17):

Yeah, I mean, I think to me it's the difference between having like a static set of facts or information that you've been told versus having a dynamic set of ideas that you can deploy to explain something in the world, and that you had a hand as a student in coming up with. It's not to say that we're asking kids to reinvent Newtonian mechanics with no help, but it is to say that we want them to understand what Newton was up to. What was he looking at? Why was he, what was he trying to explain in the world? And a lot of times that part of the story gets left out. It's like they just wandered around and, and picked up --Newton's laws were just laying on the ground, and he discovered them, well, no, he was trying to figure something out, and this is how he abstracted those ideas, made them make sense, tested them, revised them, collected data. Like that's what modeling is. And so to me, if we just teach Newton's laws and we don't contextualize them in the way in which they're useful, and create that sort of, like I said, more dynamic set of ideas in a kid's head, then we're not really doing them any favors.

Mark Royce (11:36):

Hmm. Yeah. Wow. That's good. So, in your research, I know you've done quite a bit of research, how does classroom modeling instruction fit with the framework for K-12? That and the NGSS, that's been presented. I don't know what, what year was that? First?

Cynthia Passmore (12:01):

2012, 2013. Yeah. It's been more than 10 years. Yeah.

Mark Royce (12:05):

It's been a while. So how does classroom modeling instruction fit with those, what our government calls newer ideas?

Cynthia Passmore (12:15):

Yeah. Well, I mean, I think for a long time science educators have had a sort of dilemma sometimes in trying to figure out what in the eighties and nineties was called, the "content process" kind of dichotomy or difference. Like, there's the science ideas and there's the how do you do science? And sometimes those two things didn't come together very well. And so my sense and feeling is that we've gotten a lot closer with the framework for K-12 science education and the NGSS because the how and the what are woven together in a way that we hadn't been able to achieve in science standards prior to this. It's still imperfect, of course, we're, we're always working to make things better. But, by articulating what the practices are that scientists use to make sense of the world, I think we've created the conditions for students to engage in approximations of scientific practice in the classroom.

Cynthia Passmore (13:21):

Not for their own sake, not just because we're like, you gotta know what the scientific practices are. You should be able to name the eight. But because then you, if you actually engage in them, you can see how science works and you can maybe have a little bit more faith in science, and you can understand why scientists change their ideas over time and things like that that often, create some challenges for science in the public realm. One way that I often talk about it with my pre-service teachers and in professional learning and places like that, is the modeling practice is a core, or sometimes we think about it as an anchor to which you can really attach every other practice. I mean, the practices are a web, right? They're all interconnected with one another. And you can't really disentangle that web, but from my money, modeling has a pretty big bang for its buck. So if you're really truly doing modeling in the classroom, you have to be asking questions. You have to be designing investigations to test your ideas. You have to be using your model to create explanations, et cetera. So, you know, all of the practices can be clearly joined to the practice of modeling if you're able to pull that off in the classroom.

Mark Royce (14:46):

You're saying outside of the science focused disciplines?

Cynthia Passmore (14:50):

No. I'm talking about in science.

Mark Royce (14:52):

Yeah. Okay. Well, how, how do you think that modeling practices relate to the other practices that are highlighted in the framework and the NGSS?

Cynthia Passmore (15:03):

Well, that's what I'm saying is like the other practices of asking questions, analyzing and interpreting data, planning investigations, all of those things can really be coupled to modeling. If you're really doing modeling, you have to be doing those things. If you're developing a model in class with kids with a real context that you're trying to explain, all of those other things come along

Mark Royce (15:28):

Yeah.

Cynthia Passmore (15:29):

Kind of for free. So that's why I think modeling is such an impactful practice, because it is. It's very interesting to me. Something that has happened to me many times in my career is... I work with lots and lots of teachers and educators and in myself, a teacher was a teacher, a teacher at the university. But I also work with a lot of scientists. When I talk about modeling and model-based reasoning to scientists, it's almost instant recognition. It doesn't take very long. I don't have to explain very much about what we're up to because it is their everyday life, truly. Most scientists

catch on very quickly. Now, that's not to say that it's easy to pull off in the classroom. I'm not saying that. And it's not easy for scientists, and it's not easy for classroom teachers at the K-12 level, but understanding the point of modeling instruction is very quick for scientists to catch on, whether they agree that that's the right thing you should be doing in classrooms, that's a totally different story.

Cynthia Passmore (16:33):

But understanding what we're even talking about very fast. Whereas a lot of us who are more in the education side, who maybe have never been professional scientists, I have not-- it, you know, took me years to really understand the nuances and depth of this, because it's not something I had experienced myself in education, ever. And because I myself wasn't a practicing scientist, I didn't have sort of the background experiences to pull on, to make sense of it. So that's why we need really a lot of curriculum help and a lot of images of what this can look like in the classroom. And I think what we find is that once teachers do this with kids, they're hooked. It's not a hard sell because they're like, oh, now I have a way in, to do something I've always wanted to do in my classroom and have been, you know, successful to varying degrees in probably, which is engage my kids in really understanding what we're doing. Instead of hitting it on a surface level or a memorization. Nobody's trying to do that. That's not anybody's goal in education. "Oh, I wanna make my class boring and rote,"

Mark Royce (17:51):

<laugh> <laugh>.

Cynthia Passmore (17:53):

But sometimes we don't have the tools and strategies, and I think the modeling and instruction brings a lot of that along.

Mark Royce (17:59):

Yeah. And that's fascinating for me to hear you saying that about scientists outside of the educational realm, getting it pretty quickly. My wife, before she became a teacher, worked as a chemist in a commercial lab. And she had this urging to become a teacher. And when she, early in that decision, she discovered modeling through, --by the way, her first introduction was a program at UC Davis.

Cynthia Passmore (18:36):

Oh, really?

Mark Royce (18:36):

Yeah. But it was through AMTA, a program.

Cynthia Passmore (18:42):

There have been collaborations in the past. Yeah.

Mark Royce (18:46):

And so that immediately just hooked her. And, you know, she hadn't really been teaching long before that, but immediately was like, this is the way to teach in the classroom. She was very excited and has been involved now for 20 something years.

Cynthia Passmore (19:05):

That's how I felt at the beginning.

Mark Royce (19:07):

You mentioned just a minute ago, that reminded me also in the book, Helping Students Make Sense, that you mentioned that it's hard to bring modeling practice into the teaching realm into the classroom. Why? Why is it so hard?

Cynthia Passmore (19:26):

Oh, if I knew the answer to that question, I could retire.

Mark Royce (19:30):

<laugh>. <laugh>.

Cynthia Passmore (19:32):

I think it's less hard than it used to be. But I do think that teaching in this way, that really is what NGSS is asking us to do, which is to engage kids in sensemaking, is not how most of us learned. And most, not all, but many folks who are successful and have become teachers, were themselves pretty good students. Not always. I have a couple pre-service teachers in the last couple of years who are very clear that one of the reasons they got into being a science teacher was because they struggled themselves and felt like there was no one who understood what it was like to struggle. And that they wanted to be that help to like, come from a different angle for their students. So I don't wanna overgeneralize, but for the most part, the way science was taught to us worked for us, but it doesn't really work for a lot of students.

Cynthia Passmore (20:32):

And, so again, I think it just goes back to having images of what it looks like to do something different. And so I think a lot of professional learning around these kinds of approaches to science teaching, engage the teachers themselves in the lessons as a way to experience what it's like to be a learner in a setting like this. To not have the teacher tell you everything at the very beginning about how it all works to iteratively and with revision, figure out how something works. Being well scaffolded with data and experiences that are gonna allow you to build your ideas over time. But a lot of us, you know, we didn't, it's, it's not a, it doesn't match our image of what school is like, which is the teacher telling everybody what to do. And, you know, we've come a long way in having that be the image of school. But it's still pretty strong. And I think we took a few steps back during the pandemic because so much of the online environment really lent itself only to very didactic kind of instruction. And it is the case. I mean, I've been doing this for a long time, that standing and giving a lecture is a little bit easier

Mark Royce (22:02):

<laugh> for the teacher,

Cynthia Passmore (22:03):

For the teacher, then it's less interesting for the teacher, but it is sort of easier. And there's a kind of fallacy of efficiency that we buy into about that. I've covered the material, I've said the words, I've given the lecture, I've shown the kids the vocabulary words, and therefore I've covered this thing. Whereas I think most teachers feel pretty dissatisfied with that, but sometimes revert to it because they're so pressed for time and their jobs are so hard. So those are some of the reasons I think it's hard. What we hear from teachers, over and over again is how much more enjoyable it is though once they've converted to this kind of instruction to really like, get in and explore with the kids and see what they think, and be amazed by what they can do.

Cynthia Passmore (23:02):

You know, it really pushes us into these sort of like spaces where we're like, wow, you came up with that, that is so cool. And that kids will think about things very differently than we do. And so I was just talking to some teachers yesterday, about how important it is to give it a couple of run-throughs before you're... Because the first time you

don't know what you don't know. You don't know what the kids are gonna say. There's just a lot of learning. But after you've done it a few times, it's like, oh, now I know where to guide and where to step back and when to let it go and when to redirect and, that kind of thing.

Mark Royce (23:38):

Yeah. A passion for teaching students and helping them grow in their understanding and to be effective learners is the great hallmark to me of a great teacher. And, it is exciting to watch that happen, you know, in our educational system and different disciplines and I feel like modelers that I've met-- I'm not a teacher. I'm not an educator of any kind. I'm married one. But, you know, most of the modelers I've met are pretty passionate about what they're doing in the classroom. And it seems like modeling has given them kind of a handle to grab onto and really be able to express their passion in teaching. And so that's been one reason I've really enjoyed doing this podcast is talking with people like you. And teachers. You're not in the classroom at this point.

Cynthia Passmore (24:42):

That's correct.

Mark Royce (24:43):

What are you working on?

Cynthia Passmore (24:44):

I mean, I'm not in the K-12 classroom. I teach pre-service teachers and I teach university students.

Mark Royce (24:50):

What are you teaching?

Cynthia Passmore (24:51):

I'm in a school of education so I teach our science cohort, our students who are becoming science teachers. And we do some science and we do a lot about education and pedagogy and classroom management and everything. And then I teach graduate seminars for PhD students, but I also teach an undergraduate class on learning, which is really very deeply connected to why I care about, and advocate for the kinds of science instruction that I do, because it is so well aligned with how people learn.

Mark Royce (25:29):

And so you promote modeling, I assume?

Cynthia Passmore (25:31):

Yes. Right.

Mark Royce (25:31):

The modeling approach in the classroom. Cool.

Cynthia Passmore (25:34):

And then I work with a lot of in-service teachers on grants and doing professional learning. We have a project here that does professional learning with teachers all over the Northern California region.

Mark Royce (25:49):

Cool. Are you still involved with research...

Cynthia Passmore (25:52):

Oh, yeah. So.

Mark Royce (25:53):

On educational practices?

Cynthia Passmore (25:55):

All those projects that are with in-service teachers are research projects. We just finished one evaluating our modeling curriculum, which is a year long high school biology course. And we were able to do a quasi-experiment comparative kind of study, pretty large scale, quantitative study, which is hard to do in education for many reasons. And we found that our curriculum, the students who were in the modeling condition performed better, than the students in the business as usual classrooms, which is exciting, nice to have empirical validation. We did have an interesting finding in that study. We haven't, the papers are still under construction, so there's no citations for this yet. But, one of the things we found in the experimental condition, which was the modeling classrooms, the year-long modeling curriculum, the students who had teachers who had a starting score on this assessment of what we call tolerance for ambiguity, if their teachers were more tolerant to ambiguous circumstances, their students performed better in the modeling.

Mark Royce (27:13):

Interesting.

Cynthia Passmore (27:14):

curriculum than other students in the modeling curriculum. So this was like an internal, explanatory analysis that we did. So I think that, and you know, when we say this out loud, everyone's like, of course, because you have to like, be open to open-ended situations in order to really pull ideas from kids and have them be open to revising their ideas and going down a rabbit hole and discovering that's not the way or, you know, all of those things. So it's an intuitive finding, but to our knowledge, there's no other, research out there that has that kind of, and again, we don't even have a citation yet, but We'll, we'll get there.

Mark Royce (27:57):

That's cool.

Cynthia Passmore (27:57):

Yeah. So, yeah, we do, I do a lot of research, looking at classrooms, teachers, student outcomes, things like that.

Mark Royce (28:07):

You'll need to give me links to resources for our listeners where they might be able to peruse your research papers that have been published you know, get more information about the work that you've done, especially as it relates to modeling. In your book. I'm gonna mention it again. I found it very interesting. One of the last things in there is how to get involved with modeling, or I don't remember ...

Cynthia Passmore (28:38):

How to get started.

Mark Royce (28:38):

How to get started I didn't really know about the work you guys-- I'm most familiar with the AMTA work. And I noticed you didn't mention them in that how to get started.

Cynthia Passmore (28:54):

Yeah, it is a little blind spot, I have to say. Yeah, I agree. Sorry, <laugh>. Sorry AMTA people.

Mark Royce (28:59):

So in the future you can remember maybe because there's a lot of research on I know there are. Yes. Their website is modeling instruction.org. Yes. ORG. And, uh, there's a lot of resources for people who are interested in getting involved in like the workshops that are available for new people who are interested in learning more about modeling.

Cynthia Passmore (29:22):

Yeah, definitely. And they've got some of the best offerings, I think, in the country right now.

Mark Royce (29:26):

Yeah. From my understanding, it seems that way. Yeah. That's really cool. So the book, Helping Students Make Sense of the Work using Next Generation Science Practices, is that a book available to my listeners? That might be

Cynthia Passmore (29:47):

Oh, oh yeah, that's, yep. That's available, from the National Science Teachers Association. It's, uh,

Mark Royce (29:52):

NSTA,

Cynthia Passmore (29:53):

NSTA. Yeah. So it's at their bookstore. They worked with us on the practices, but they have books also on the other two dimensions of the framework. So there's a book on core ideas and there's a book on cross-cutting concepts as well. So they've created supports for teachers around the Next Generation Science Standards, and that book is one part of the collection.

Mark Royce (30:19):

Okay. And is that something they can get to online?

Cynthia Passmore (30:24):

At the NSTA website bookstore.

Mark Royce (30:27):

Cool. I'm gonna have you send me, if you would, email me links so they can quickly get there. for that stuff and any other links that you want to send me, we'll post 'em on our website. Our listeners usually subscribe to the podcast through Apple or Google or whatever. But, but they can also hear all our, the whole history of our podcast and get deeper resources from the individuals that I've interviewed through the website. That's science modeling talks.com. And this interview will have its own page and will include your bio and any links and stuff that people would be interested in. So anything great that you think might be interesting for our listeners, then I would love for you to send that to me, and I'll include 'em on that page on the website.

Cynthia Passmore (31:26):

Sounds good.

Mark Royce (31:28):

Well, it has been a absolute joy talking with you, and I really appreciate the work that you've done, first of all.

Cynthia Passmore (31:38):

Thank you.

New Speaker (31:39):

Because it's been obviously a labor of love and a lot of work. So I just wanna say thank you for being my guest today.

Cynthia Passmore (31:52):

Oh, thanks for having me on. It's a pleasure.

Mark Royce (31:53):

Yeah. So maybe we'll connect another time.

Cynthia Passmore (31:57):

Yes. Great.

Mark Royce (32:00):

You take care.

Cynthia Passmore (32:00):

Thank you.