Mark Royce (00:00):

Hello, Mark.

Mark Schober (00:01):

Hello, Mark.

Mark Royce (00:03):

How are you today?

Mark Schober (00:04):

I'm doing just fine it's a hot, steamy day in New York City.

Mark Royce (00:09):

Well, it is uh, it's supposed to be 95 today on the West coast, central California.

Mark Schober (00:15):

Okay. That is actually hotter,

Mark Royce (00:17):

But it's dry. It's not humid. So I like that. How are you doing handling this whole pandemic thing personally? How's it going for you? What are you doing in it? Anything cool or special or something worth sharing?

Mark Schober (00:35):

It's been interesting 'cause my spouse and I live in a 400 square foot studio apartment on the West side of Manhattan and, we're both teachers and so all through the spring, we had to navigate teaching in a tiny space and it was... It was challenging. So sometimes I would be in the closet and sometimes she would be in the closet while the other person was out in the main room. We've been in New York this entire time. Early on, we would hear the sound of sirens almost continuously outside as people were being taken to hospitals. And it's notably different now. Here at the end of July, things have definitely quieted down, but we're a little nervous too as there's been a huge diaspora from the city. And as people come back into the city, we're a little concerned that that's another possible spreading event, but in the meantime, we've tried to get outside and get our 10,000 steps a day. And so we've really come to know our neighborhood very well, through our masks. And my go-to social distancing activity has been, I've gotten out of the city a half a dozen times to drive a couple hours North to the reservoirs that supply water for the city, which happened to have really nice dark skies. And I've been able to do some astrophotography there. And that has been a really nice break for me.

Mark Royce (02:03):

So stars. You're shooting stars.

Mark Schober (02:06):

Yeah. Stars. The Milky way. I'm able to do a little bit of deep space imaging as well. And it's been a great learning experience. I'm hoping to turn this into a student trip, that where we'd take students to Big

Bend national park in Texas, to learn about astronomy and this interesting process of trying to take pictures in the dark and capture the sky.

Mark Royce (02:33):

Are you posting your images somewhere for public?

Mark Schober (02:37):

I think I posted a few on Twitter, and I should post a few more on Instagram ... That's most everybody I follow on Instagram are these fantastic space, photo posters.

Mark Royce (02:49):

If you send me your Instagram handle, I will put it on the website on the interview page for your interview and people can check it out. And we'll also do your website and you sent me a headshot, which everybody does for the show. And there's this really beautiful young lady with you in the headshot that you sent, Who is that person?

Mark Schober (03:13):

in 2016, my wife and I got to travel to India to work at the Augusta school where we were working with teachers and we were working with students and, during a number of evenings, we went into some of the rural schools around this kind of hub school. And I was talking to this 13 year old girl who was reading to me in Hindi and she was also talking to me in English and I was asking her to use her finger to follow along in the book so I could see what she was reading. And I was just so struck by this child and here we were in a one room school house that had about 50 students in it. And her ability to read was really the thing that was going to determine whether she would be married in another year or two, or whether she would be able to go on to additional schooling. And so, the importance of educational opportunities for kids in, in this case, this was Southern rural India, is so critical. And even though child marriage is outlawed, it often happens in rural areas. I got to work with the astronomy teacher at Augustia and we developed a bunch of hands on activities for their astronomy program to take advantage of a really nice planetarium facility that they have at this school. And I really enjoyed my time there. And I got to learn so much about Indian culture, the Indian people, and it was really fascinating.

Mark Royce (05:02):

That's a wonderful story. That is great. So Mark, tell me when and how you were first introduced to the idea of modeling instruction. And then tell me a little bit about how it impacted your approach to teaching.

Mark Schober (05:17):

Well, I'd back up to a couple of years before that, when I was in grad school at Miami University in Oxford, Ohio, my graduate professor, James Poth was a test site for the brand new materials that had come out of the University of Washington called Tutorials in Introductory Physics and Physics by Inquiry. So I was Jim Poth's lab assistant. And so we would sit down at lunch and we'd look at these research-informed materials and how beautifully they were structured and the system of using Socratic questioning and dialogue to help bring students along in their understanding. And so I had this really robust, on the job training as a TA working side by side with my professor and teaching these courses. And when I moved to St. Louis in 1996 to start teaching, I was kind of at a loss because here I had all this

neat experience, but it was -- I was familiar with materials that had been written for very specific audiences.

Mark Schober (06:29):

Physics by inquiry is for pre-service elementary teachers. The tutorials in introductory physics are for undergrad physics students in that first year of physics where the tutorials were to be used in the recitation sections. So when I started teaching in St. Louis in 1996, I found that these materials that had been written for very specific audiences didn't translate well to my high school physics students. And two years into my teaching, I was introduced to the modeling instruction program and was sent off to University of California Davis to go and participate in the workshop. And when you take a modeling workshop, there's this certain kind of process of unlearning certain teaching habits that you've had and learning new teaching habits and being such a young teacher and having such a strong background with these fantastic materials from the University of Washington, I was really ripe and ready for the kinds of things that modeling allowed me to do it suddenly said, Hey, I can use all of those skills that I had developed working with my graduate advisor, but now I had this much more flexible structure in which I could use it with my students. I could tailor the existing modeling materials for the needs of my students and to help balance where their strengths and weaknesses are so that I could go and meet my course goals in that way. And so that flexibility that modeling gave me allowed me to jump in feet first and try and do modeling the best I could right from the beginning. And that was, it was an interesting kind of preparation that really made me able to take full advantage of the training that I got through the modeling workshop

Mark Royce (08:41):

Pick up from there. So you did the workshop, you got these new tools in your hands. How did you employ them and how did it impact your teaching?

Mark Schober (08:51):

For me, the thing that was particularly nice is that it took me all out of the focus, the spotlight in every class period. Instead the discussion in the class became the focus so that I was able to go and instead of trying to ask students every day, with their limited understanding of physics, to try to get into my head, instead, I was putting the students in a position of "explain this to me, tell me about what you're seeing." And then I could use all of my physics experience to try and get into the student's head. And that was so key because every day then I'm seeing where every student is in their learning, what they're having trouble with, what they're getting and where I needed to spend more time with the students to help them better understand the concepts of physics.

Mark Royce (09:49):

That's great. I picked up a quote from you somewhere, and you said modeling is only as good as your assessment. That was a strong statement. And I want you to expand on that a little bit.

Mark Schober (10:04):

So for the first 14 years of my teaching in St. Louis, and then a few years here in New York, I was still doing my assessment in a very traditional way. You know, occasionally give a couple of quizzes and then the end of the unit give a test. And then a couple of weeks later, you give the next test. And I would get to like the end of a first semester final and students that had struggled with ideas early in the year were showing me that they completely understood these ideas. And I was thinking, how does this make sense

now that their grade should be an average over everything that they've done all semester long. Here at the end of the semester, they've really shown me that they can do these things. Um, and I had lots of other discomforts that came through assessment. I mean, a student would maybe not do nearly as well as they wanted to on a test. And what, what do I do I say? Study harder for the next test? I mean, that doesn't really do anything to remediate any of the issues that may have been present in the previous unit. So I had these kind of discomforts. One more was just about the tests themselves. I always felt this really terrible tension in tests. I was trying to put enough material on the test so that if a student would miss a single question, it wouldn't completely destroy their grade, but I was trying to keep them short enough that the kids could complete them in a class period. And then at the same time, I wanted to make sure I was asking questions that were robust and interesting. And these tensions were at cross purposes to one another. And I felt that the tests that I was giving students weren't particularly good.

Mark Schober (11:58):

So in about 2012, I met with one of our physics teachers here in New York who has been a good friend through the years, Seth Guinals-Kupperman. Over dinner, he explained to me this idea about standards based grading. I had never heard of it before. And he explained, it's like the difference between having that receipt come back after dinner, that just has the total on it versus having the receipt that's itemized saying what all went into this. And I love the idea right from the beginning. And I was daunted by the challenge of implementing it, because the logistics seemed very difficult to me. So I was lucky enough to, soon after that, spend some time working with Kelly O'Shea and talk to her about how she did standards based grading. And once I'd talked through some logistical possibilities with her, I was ready to jump in feet first. And the thing that's so wonderful about it in a modeling context is that what I've done is I've written down what it is that I want my students to understand and be able to show me by the time they complete the course. So the students have this very clear list of objectives about what I find is important in the course. And some of those things are those very straightforward kinds of, "I can use force diagrams and vector addition diagrams to represent and solve unbalanced and balanced force problems." They're concrete combinations of a skill and some content area. I also have a number of objectives that are related to lab skills and what I want students to get from labs and how I want them to be able to show me not just necessarily the specifics for a particular lab, but what is that lab skill that's connected through all of the labs that we do all throughout the year, their ability to collect data, to analyze and interpret data.

Mark Schober (14:13):

I also have some skills where I'm asking students to be able to combine ideas from multiple models. That's my synthesis objective. I want students to be able to combine ideas together to solve robust problems. Because sometimes, standards can be a little piecemeal. So that's a way of getting around that. And so this change to the way that I think about assessment has really changed a lot about how I do, modeling. Every assessment is an opportunity for students to show me what they know, and it's an opportunity for feedback and the students get to the point where they're like, "can we have another synthesis quiz? We want to show you that we can do this. And we want to be able to get credit for showing you that we did this." And it's that kind of a kind of excitement for assessment that I think is really remarkable. I no longer feel like I'm that teacher, that's the judge of good or bad, and then it's done and we're gonna leave that to some impartial grading program. That's going to average hundreds and hundreds of points together. When we grade point-wise like that, we have lots of biases built in that we really don't even recognize grading is a fundamentally subjective practice. And so when we do that, we need to be very deliberate about it. And so that's why I think the standards based grading has been really important for me. So I can really think for students to show me that they have an, A level

understanding, they need to be able to demonstrate a certain number of these synthesis proficiencies for students that are able to show me all of the fundamental level proficiencies, that's going to put them in a good place to earn a B in the course and students that are, that are struggling with some of those basic concepts of the course. Well, that's maybe going to be that C category. And it allows me to take a much bigger picture, look at how the students are doing, and it gives the kids this very, very specific feedback. If they've not done well on something they've got, this is the objective that they need to show me and they can say, "Mr. Schober, how do I get this idea down better so that I can show you I understand this?" And we sit and we work together until they're able to do it. And so, it really helps to improve that sense of collaboration between the teacher and the student. And that we're all on the same-- We all have the same goal. I want the students to learn the physics. That's, that's the goal. I'm not trying to make some set of hurdles that only certain people will pass. I'm not trying to separate people out on bell curves and things like that. That is not my job. My job is to help every student learn physics and be proud of the work they've put into physics and the things that they have learned in my class.

Mark Royce (17:28):

You know, I know that physics is your primary focus in teaching, but you've also taught other of the STEM disciplines like chemistry and engineering and astronomy. And you've had a pretty broad experience in there. What advice would you give to those who are not physics teachers, but they're employing modeling. Any specific advice for outside of the physics classroom?

Mark Schober (17:55):

When I started it, I thought I would just do it with my physics class and I gave my chemistry students their first quiz. And then I was looking at, why should I give this student an eight out of a 10 that doesn't tell the student what concept they understood and what concept they weren't getting. And so I then just jumped in right away and did it with chemistry as well. That is probably not the best way for most people to do this. On my website I wrote down, I tried to kind of break it down into a sequence on how you could kind of migrate yourself from a points based grading system to a standards based grading system. And the very first place to start is to really decide what it is that you want your students to come away with from your course. It's to write down those learning objectives. Those are so key because the learning objectives serve multiple purposes. They make the course content clear to the students. And in the case of modeling how the models build upon one another becomes very clear. By the time I get to unbalance forces, I only add one new learning objective because all of the other learning objectives about motion and balanced forces all apply in the unbalanced forces model. So that kind of transparency about what the course content and structure is, is really, really important, but it also focuses my assessments. So instead of these assessments with this terrible tension about being too long or too short or too many rinky dink questions, most of my assessments are a single multi-part robust question that the students can answer in a half a class period to three quarters of a class period. And it's a question that's mostly blank space, so that there's plenty of opportunity for the kids to demonstrate with multiple representations, which we always emphasize in modeling how they understand a particular idea and how they can communicate their understanding to me or to one another.

Mark Schober (20:18):

The learning objectives are useful in communicating the core content of my course to administrators and to parents. It's also useful in just making sure I'm keeping on track in my daily teaching. There are some things that as we are working through and building ideas in the course, those are the fundamental things that are going to feed into and be assessed in one of these learning objectives. But there's a lot of

things I do in my class that don't feed into those learning objectives. I also have un-assessable learning objectives. I have goals for my students that you can't measure, and you probably shouldn't measure. I want my students to go away excited about physics. And so there are fun bits of trivia and other things that we'll bring into the course that we'll do some demonstration or something that it doesn't necessarily need to be assessed, but it's something that builds excitement and enthusiasm in the class. And I think that those are as important as anything that we do, to build a learning community where kids feel comfortable and they feel valued. They feel that their voice is being heard. And I really think that this assessment system is a way that really helps to nurture that feeling in the classroom.

Mark Royce (21:44):

That's awesome. I also heard that you have played a significant role in developing materials for physics modeling in light and waves, and specifically, something called models of light, which I'm not familiar with, but many of our listeners may be, but some may not be as familiar with what that's all about. Can you speak to that and tell us a little bit about the work you've done in that area?

Mark Schober (22:12):

So, when I took the modeling workshops, the 1998 workshop was the mechanics modeling where I kind of learned the nuts and bolts of how modeling works. When I returned in 1999, we divided up into teams where the goal was to take what we'd learned about modeling and to apply it to other content areas in physics. So I was working on the content area that was built around light. So my team, we sat down and we worked on trying to flesh out what does light in the context of modeling look like? And the thing that's really quite striking, I think is it looks very different than most textbooks present things. If you look at the table of contents for light, they'll break things down into geometric optics, lenses and mirrors and reflection, and then they'll break things up into, other kinds of, of optical effects like diffraction and interference and polarization.

Mark Schober (23:19):

And if you look at these things, you're kind of thinking, this is just kind of one random topic after another, how does this build upon anything? So our idea was to restructure things, according to really how these conceptions of light developed. These things really started with this corpuscular... This little particle model of light, which is an idea that was favored by Newton. And we look and we say, Hey, what if we imagine light as a particle? What kinds of things can we explain with that? And so we can explain things like shadows and pinholes and things about reflection. And once we get to refraction, we get to a situation where it kind of works, but the model really gets stretched. And we really have to say, well, this can't be just some simple light particle. It's got to have some kind of structure that interacts with the structure of matter in order to bend, as light goes from one material to another.

Mark Schober (24:24):

And it's one of the wonderful points where we can actually ask students, be creative here, what must light he like so that it gives us this behavior. It's, it's such a very genuine scientific activity to think creatively, which is the way a lot of models are developed. As we do that and we come to this more complicated model of light, then we get to a point where we think, ah, maybe there's another way to look at this. Refraction can be explained by particles, but it's a little awkward. So we look for other options for a model. And so we start playing around with waves. Waves are something that also will reflect and will form shadows. And we start looking at two dimensional waves and we start saying, Hey,

waves can do everything particles can do, but now they very naturally do some things that were kind of hard to describe.

Mark Schober (25:26):

Two dimensional waves can be very easily shown in a ripple tank to demonstrate refraction. And we've got this much more elegant model. And now it's able to do really interesting things. We can explore things like two source interference. We can actually measure a wavelength of light, all of these kinds of robust ideas that come out of a wave understanding of light. But then, if we go and just look a little deeper, we can look to this thing called the photoelectric effect. And we get this wonderfully interesting phenomenon where if you take light and you shine it on a metal electrons will pop off. And when you go and you look at that really, really carefully and what the patterns are, it's bizarre because some of the patterns are really better described by particles and other patterns are very much better described by waves.

Mark Schober (26:25):

And this is of course, what Albert Einstein won his one and only Nobel prize for reaching into his imagination and to explain and develop a model for light. That's this wonderful combination of waves and particles. The term photon emerged well after his paper, but that becomes our third model of light. And it gets us into all of these lovely, robust applications. As we look at things like structure of atoms, spectroscopy, Doppler effect, all these kinds of wonderful things that we can understand in very interesting ways. So, I was lucky in 2000, I was invited to be part of the team to take other workshops sites' materials on light, and we edited and collated all those together into the set of materials that we're currently using for the models of light. And so it was wonderful there, I got to see all these different ways that people were thinking about things and how they were approaching models of light and got to think about how to combine those into a coherent storyline, really write out some pretty careful teacher notes because we recognize that not everybody would get the opportunity to take an additional modeling workshop.

Mark Schober (27:48):

that was specifically focused on models of light. And so we were really deliberate in making careful teacher notes and I think they hold together quite nicely. And they're just a really lovely example of that model-building process.

Mark Royce (28:06):

Is there a place where our listeners could find that you're -- are you published on this models of light stuff or is there a place where physics teachers could find this material to integrate into their classroom?

Mark Schober (28:19):

So it's all on the AMA website. So that's part of the member resources, and the models of light, and we've done, periodic updates and revisions to keep the files up to date and all of those resources are there,

Mark Royce (28:37):

Would you be able to send me a direct link that I could put on the website that people could go right there?

Mark Schober (28:42):

Yep. I think I can do that. Yep.

Mark Royce (28:43):

Okay. And it's accessible only by members if I'm remembering. Okay. Well, there you go. If you don't have a membership, there's a good reason to join up and help support the AMTA. You know, my wife was telling me that she was really impressed with some of the demo tools that you've developed for classroom use in the physics classroom. Can you tell me about how that came about and the kinds of things that you've been resourcing to other teachers?

Mark Schober (29:15):

So when I was teaching in St. Louis, I had some really spectacular community physics teachers that were part of the St Louis area physics teachers. So one of those is Rex Rice. Another one of those is Bill Brinkhorst and they were very much into make-and-take workshops. We would often come together, we'd build a piece of apparatus and then we would use it to data and do one of the labs that are integral in the development of the physics course. And I love to build things. And so I have been hooked on this idea of making equipment to support our teaching and especially trying to figure out ways to make it so that it's low cost and accessible to teachers so that we can send them, not only with a piece of equipment, but also an entire lab set of equipment, if at all possible.

Mark Schober (30:13):

And so over the years, we've done things like an LED photoelectric effect apparatus that was originally designed by an UMSL professor, and we've made many more of these so that they're available to teachers. I've made kits of materials for the workshops that I've done in light and electrostatics, so that each teacher has a bag of material they can take away that they can use in order to work with their students and not just be able to see the materials in the workshop, but to actually have those same materials when they go back to their classroom, greatly increases the chance that they'll actually do those activities with their students. Some of the more recent things I've done take advantage of the fact that my school has a laser cutter. And so it's allowed me to fabricate materials that we're then able to assemble together as a group.

Mark Schober (31:12):

So in teaching astronomy and understanding seasons, I like to take Globes and prep them so that, along several different latitude lines, there's a pin stuck in and you get 24 pins along a latitude line. And so every illuminated pin would correspond to an hour of sunlight. But then you need a different sort of mount than most globes have, because most globes have the little arm over the top that would cast shadows and get in the way. And so I was able to fabricate a really nice, simple laser cut base that could be used to hold these in place quite nicely. That has been a lot of fun. The ability to cut plexiglass with a laser cutter is really fantastic too. So we've been able to make picket fences of a variety of sorts, including circular picket fences for another Rex Rice design, a circular motion apparatus. And I like doing that and I like working with teachers in building materials.

Mark Royce (32:22):

So how do people get ahold of those things from you guys, either the plans and a lot of people won't have a CNC machine to take, you know, cut their own custom pieces.

Mark Schober (32:34):

Yeah. So, the other thing is, I've tried to publish, some amount of resources for how people could do this, on their own. So some of that's on my website, for example, table clamps. I love table clamps in my physics classroom, but to buy a table clamp is a about a hundred dollar investment. And I'd like, say, Oh, maybe 16 table clamps. Well, so if you compare the cost of 16 purchased table clamps to the cost of one, really good 3D printer, you can easily 3D print a whole bunch of clamps. And so I've published a bunch of the files and designs that I made for making 3D printed clamps to use in my classroom. And I've been working with them and using them, and they've been robust and they've held up quite nicely. And, you know, if, if one happens to get broken or something, you know, you've got an investment of about $2 of plastic in it. And then you can set up the 3D printer and let it print away. And eight hours later, you've got another current clamp printed.

Mark Royce (33:50):

That's awesome that you're sharing those files, the printer files, because a lot of schools now are getting those, you know, collaborative use among the school disciplines. I will make sure that the links that you send me will be on your interview page on our science modeling talks.com website. That will be wonderful to share those things with people. So is there anything that we haven't talked about that you would like to talk about? This is a chance for you to say something to people that are of your tribe.

Mark Schober (34:27):

The thing that was so important to me in my growth as a physics teacher was the St Louis area physics teachers, because in any one school, we don't have enough physics teachers to have a really diverse discussion about different approaches to teaching. And most physics teachers are the only physics teacher in their school. So we really need to form communities. And I gained so much from the community in St. Louis that I am forever indebted to them. When I moved from St. Louis to New York City, I was already eager to join whatever community group existed for supporting physics teachers and found that there wasn't any, and I had some fortunate connections through the school I was working with to a professor at Teacher's College, and we got a conversation going and very shortly after we started up Physics Teachers NYC, and we were able to run a modeling workshop soon after.

Mark Schober (35:34):

And we really quickly realized that that name would be too limiting because so many teachers don't just teach physics. They teach physics and other things, chemistry and math and everything. So, after a year we renamed the group STEMteachersNYC. So that group starting off from this little pod of people has now developed into a huge organization. We're running the lots of workshops so that we'll get together on weekends and in the summertime we'll get together for weeks at a time, if possible. This summer, of course, with the pandemic we're running all of our workshops virtually, but that community has been fantastic. And it's gone in ways that have been really wonderful because I have certain kinds of expertise that I can offer from my point of view, things about physics, things about making materials for teaching, things about grading.

Mark Schober (36:39):

But we've had teachers that have talked about how do we use what we know to better support elementary teachers in their development of science understanding in small children. We've have some really incredible people who have been doing work with culturally responsive teaching. We also have other people who have brought their expertise in how do you teach in a classroom that has a number of

English language learners in it? How do you do science in that environment? And so the kind of richness of learning from one another in a professional development community has been so rewarding and so wonderful. So as a result, some STEM teacher, XYZ organizations have popped up across the country,

Mark Royce (37:29):

Which is great, by the way. We need that local connect.

Mark Schober (37:33):

Absolutely. You need those people that you've seen in person you've met and you know where they're coming from, and you can say, Oh, so and so is in a similar situation to me. So when I have that particular question about some teaching practice or some school requirement, I can reach out to that person and ask them, how are you handling this? Or we can sit down and we can kind of puzzle through it together. Those kinds of local connections are really, really key. And again, they've been so important in my development. I'm so happy that I've been able to continue to learn through a group like that and continue to share some of what I've learned.

Mark Royce (38:15):

Yeah, that's awesome. Well, you know, one of the reasons we do this podcast is because we want to spread the word and get people connected and give them information from thought leaders and, and modelers like you. And it's been a real pleasure talking with you, Mark. And I know that what you've shared today is going to be very meaningful to those who are listening. And, I want to encourage everybody to go dig deeper on the website at sciencemodelingtalks.com go to Mark's interview page. His interview will be posted, and it'll take you to a page just for his interview, with the transcription of this interview and all the links that we've talked about and his website, for example. And so it's just been really good. And I want to thank you, Mark for taking the time to talk with us. It's been great.

Mark Schober (39:09):

It's been my pleasure. Thank you.