Science Modeling Talks

Episode 66 - "In learning, especially for physics, a key component is soak time"

Guest: Geoff Nunes

Mark Royce (01:11):

So, hi Geoff. How are you doing today?

Geoff Nunes (01:14):

I'm doing fine. Nice mellow Sunday.

Mark Royce (01:16):

Nice mellow Sunday. Yeah, me too. Out here on the West coast. So I'm excited to talk to you today 'cause there's a lot going on in your life, and I was really impressed when I started reading about your accomplishments and your contributions. So, I wanna start out though by asking you, how did you first learn about modeling instruction? What brought you into it?

Geoff Nunes (01:43):

So, I started my teaching career teaching at the university level. I was at Dartmouth College for almost eight years, and I was teaching a big lecture course on mechanics, about a hundred students. And the second time through I made this mistake, I went to the final exam and I took out some of my questions and I inserted this thing called the mechanics baseline test, which is very similar to the force concept inventory. It's got slightly more questions. And what I discovered was that all of these very bright students who were all getting, A's in my class, all flunked that part of the test. So I learned that although I thought I was teaching, I was using peer instruction methods 'cause I'd been to a little mini workshop hosted by Eric Mazur at Harvard. But my students weren't actually understanding the why of anything.

Geoff Nunes (02:51):

So I started to root around, look at people thinking about how to teach physics. And I ran across some papers from David Hestenes. And this was in the mid nineties, so it was a long time ago. And I began to think about how I could possibly do that at the university level 'cause it seemed very focused on high school. And then what happened instead was my wife got a once in a lifetime job offer in Philadelphia. So, I left Dartmouth and I went to work for DuPont in their central research and development lab for about 15 years. And then when I came back to teaching at the high school level, I knew what I wanted. And the summer after my first year of teaching, I took my first modeling workshop and it's been modeling ever since.

Mark Royce (03:50):

So your modeling experience was primarily in the high school setting?

Geoff Nunes (03:54):

100% in the high school setting. But I learned about it in the mid nineties. And I basically waited 15 years to actually

take a workshop and start to do modeling.

Mark Royce (04:07):

Okay. So you never used modeling instruction techniques in a university setting at all? Interesting. I'm always curious about the difference between teaching in a university with modeling and teaching in a high school with modeling. It seems like there might be some interesting differences there.

Geoff Nunes (04:26):

I think in the mid nineties there weren't even workshops yet, things were really just getting going.

Mark Royce (04:34):

Mm-hmm <affirmative>. Yeah. Now you have your PhD?

Geoff Nunes (04:40):

I do.

Mark Royce (04:40):

And you had achieved that before you started teaching in high school?

Geoff Nunes (04:46):

Oh, before I started teaching in college. But I went to grad school. I did a postdoc at IBM and then I started out as an assistant professor at Dartmouth.

Mark Royce (04:59):

It's fairly rare for high school students to have a teacher who's got their doctorate in physics or whatever their discipline.

Geoff Nunes (05:12):

Yeah. There's not much that's usual about my career in physics, so,

Mark Royce (05:17):

Ah, interesting. <laugh>,

Geoff Nunes (05:20):

You know, one of the things that's great for me as a high school teacher having a PhD is for me, all the stuff that I'm learning is about pedagogy. How do I teach better? I don't have to worry about do I understand the physics?

Mark Royce (05:39):

Hmm. Because you got that down nailed.

Geoff Nunes (05:42):

I should hope so.

Mark Royce (05:43):

Yeah. <laugh>,

Geoff Nunes (05:44):

I still make mistakes, right?

Mark Royce (05:46):

Sure. Yeah. That's awesome. I read, am I correct that you're in your ninth year at high school teaching? And you're in a private prep school?

Geoff Nunes (05:57):

I teach at St. Joseph's Preparatory School in Philadelphia. It's a Jesuit high school, all boys.

Mark Royce (06:05):

Ah, interesting. Cool. So, I know besides in the classroom, you are also involved, and you have work in developing new labs and, and helping refine and enhancing established labs. Talk to us a little bit about that and what that all means.

Geoff Nunes (06:29):

Well, I think that especially for modeling instructions, it's so important that the lab be accessible to the students and actually correctly show them the physics you're trying to teach them. So if they're doing a kinetic energy lab and the kinetic energy should depend on the velocity squared, they should get a really good v squared out of their data. It shouldn't be something that they have to look at-- used to have the expression "looking at your data with lover's eyes," they shouldn't have to do that. It should be obvious what the result is. And I've also spent a lot of time on mini labs, so things that can introduce students to a new concept. So, right now I'm just finishing up the circular motion unit in my mechanics class. And so I introduced that, first I introduce it with, this Pepsi ad where this, par-cour guy runs a vertical loop.

Mark Royce (07:41):

Wow.

Geoff Nunes (07:42):

And so I start with a picture of a rollercoaster, just a still photo when the train is at the top of the loop. And I ask them all why it doesn't fall off. And they all say, well, because it's attached. And then I show them this Pepsi ad and he's not attached. He's just running around the loop. And so that gets them thinking, and opens up the idea that something else that they did not expect is going on. And then I just have them run a marble around the outside of a paper plate and have a discussion about whether or not the velocity's constant. And most of my students say the velocity is constant. And then I have to remind them that velocity has a direction and like, oh yes. Okay. And then the exercise ends where I give them a paper plate with a cutout. So if they run the marble around and it gets to the cutout, it runs across the table in a straight line and they have to draw a prediction of the path before, and you get all kinds of, it's gonna curve this way, it's gonna curve that way. You get all kinds of predictions. And then when they, actually do it and they see the marble goes dead straight, there's another aha moment for them. I'm trying to build as many aha moments into the class as I can.

Mark Royce (09:07):

Yeah. Very cool. So your work with developing these labs, you've learned a lot. How do you share that information with other teachers?

Geoff Nunes (09:18):

Mostly, I just talk to my colleagues. There are three of us who teach physics at the school. Um, I have not done a lot

of public stuff with presentations at conferences or things like that.

Mark Royce (09:33):

No website, where you share this kind of information that you've learned.

Geoff Nunes (09:38):

Well, I have a website, but it's not like that. I basically put software tools on my website. That are helpful. They were helpful to me in teaching and so I share them.

Mark Royce (09:51):

Yeah. Well that's cool. And that website is the... I'm looking here at my notes. noragulfa.com

Geoff Nunes (10:00):

noragulfa.com Yes.

Mark Royce (10:03):

Interesting. I looked at that website and it was really intriguing me not being a physics person or a science teacher at all. I thought it was a fascinating site. And the resources you had on there looked awesome. And, uh, so if our listeners are interested, Nora Gulfa is spelled N-O-R-A-G-U-L-F-A-N-O-R-A-G-U-L-F-A.com. And, you should check it out if you're a physics teacher or just interested in, in seeing the tools that Geoff has posted there, I think it's worth a trip to go check it out. I would encourage you to also include some written data or written information about what you've learned in those, kind of like the story you just told us was really cool about how you're working with the kids and that kind of thing. So just a little encouragement from me to you. 'cause you have a wealth of knowledge there that I think is worth sharing. Anyway. Any more about the developing of new labs and refining?

Geoff Nunes (11:13):

In the modeling curriculum, there is-- the introduction to energy involves seven or eight energy stations that the students go around really quickly and they make a baking soda and vinegar bomb. They turn a crank on a generator to make a light glow. They do all these energy things. And I thought to myself, well, that's really great. And the students have a really great time, and it sort of gets them thinking, can I do that for other things? So I came up with the first unit where we start thinking about forces. My first lesson is, I call it speed dating with forces. And I just have a bunch of stations around the room. They have to pick up a barbell, they have to stretch a spring. There's a little pump up toy that launches a car with air pressure across the table. Just all kinds of different forces. They have to drag a box full of rocks with a rope just to introduce them to all of these different kinds of forces. And then we have a discussion afterwards to point out that every single time they experience one of these forces, there were always two things. It's not just one thing, like when they pick up the barbell, there's the barbell and there's the earth. Just to sort of start to build up the idea of what is a force and what is its relationship to an interaction.

Mark Royce (12:50):

Huh. Awesome. Speed. Dating with

Geoff Nunes (12:54):

Speed dating with forces.

Mark Royce (12:55):

Speed dating with forces. That's clever. I like that idea a lot. So, talk to me a little bit about how modeling has influenced your classroom approach in your teaching.

Geoff Nunes (13:11):

Well, going back to that story about teaching at the university level and putting this mechanics baseline in the final exam-- I grew up in the tradition of the lecture demonstration and when I was a graduate student, there was a really excellent professor for whom I was a teaching assistant. And I would sit in the back of a lecture hall and he was standing in front of like 450, mostly pre-engineering, students. And he did all of these fantastic demonstrations and I learned a lot. I thought that was great. And so when I started out, that's where I was. I wanted to do demonstrations and tie them into my lecture because I thought that's how you would communicate. And that's what I was doing at Dartmouth, which had tremendous resources for that. They had a big workshop for lecture demonstrations and a really good guy who ran it. And he could give you a demo for anything you wanted in 10 minutes. I'd go in, I'd say, Ralph, I need to do this. He'd say, oh, I've got one of those. And so it was really kind of shocking to me to discover that it was ineffective.

Mark Royce (14:32):

Interesting.

Geoff Nunes (14:33):

Because it turns out that, and this is what I tell my students and they don't believe me. I say, I can't teach you anything. Right. And that's not about you. It's that nobody can teach anybody anything. People have to teach themselves. And so what you as a teacher have to do is provide the environment in which the students can teach themselves. And that's what modeling does. They're doing all of it. You are really just providing the framework. Here's the lab, what did we learn from the lab? You know, I can ask them, put this on your whiteboard, put that on your whiteboard. But they have to look at the whiteboard and see what it is that the experiment is telling them.

Mark Royce (15:20):

Wow. Very interesting. What have you discovered as a secret that you wish you had known before you started modeling?

Geoff Nunes (15:34):

It took me a long time to realize that you have to do what works for you. You know, I teach at a school that has the schedule that it has. Classes are short. I don't have block scheduling or anything like that. Also private schools generally just don't have as many school days as public schools do. You can't really do the full thing the way you learn in the workshop. And so you have to figure out what's the stuff that I really have to keep in order for the students to be learning? And what is the stuff that I can sort of slice out and not cripple the effect? So I have to make it good enough. I can't let the perfect, the good be the enemy of the perfect or no, the perfect be the enemy of the good. That's how it goes. I can't let the perfect be the enemy of the good.

Mark Royce (16:39):

Right.

Geoff Nunes (16:40):

And, you know, it took me, I think, three or four years of doing the modeling before I really found my groove where I could be effective and do the really important parts of the modeling and not worry about so much about the stuff I had to leave out.

Mark Royce (17:00):

That's an interesting insight that I think is pretty cool for you to share with like, new modelers, people who are just starting out.

Geoff Nunes (17:10):

Everybody's school is gonna be different. Everybody's students are gonna be different. And there is sort of the er model that is the perfect modeler in front of the perfect classroom. And you're never gonna have that. So you have to figure out what works for you, your personality. The class of students. Every year, the students are a little bit different. You always have to be making adjustments, but you always have to say, okay, I've got this, this is good. It may not be perfect, but this is good.

Mark Royce (17:42):

Yeah. So, it's not just following a set of really rigid rules in the classroom around modeling. Would you agree?

Geoff Nunes (17:53):

I would agree with that, yes.

Mark Royce (17:55):

Yeah.

Geoff Nunes (17:56):

It's not that...yeah, the workshops, they present an ideal, the thing, a thing you should aim for. And you just have to not beat yourself up when it turns out that perfection is unattainable.

Mark Royce (18:13):

Yeah. That's good. That's really good. So tell us about your best teaching or modeling tip. Like, what's the thing that you would share with others that you think is one of the strongest things that you could share with other teachers?

Geoff Nunes (18:34):

Oh, that's a tough one.

Mark Royce (18:36):

<laugh>. Yeah.

Geoff Nunes (18:39):

Yeah. Sort of, the fundamental thing that happens in my classroom is I don't answer student questions. So, the students will be working at their whiteboards and some of 'em, one of 'em will come to me with a question and his group mates will say, no, he's not gonna answer that. Or my standard response is, that's a really good question. What do you think? Because I want them to do the thinking. Right. That's the thing that has to happen. And, at the beginning of the year, they're very frustrated by it. And by the end of the year, it's sort of the classroom joke that, of course, I'm not gonna answer the questions. They have to talk in their group, talk to their classmates, and figure it out. Of course, when they get really stuck, you have to help them over the hills.

Geoff Nunes (19:36):

But when the students get stuck on a problem, usually my first question to them is, where is your system schema? You know, this is something I've actually discovered relatively late in my teaching career. I took, an introduction to modeling workshop even though I'd had a couple of workshops with Jess Dykes, who teaches at a nearby high school and has led a lot of modeling workshops. And it was a little short two day, introduction to energy for a physics first course. 'cause I was interested in whether or not we could do physics first at my school. And I just realized the power of the system schema as Jess presented it. And so I've started demanding that of my students, that when they start a problem, they draw a system schema first, and then if it's that kind of problem, then a force

diagram. And students never wanna start there. They wanna start slapping equations on the board and manipulating them and get the numbers in there as quickly as they can, get rid of the symbols, and they get stuck. And the first thing I'll say is, oh, where's your system schema? Where's that force diagram?

Mark Royce (20:56):

My listeners, our listeners may know what you're talking about when you talk about system schema, but I don't. So help me understand system s schemas.

Geoff Nunes (21:07):

Oh, okay. So, let's suppose that, the problem they're solving involves, I don't know, the acceleration of a toy wagon and, Timmy's pulling one way and Tommy's pulling the other way. And the problem is to find the acceleration of the wagon. So, they start by, writing wagon on the board and putting an oval around it. Okay. That's the wagon. Who is interacting with the wagon? Well, there's Timmy, so Timmy's in an oval, and then a line connects Timmy to the wagon. 'Cause Timmy's interacting with the wagon. Same for Tommy. And then what else is the wagon interacting with? Well, there's gravity, so it must be interacting with the Earth and it's sitting on the sidewalk, so it must be interacting with the ground. So there are all these interaction lines, and then they're focused on the wagon.

Geoff Nunes (22:03):

So you have them put a dotted line around the wagon, that's your system boundary. And every single line that crosses that system boundary has to be represented as a force on their force diagram. So if four lines cross the system boundary, there should be four forces on their force diagram. It's very good. And you know, the power of it goes way beyond that. So when you start talking about Newton's third law, you have the idea that between, let's say Timmy and the wagon, there's one interaction, which is why the force that Timmy exerts on the wagon and the force that the wagon exerts on Timmy have to be exactly the same except for the direction. Because really there aren't two forces there. There's one interaction, and that single line that connects Timmy and the wagon really helps, I find, in teaching about Newton's third law.

Mark Royce (23:10):

Wow. Okay.

Geoff Nunes (23:10):

Which I never call Newton's third law. That's another discovery that I made.

Mark Royce (23:16):

Why not?

Geoff Nunes (23:17):

Because my students come with their head full of things that teachers said to them in middle school, and usually, they were presented in an unhelpful way. And if you use the same language, the knowledge that's already there blocks the new knowledge.

Mark Royce (23:39):

Interesting.

Geoff Nunes (23:39):

So, over the years I've used a force concept inventory as a pre-test and post-test every year for my students. And, every year when I looked at the questions on the force concept inventory that addressed the third law improve-

ment was slight. And then one year I started calling it the law of interactions instead of the third law. So that I never accessed these things like for every action there's an equal and opposite reaction that they have in their head that are unhelpful in understanding. And I saw a big improvement in the post-test on those questions in the force concept inventory.

Mark Royce (24:27):

You are obviously very passionate about teaching physics. How did that evolve in your heart?

Geoff Nunes (24:36):

To be honest, what motivated me to become a physics teacher was a lot of bad physics teaching that I was subjected to. You know, you sit there in a college class and you're like, this is beautiful. Why is this course so awful?

Mark Royce (24:53):

Oh my.

Geoff Nunes (24:55):

And so, as it turns out, I also happened to come, from a family of teachers. My mother was a teacher. My brother and sister are both teachers. I have an aunt and an uncle who are teachers. I have cousins who are teachers. It just seems to be the family business. My father was not a teacher, and he was always mystified as to how he wound up in this situation.

Mark Royce (25:22):

Yeah. Just a weird side note: I grew up with parents that were both teachers also, and I swore that I would never marry a woman who was a teacher. I didn't want to live with that again. And I married a chemist. And then after a few years of marriage, she decided to become a teacher. So that's been her-actually beautiful- career and calling. That reminds me, you mentioned physics first, the curriculum approach that puts physics in the order of the disciplines, you know, in the freshman year, if it's a four year school. Are you, is your school adopted? Has it adopted that?

Geoff Nunes (26:11):

No, no. I'm the only modeler at my school. So my teaching has mostly been juniors and seniors. We recently upgraded and split our junior senior course into a regular physics course and AP physics one. So the last couple of years I've been mostly teaching AP Physics one, which is quite a challenge because there's quite a bit more material, especially this year in that curriculum than is in the standard modeling curriculum. So again, it's this, how do you keep true to the modeling approach and go faster? Because generally in learning, especially for physics, a key component is soak time. The students need time with the concepts. And as the curriculum gets more and more packed, that's a challenge because the AP One curriculum has solid body rotation in it. And, as of this year, it has fluids in it, but I don't get extra days for that. So you just have to decide what to cut and what to keep so you can make it modeling and still cover all of the material for the AP exam.

Mark Royce (27:38):

So are you only teaching AP physics or are you teaching intro? You know, the basic?

Geoff Nunes (27:43):

This year, I have two sections of AP physics, and I have two sections of a freshman physics course that is not a modeling course. I have two co-teachers. There are three of us teaching eight sections of this course. But, as I said, I'm the only modeler and the school's not really ready for modeling on that course.

Mark Royce (28:08):

I understand. So I wanna revisit a little bit the website, Noragulfa.

Geoff Nunes (28:16):

Okay.

Mark Royce (28:18):

When I looked at it, it has some really cool tools, several tools that seem to me would be really helpful to physics teachers. Is it fairly widely used, your website, or do people need to know more about it? Are there listeners who may not be aware of it?

Geoff Nunes (28:35):

So, the most widely used part of the website is the plotting program. And if I look at my Amazon Web statistics, there are thousands and thousands of users of that in the United States, and then a smattering all across the globe. There are people logging in from the Czech Republic who use it from Russia who use it. But, you know, just onesies and twosies but, there are thousands of users in the United States. So that's really, you know, a tool, rather than something really aimed at teaching. A couple of years ago I added a video analyzer. So students could put in a video from their phone and they can track a trajectory like Logger Pro allows them to do. And I did that when Vernier announced that they were no longer gonna support Logger Pro and Graphical Analysis didn't include videos, and that was something you'd have to pay for. And I said to myself, well, I bet I can make something that works for free.

Mark Royce (29:56):

Okay, <laugh>, that's cool. That's really cool.

Geoff Nunes (29:59):

Sorry, Vernier, you make great stuff. And then there are other things like, I have a Newton's Cannon program on there. I built that because I had a lot of students who had trouble understanding that there's still gravity on the Space station. All the media, when there's a special and there's pictures of people in space floating, it's always talked about as being zero gravity. And of course, that's completely unhelpful when you're trying to teach them about orbits and circular motion, where gravity is making things go round. So I made a Newton's Cannon simulation. I like the historical connection to Isaac Newton, of course. But, the thing that really made it start to work for the students is when you load up, there's what I call the flat Earth option.

Geoff Nunes (30:58):

So what is Newton's cannon? It's a picture of a planet with a giant mountain and a cannon at the top of the mountain that fires cannon balls horizontally. And so I just put a horizontal line across the base of the mountain, extending out into space on either side of the planet. And when they fire, when the cannonball gets to this flat line, you know, it hits the ground. And so I tie back to the projectile motion unit, which we've just done. So they understand what's going on in projectile motion. They know that it's gravity that's making the thing arc down and hit that line. And so there are questions that go with that, that reinforc the thinking about it's gravity that's making the ball follow this curve trajectory. And then they unclick the flat Earth checkbox. The flat Earth goes away, they launch exactly the same, and now the cannonball orbits the earth.

Mark Royce (31:57):

Yeah. Wow.

Geoff Nunes (31:57):

So, it really helps them understand that gravity is the key thing here.

Mark Royce (32:04):

Yeah, that's great. Visuals. Very cool. Other tools on the site?

Geoff Nunes (32:09):

So when I teach harmonic oscillators, there's a couple of labs that they do. They look at period as a function of mass on a single spring, and they look at period as a function of spring constant across a range of springs. And in both cases, they get a constant, about 6.2 in front of the formula that they get out of the fit. It's like, what is 6.2? And eventually they figure out that they're looking at two pi, and then their next question is, well, why two pi? And so, you know, I could just send them to the website where there's a little simulation of something going in a circle, and there's two oscillators going back and forth in sync with the circle, drawing a sin and a cosign on the screen so they can see, you know, you'd like to think that they made that connection in math class when they learned some trigonometry.

Geoff Nunes (33:08):

But, I think that physics makes it much more direct. I have an electric field simulation program. I've first started using the PhET program from University of Colorado called Charges and Fields. And I was always frustrated that it didn't draw field lines. I was like, this is a computer, it should draw field lines. And I was always frustrated that it didn't have a capacitor in it because I really wanted students to be able to see what the field looks like in a capacitor. 'Cause a capacitor is really good for talking about potential energy, and the energy being stored in the electric field. So I, this was during the pandemic lockdown when all of a sudden I couldn't go anywhere and I had some time on my hands. So I made a program that draws field lines and has a capacitor in it.

Mark Royce (34:06):

<laugh>. That's awesome. Wow. Geoff, it's been awesome talking with you. And you obviously have a lot of great stuff to share, and I think your students are fortunate to be learning under your tutelage. I think it's a very, very cool thing. And I want to thank you for being a guest on our podcast. I I think our listeners are gonna enjoy listening to this episode.

Geoff Nunes (34:32):

This has been fun. I've enjoyed it.

Mark Royce (34:34):

Good. Thank you. I'm glad. And so, uh, oh, my wife Brenda says to tell you, hello.

Geoff Nunes (34:41):

I saw Brenda yesterday at ConnectED. Oh, cool.

Mark Royce (34:44):

Yeah, that's right. She was helping with that one. Awesome. Well, sir, Dr. Nunes, thank you very much again for being our guest here.

Geoff Nunes (34:56):

You're welcome. And, as I like to say, model on.

Mark Royce (35:02):

Nice. I may use that <laugh>. Thanks, Geoff. I'll see you next time.

Geoff Nunes (35:07):

All righty. Bye-bye.