Mark Royce (01:24):

So Larry, tell us about the importance of modeling in your life.

Larry Dukerich (01:30):

Well, modeling changed the trajectory of my teaching career. I had been teaching 17 years and I realized that I was as good as I was going to get and I wasn't happy with the job I was doing as a teacher. My students still had the same problems year after year. I gave these crystal clear lectures, I worked problems out very carefully and the students ran into the same difficulties. And so I realized there was something that I needed to change. And that's when I encountered the modeling instruction invitation.

Mark Royce (02:11):

So in the early days, as you began to discover these methodologies and you got kind of turned on to the idea of a different approach to your teaching style, what was it that first hit you and kind of made you step back and say, wow,

Larry Dukerich (02:28):

well, the first thing was that the emphasis was switched from giving clear transmissionist style approach to teaching to one in which I, as the teacher elicited the student's views. And so I listened more and worked hard to draw out their thinking. So then I could know where to strategically intervene. If you're just talking at the kids, then you're making the presumption that what you say makes sense to them and will clear up any difficulties they have, but it isn't until you let the students do the talking that you find out what they know and don't know.

Mark Royce (03:14):

You know, Larry, you've been involved since the very first workshops. You got to meet the men who were the founders of these ideas. It's coming up on 30 years now that they've been sharing this approach with others. Can you tell me a little bit about what it was like at the beginning when, when you met Malcolm Wells and Dr. Hestenes?

Larry Dukerich (03:38):

Well, it was really interesting, the dynamic between David and Malcolm. David was a theoretician who had been working on models and modeling since the seventies having published articles in the American Journal of Physics. And he worked with Malcolm Wells who was a high school physics teacher in the Phoenix metropolitan area who was unhappy about his own instruction and thought he would try to see what this modeling was all about if it would make any difference. And so part of what happened was there was this test developed by Hestenes, Ibrahim Halloun and Greg Swackhammer called the force concept inventory. It has 30 questions, basic fundamental concepts involving kinematics and dynamics, how things move and why they move. And he, Malcolm Wells gave it to his students and was dismayed at how poorly they did. And so that indicated to him that he needed to find something different to do. And that's when he worked on his doctoral work with Hestenes. Uh, I probably ought to say that, um, Malcolm Wells, once he started implementing aspects of modeling instruction in his own classroom, had students show significant gains on the force concept inventory, the FCI. And so this was something that was very exciting to Hestenes and Halloun and Malcolm Wells and they put in for a grant proposal to see if they could replicate this. They wanted to see was this idiosyncratic or could they get other physics teachers to show the same gains. And I was lucky enough to get in on the ground floor back in, uh, 1990.

Mark Royce (05:28):

Through the years you have been, after that start and introduction with Hestenes and Wells and all those guys back in the early days, you've kind of carried the torch forward as you've been leading workshops, also. I'm curious about what you've observed in the development of modeling over the years

Larry Dukerich (05:49):

after the pilot workshop, 1990 to '92 Hestenes and Halloun got an NSF grant to extend this to teachers around the country. There were three phases of workshops, beginning in 1995. I led the one at Arizona State University and Greg Swackhammer led the one at the University of Illinois in Chicago. These are with experienced physics teachers that we recruited for around the country that we hoped would become workshop leaders in their own right. And many of those people did. Phase two and phase three involved the people who were in our workshops who were selected to become workshop leaders. And then they, in turn, we had three workshops in 1997 and '98 and another three in '98 and '99 at various sites around the country.

Mark Royce (06:45):

This was a very exciting time of development and I'm kind of curious, is in those early years, did you guys run into any difficulties or what you would have seen as roadblocks or concerns about the development of these workshops and, and the propagating of more and more teachers becoming the influenced by modeling instruction?

Larry Dukerich (07:07):

I am not sure I can say there were roadblocks. I mean, there were, um, there's always difficulties when you're trying to implement a reformed approach to teaching there are skeptics who will say, well, this isn't the way we learned teaching physics. What's wrong with the way that we learned physics? I mean I was at a, uh, American physical society meeting back in 2000 where there were teachers who would say, what's wrong with the way we're currently teaching physics? And the guy in the workshop said, well, what fraction of humanity do you as a Ph.D. Physicist represent? You know, maybe a hundredth of 1%. What we have to do is find a way that makes physics, uh, approachable to a larger audience of people. And it frankly, it the way it is taught traditionally, it's barely comprehensible to students in high school and college. So as far as implements go or impediments or whatever roadblocks as you were starting to say, there are teachers who were in schools where they had a fair degree of autonomy and they were able to implement the approach. And then there were teachers who, um, had to either teach along a certain line or they couldn't diverge too much from the way things were currently done in their school district. And so they had difficulties fully implementing modeling. Then again there, on the other hand, there were teachers who got it. I mean they understood what modeling involved and were able to implement it reasonably well. And then there were teachers that we had sort of just a an incomplete understanding and made it more difficult for them.

Mark Royce (08:54):

There's always the beauty or the excitement of the breakthrough and the things that really help move a movement, if you will, like this forward. Can you speak to us what some of those moments were for you?

Larry Dukerich (09:08):

Well, what the neatest part of conducting a workshop is watching the teachers start to realize that what they're experiencing is a novel way to run their classrooms. In the three or four week workshops that we conducted back then, the initial reaction was skepticism, disbelief, uh, uncertainty, and then it became, they started realizing, oh, this is different, this actually has possibilities. And then they started getting really excited about it as they started to realize how much clearer their students' understanding could be if they employed modeling in their classroom. The problem that we all rookie modelers have is managing classroom discourse in a way where you get the students to do as much of the talking and thinking as possible. Without giving answers away, at the same time without getting them too frustrated. Remember, students have played the learning game for a long time by the time they get to high school and they know that what they're supposed to do is listen intently and respond to the questions that are being asked and regurgitate the knowledge that they think they understand. And when you sit there and ask them to, um, well, how do you think about this? Or what can we do about this or what's wrong with this particular view of matter? That's really different from the way they've been learning. And some of the students really push back on that. This isn't the way you're supposed to go. You're not answering my questions. You know, why aren't you giving me an answer? Why are you answering a question with another question? So it gets , it can get frustrating for, uh, students and uh, it takes teachers, um, several years of working through this before they develop a facility to guide the discussion in a meaningful way.

Mark Royce (11:17):

So that speaks to the importance of the individual teachers who employ this methodology, learning over time to become masters at it.

Larry Dukerich (11:31):

Yeah. It's not something that you just sort of pull off the shelf, open up to page 27, and then run the lesson. I mean it requires practice and that's one of the things that we did in the earlier workshops, which lasted a little longer to give the teachers an opportunity to play the role of students and teachers and guiding mock classroom lessons.

Mark Royce (11:51):

So I read a statistic recently that said there's over 12,000 people who have been through the workshops since 1990. 12,000 teachers. Does that seem accurate to you?

Larry Dukerich (12:03):

I think that's a reasonable estimate. I mean there are more in physics than there are in chemistry and more in chemistry than in biology, but the numbers are increasing steadily.

Mark Royce (12:13):

So what would you say to somebody who has not been to a workshop? If you go to a workshop, you'll magically be a better teacher.

Larry Dukerich (12:23):

If you go to a workshop, you're going to be exposed to a reform pedagogy, which is going to require you to change the way you manage your classroom. If you are looking for a way to improve your instruction, then this is going to be something for you. If you're completely happy with what you're doing, then you wouldn't be going to a workshop anyway.

Mark Royce (12:47):

Okay, so now to those who have been through workshops or have been doing it for a little while, what would your encouragement to those instructors be?

Larry Dukerich (12:57):

I think it's important to recognize that you're part of a larger community. There are people who are experts around who are willing to mentor other teachers. We have listserves which have large numbers of people like the chemistry listserv has. I think it's over 2000 people subscribing to it who pose questions and get help from other modelers on issues that can come up. So you have to reach out and recognize that there are other people there to help you. You have to recognize that this is not something that you can just flick a switch and become a modeling instructor overnight. Just like anything, it takes time. Hestenes this has cited the work of psychologist Andrews Erickson on a number of occasion where he talks about the development of expertise and he says that in a lot of fields i takes up to 10,000 hours of deliberative practice in order to become an expert. Well, that translates to about six years of classroom teaching and I'm going to tell you that it took me several years working through this before I started feeling reasonably comfortable at doing it in my own classrooms.

Mark Royce (14:12):

So David Hestenes is -- I've heard somebody, I can't remember who -- referred to him as the father of modeling instruction. I really am looking forward to doing an interview with him at some point in the near future. But you were close with him. You worked closely with him. What would you say he would want to articulate to young, like first workshop teachers?

Larry Dukerich (14:39):

I th ink he'd want to say, don't give up, keep after it and make sure you understand the crucial elements of implementing modeling instruction. And to do that you have to rely on your workshop experience.

Mark Royce (14:55):

How accessible are the resources and how accessible is the information or even the ability to speak with somebody like you or Dr. Hestenes or at least grab ahold of materials beyond the workshop for someone new at this?

Larry Dukerich (15:10):

Well, one of the things that several modelers became very concerned about was the fact that many National Science Foundation projects come into bloom, flourish for a bit, and then fade into the dust as the funding for the project goes away. And we wanted to make sure that modeling, um, didn't suffer that same fate. So a group of modelers in 2007 established the American Modeling Teachers Association. This organization is one of modelers by modelers for modelers. It's grassroots. It has a very minimalist infrastructure, not like the National Science Teachers Association, for example. But what it does is it provides resources for teachers. It's a place where teachers can go and learn about the various workshops that are made available around the country each year. I mean there's somewhere between 50 to 70 workshops each summer nationwide for teachers. And that's where they find out about it. It's the repository for a set of curricular materials that are continually being updated. There is a member forum where teachers can pose and get questions answered in physics, chemistry, biology, physical science, earth science, et Cetera. And there's also a number of listservs to which teachers can subscribe. Most teachers lurk on these listservs, but you find out some interesting things from time to time and

people will pose questions and other people will provide answers. So when you see this, you realize you're not alone. It's not one of those one-and-done kind of professional development experiences that most people have. You go to it, you learn something about it and it goes away.

Mark Royce (17:10):

You mentioned that the member website has a repository of curriculum support and I know that you've been involved with developing curriculum specifically around the chemistry courses. Talk to me a little bit about the philosophy behind developing curriculum and support for modelers and what you're envisioning as as this moves forward.

Larry Dukerich (17:33):

Well, when you go to a workshop, teachers play the role of student as they run through the experiments, collecting data, analyzing it, having to interpret it, and explain what's going on. And same thing with worksheets, tests and quizzes, that sort of thing. And they get the feeling for how modeling instruction differs from their traditional classroom practice. When you go to teach the approach in your own class, it's easy to say, oh, um, gosh, what was that all about? How did they run that lesson? What was going on there? It's not easy to remember the details. So one of the things that we do for the teachers in the curriculum repository is provide a robust set of teacher notes that guides the teachers on how to conduct the pre-lab discussion and then how to perform the experiment and what kind of data to expect and how to guide the students in the post-lab discussion. So those serve as reminders to teachers. Oh yeah. Uh, 'cause you're going to be doing this months after you went through the workshop. It's a great way of refreshing your own memory as to what's going on. So that's an invaluable resource for teachers.

Mark Royce (18:57):

Awesome. So what keeps you going? You've been doing this awhile.

Larry Dukerich (19:04):

Um, I miss the classroom. I retired 10 years ago, but one of the things that makes me feel good is working with classroom teachers and seeing them eager and enthusiastic about changing their classroom practice so that they make science instruction more enjoyable for their students. One of the things that happens to me frequently is that people will say, um, so what do you do? And I'd say, well, I teach, oh, what do you teach? Chemistry. And then the typical answer is, Oh, and then my response is, you should have had me for an instructor. And I'm not trying to brag, but I'm just saying that the students enjoyed being in my class. I mean, I had students who would look at their attendance and I'd say to them, Hey, you, you missed every period except my period yesterday. Well, I wasn't feeling very well, but I knew that I couldn't miss your class. Or yours is the only class that I feel like is worth attending. There were a lot of, uh, students who, especially the students who are not the A students, the ones who always are successful and play the game. But the students, they would tell me, you're the first teacher who is interested in how I thought. You asked me what I thought and how I thought about things and you wanted to know what was going on. And that's what's exciting to me. That was always what was exciting to me is the seeing how, um, kids thought and how their thinking changed as they came to, uh, a better understanding of what was going on. Well, the same thing happens with my working with teachers when I see them get excited about how they can make the material easier for students to understand and make their students more successful. Then I'm feeling like I'm reaching students through these teachers.

Mark Royce (21:03):

Well, so modeling instruction isn't just a series of behaviors that the teacher performs in the classroom. Obviously you engage your students in a way that causes them to really appreciate it. So what would you say to these young modelers on how to do what you just talked about? Students didn't want to miss your class. Students said you're the one teacher that kept me there. What would you say to a young modeler on just how they handle their classroom and what were the things that made your classroom that successful in that, uh, intriguing to your students that they could employ?

Larry Dukerich (21:39):

Well, I would say to them to the reflect on their, their workshop experiences. Most teachers have found that, and I'll give you an example of my own case. I had just taken algebra-based physics course in the summer before I went to my first workshop in an effort to, um, refresh my memory because remember I had been a chemistry teacher for 17 years. I hadn't done physics in a long time. So I said, well, I'll take this Algebra based physics class at Arizona State and I will, uh, beef up my background. You know I did quite fine in the class but it wasn't until I went to the modeling instruction workshop that I really understood the content at a much deeper level than I than I did before. Before I would basically do all the problems at the back of the chapter and then hope and pray that items on the task were like the questions on the chapter and if I got a novel situation I was stuck because I didn't really know how to think deeply about what was going on. But in the modeling workshop you learned how to analyze the situation and realize that your understanding of what was going on was centered around a model rather than a problem and its solution. Well I just tell the teachers, think about the kinds of experiences you had in your workshop and try to replicate that in your own classroom practice. Try to get your students to get excited about why you're doing something. Hestenes used to talk about the fact that for most physics students, the course is just one damn thing after another. And what we want students to realize is that there is a reason you're doing the stuff in chapter two. It answers questions that were sort of left hanging at the end of chapter one and so on.

Mark Royce (23:32):

Now you bring up a point that I've heard modelers talk about that there is kind of an order to building a foundation and how models interact with each other. Can you talk a little bit about that? For the uninitiated?

Larry Dukerich (23:47):

Well, it's important to set the stage for why you're starting to study some new phenomenon. You don't sit there and say, well, I'll give you an example that's early on in chapter one in the chemistry curriculum, we examine mass as a property of substances that talks about how much stuff is there and volume as to how much space it occupies. But we sit there and ask the students, um, is there a connection between how much space it takes up and how much stuff is present? Well, they say, yeah, I think there probably is. Well we say, well let's test that out. And then we measure mass and volume and we plot the graph and we find out that the slope of the graph is the density of the object. We don't say today we're going to do the density lab and we're going to plot mass versus volume and, and this is what you're going to get. Students, um, aren't told what to expect before they do it. That spoils the fun of the discovery when it comes to moving from unit five into unit six. For example, we might say at the outset of unit six, well we talked about, we know that atoms combine in certain ratios, but we haven't really talked very much about what holds them together. Well, what does hold them together? We realize that electrical phenomena are involved in some way 'cause we used an electrical current to take water

apart, for example, into hydrogen and oxygen. Let's examine electrical properties of matter. So then they go and do that and then they develop a model of the atom that was different than the model of the atom they had them that they had before. But the important part, and we stress this a lot, you need to give students some reason for why they're doing the next unit. It has to satisfy some question that was left only partially answered in the previous unit.

Mark Royce (25:47):

That's great. You know, Larry, you've been a real influencer in this area for teachers and you've impacted a lot of teachers' thinking, we haven't really talked about all your accolades, which are many, but you've written papers you've published in national level journals. You've been involved I believe with getting the conceptual tests developed for high school chemistry on a large scale.

Larry Dukerich (26:15):

Well, yes. Um,

Mark Royce (26:19):

Tell me a little bit about what that that is.

Larry Dukerich (26:22):

So um Doug Mulford, who was at Pepperdine at the time, I believe, developed a thing called the chemical concept inventory and it was for college students and we talked to him and said, we think we can adapt this and expand upon it and use it for high school students. He said, go ahead. I'd like to see what you do. So we came up with what we call the assessment of basic chemistry concepts or ABCC that's been in development since 2005 and it turns out that Brenda Royce worked on this in terms of, uh, collecting data and analyzing student responses to look for the, um, reliability of the items. And it's been pretty carefully validated and it's been given to chemistry students around the country for a number of years. We're still trying to collect and analyze the data because what we want to be able to do is to show how, uh, use the data, like the FCI data did to show that modeling instruction can lead to an improved classroom understanding.

Mark Royce (27:27):

Is that test distributed primarily through modeling communities and channels, or is it more broadly available to high schools across the nation?

Larry Dukerich (27:37):

While the test is a primarily available to people who attend modeling chemistry workshops, we invite other chemistry teachers to request a copy and they're free to use it as long as they follow the acceptable use guidelines.

Mark Royce (27:52):

So how would they find that? A copy of that test?

Larry Dukerich (27:56):

They could learn about it from the AMTA website. Uh, they might find out about it from a fellow colleague. We certainly talked about it in the paper that I wrote for J. Chem Ed in 2015 I talk about it.

Mark Royce (28:11):

Oh, okay. Uh, we'll, we'll try to make that article. If it's okay with you, we'll make that article available on our website.

Larry Dukerich (28:17):

You can do that.

Mark Royce (28:19):

Okay, that's great. So modeling instruction came out of a physics focus and evolved and grew into a chemistry focus and is currently evolving being considered by biologists to incorporate some of the methodologies into their instruction. But specifically your focus has been on chemistry. Can you tell me how that differs from traditional instruction and you know, maybe how modeling in general differs from traditional lecture-style instruction?

Larry Dukerich (28:55):

So I think that it differs in three key ways. It's, the way the content is organized, first of all. Second, the role the lab plays in the development of concepts. And third is the way that the instructor and students interact. So in the first thing, the course is organized around a small set of models which gradually evolve as you look at more and more complex phenomena rather than 28 chapters that you try to wade through. There's only a handful of models that we use in a chemistry class. You know, we started with a simple particle model and then it develops more and more features as it goes along as you look at other phenomena. Secondly, the lab, I don't hand out a set of instructions that are a cookbook that the students follow and just go through and get done. One of the things that really struck me when I was teaching AP chemistry is I asked students in one group, so tell me why are you doing step six? What I really was asking for was what are you trying to accomplish in step six? But the students said, well, it follows step five so it was clear to me that the students were just going through the motions of following the directions and they weren't recognizing what it was they were doing as they were doing it. In a modeling lab, we in the pre-lab discussion, we talk about what it is we're trying to accomplish and how we go about doing it and we try to negotiate with the students, so what's the best way to do this and how can we collect the data? How can we control for these other factors or keep some of the parameters constant so we could just examine the variables of interest and the students generally have a sense of what's going on so that when you hand them the set of instructions, they hardly have to refer to them. The last thing is the way students and teachers interact. I spend the vast majority of my time listening to students and asking them questions to get them to tell me what they think and if what they think is not quite scientific reasoning then I have to think of ways to guide them without telling them how to get there. That's part of the art. Those are three key differences between modeling course and a traditional course.

Mark Royce (31:20):

That's awesome. So you're obviously still involved in teaching workshops around the country. And I saw somewhere, I think my wife said you had taught in Singapore as well, but what else do you do with your time now that you're retired from the classroom? How are you spending your days, Larry?

Larry Dukerich (31:37):

Well, in addition to running workshops and helping to develop curriculum materials. I'm also a part time consultant for Vernier software and technology. That company has been very, very supportive of

modeling instruction from the get go, starting off by loaning us equipment to help us run workshops back in 1995, providing gift certificates to teachers who will participate in a workshop, and lab manuals as door prizes to workshop participants.

Mark Royce (32:09):

So did your involvement or relationship with them evolve from your passion for modeling? Were you seeking out their help? How did that connection happen?

Larry Dukerich (32:18):

Because the lab plays a central role in modeling instruction. Any ways that you can use technology to help with the collection and analysis of data where the students can make sense of what they're doing is invaluable. And Vernier has been very helpful in the collection and analysis of data, so we have been using their probes and sensors and software since the '90s.

Mark Royce (32:49):

Ah, cool. So there's a connection between Vernier and the modeling community that seems more than just a commercial relationship.

Larry Dukerich (32:56):

Yes. I'm not trying to say that they're the only company who has helped out, but Vernier has been really super supportive of the modeling community. They recognize that modeling teachers want their kids to do science rather than read about science and so it's totally in keeping with Vernier's approach to having students collect and analyze data.

Mark Royce (33:23):

Well maybe I'll approach them about sponsoring our podcast. Well this has been really great, Larry and I and I appreciate you taking this significant amount of time this afternoon to speak with me and share with me your thoughts on modeling instruction. You want to say anything like closing words to those who are listening?

Larry Dukerich (33:46):

I'd like to say to people who are uncertain about modeling and what it means and whether it's something they might want to try to do. It's a culture, not a cult. I have just found, once I started teaching with modeling that I found the experience in the classroom much more satisfying. My students found the course enjoyable and wanted to take more science. Places that have been implementing modeling have seen science enrollment grow, increase in the number of advanced courses that students take. It's something that I think people can be excited about.

Mark Royce (34:27):

That's wonderful.