Mark Royce:	00:00	Colleen, you've been teaching since 1978?
Colleen Megowan:	00:04	That is correct.
Mark Royce:	00:05	What drew you into the modeling world?
Colleen Megowan:	00:08	What drew me into the modeling world was an email from Jane Jackson, announcing a modeling workshop that was going to be in Davis, which was just down the road from where I was teaching. And the hook for me was that it promised the utilization of technology to learn physics. And this is something that I really wanted for my students. We had no technology in my classroom. It seemed very 19th century to me. So this was going to help me make the case that we needed to invest in some classroom technology so that students could take data like real scientists.
Mark Royce:	00:48	So it wasn't so much about the methodology as it was about getting some your hands on some tech.
Colleen Megowan:	00:55	Um, it was, initially, and it was also a paid opportunity to learn. There's, it's a real incentive when you're making, I don't know, $25,000 a year to go to school to learn to do something, to help you be a better teacher and get paid in the process. So, that was really attractive too, and that was something that I did almost every summer. So I was on this trajectory to professional growth. I kind of knew where I thought I wanted to go, which was better integration of technology to support learning, and that was the hook for me.
Mark Royce:	01:37	Wow. So, you went to a workshop and this was in '98, if I remember correctly.
Colleen Megowan:	01:44	That's correct. That is correct.
Mark Royce:	01:46	And so your expectations were to get there and learn some cool stuff and also get some technology in the classroom. But, what surprised you about that class or that workshop?
Colleen Megowan:	01:56	I think the most surprising thing was that the technology was incidental. And the thing I valued the most by the time I was done with that workshop was the whiteboards and the conversations that we had in constructing those whiteboard representations. It was great to be able to, to get my hands on some tech and to learn how to use it in my classroom. And the workshop came with a small grant that could be used to purchase some technology and that was good. But I think the

		whiteboards and the discourse were the big reveal for me. I could hear others think for I think the very first time as a teacher.
Mark Royce:	02:48	What do you mean you could hear them think? What do you mean by that?
Colleen Megowan:	02:52	When you work with others to co-create a representation, you have to talk. You have to talk about what you think is going on, how it should be represented, what the things you write down on a whiteboard mean. You have to talk. And so in student mode, in that workshop, I was talking with other teachers and we were collaboratively sense-making and I could hear that happening. And then when I got to listen to what other groups were doing and hear them collaboratively sense-making, I realized that this is what I would be able to do in my own classroom. I could know what my students were thinking by listening to them.
Mark Royce:	03:37	You mentioned though that the whiteboards were a part of that discovery for you. What, can you explain that a little bit?
Colleen Megowan:	03:45	Yes. Well, whiteboards are pretty low tech there. Um, I think 24 by 32 inch erasable whiteboards that are large enough for multiple people to write on at the same time. Let's say a group of three people can write on them at the same time. So your thinking can evolve as you're talking. You can sketch what's your thinking? It's better than gesturing when you talk, especially when you talk about physical things. If you can make little drawings, or if you can make a graph, or make a mathematical expression to represent what you're trying to convey. It's just much more complete communication. And the fact that you have that conversation with your teammates as you're building your whiteboard reveals how you are thinking about the conceptual model you're representing.
Mark Royce:	04:46	I kind of scanned a bit of your doctoral dissertation.
Colleen Megowan:	04:48	Did you really? Wow!
Mark Royce:	04:50	Just scanned. And the one thing that popped out to me was how you integrated the use of white boarding as you were just talking about. And so you've really focused on or done some deep dive into the white boarding idea.
Colleen Megowan:	05:03	I have.

Mark Royce:	05:05	Do you have any other key insights that you want to share that you picked up during that study?
Colleen Megowan:	05:10	My biggest insight, I think, in terms of practicality for a teacher, is that we tend to be zoomed in on the details when we are doing problems or, tackling anything. And it's very necessary for us as teachers to zoom out to the big picture and to help our students learn how to do the same. Students will also live in that tiny zoomed in space and lose track of what it is they're actually trying to, to figure out in the big world. And it becomes the teacher's job to zoom them back out to the model to see, okay, what am I working on here? What is the effect of what I'm doing on the whole system?
Mark Royce:	06:06	How did your administration and your colleagues respond to the way you started teaching after finding this new methodology?
Colleen Megowan:	06:17	Other than my asking for whiteboards when I returned to school and being more interested in those than actually the technology that I had been lobbying for, I don't think they noticed right away. I think the biggest shift was students. When I started teaching with modeling, I was teaching ninth graders in a, in a course called conceptual physics. And I was teaching 11th and 12th Graders in honors physics. There were striking differences between the two groups. The students that had me for honors physics had had me two years prior for conceptual physics because we were a Physics First school and they felt like the rules of the game in my classroom had changed and there was some pushback. But, um, I think the overwhelming response was that the ninth graders who were starting high school and they were up for something new, they loved it. They were so excited to be discovering that knowledge resided in their peers and not just the teacher. That doing things themselves and figuring things out themselves, figuring them out together, was what moved the class forward. So I think if anybody heard about it, they also heard about it from, um, excited girls. I taught at a girls Catholic high school going home and telling their parents, wow, this physics is great. And honestly, who expects that? Right? Um, what parent expects their daughter to come home, their 14 year old daughter to come home and say, "Physics is awesome! I love this!"
Mark Royce:	08:12	That's wonderful. You mentioned, that the, the students would see that there was knowledge in something they could learn from their peers, not just the teacher. That's an interesting observation. Can you talk to me a little bit more about that idea?

Colleen Megowan:	08:30	Sure. If you've seen a modeling classroom, you know that the teacher shows them something and then gives them a task to do and the students work in small groups to do this task and to figure out how to make sense of it. Once they have done what they can in their group and they come together with their white boarded findings and talk to the entire class, the teacher doesn't tell them anything. The teacher guides the conversation with strategic questioning. And in order for something to happen in the classroom, it has to come from students. So this is what makes modeling difficult to learn how to do as a teacher to manage by indirection. But when you can do it successfully, students realize that they don't have to wait for the teacher to tell them the answer. They can figure out the answer themselves. They also figure out that even though they may not have been able to figure out that answer themselves for homework, doing a worksheet, that when they sit down with their group of two other students that, inevitably, the three of them can figure it out themselves. So that's actually very empowering I think for any student. But, um, it was terrifically empowering for these girls and it was delightful.
Mark Royce:	10:02	It seems like it would also deepen their learning and retention.
Colleen Megowan:	10:04	Yes. And their enjoyment too of the learning. There was a huge jump in enrollment in science courses following the switch to Physics First and the introduction of modeling instruction. So those two things happened pretty close together. And, um, we went from two thirds of the student body taking a science course in any given year to 120% of the student body taking a science course in any given year. Which means that juniors and seniors, some of them were taking two sciences because they had spaces in their electives.
Mark Royce:	10:48	You know, you've twice now mentioned the term Physics First. And some of our listeners may not know what that is referring to and why it's important. Can you expound on that a little?
Colleen Megowan:	11:03	Sure. Physics First is a science sequence in which you begin high school, ninth grade, with physics, an algebra based physics course. And then this is followed by chemistry. And then, you take a course in biology, sometimes called capstone biology. That is very 'meaty'. You can do really good cellular physiology and biochemistry if you've already had a year of chemistry before you take biology rather than the traditional sequence, which would put biology first and you would spend your first nine weeks perhaps of biology learning enough about carbon, hydrogen, oxygen, and nitrogen to get along for the rest of the

year. So, it's a sequence that makes good sense and it's becoming much more popular.

Mark Royce: 12:03 I was just going to ask you that. How well received is that kind of sequencing in the coursework over the high school years?

Colleen Megowan: 12:11 It's a definite advantage for students who have an interest in the STEM disciplines. It's pretty well documented to increase interest in STEM course taking beyond high school or majoring in one of the STEM majors. And we did see that at the high school where I taught the girls Catholic high school where I taught. We had, um, I did a poll in the early 90s and we had about 15% of students who graduated majoring in math, science, engineering. And by the time I left in 2001, we had over 40%. So, there is a good correlation to more science course taking and more, science and engineering majoring.

Mark Royce: 13:01 So I know you have an opinion about the integration of math and science, which is a little different approach than traditional as well. Can you talk about that a little bit?

Colleen Megowan: 13:12 Sure. I, actually had the opportunity when I left Sacramento to go to, Phoenix and begin my PhD. I went to teach at a brand new high school. It was a Jewish high school and it was very small. We had twenty-two students in that first year, eighteen freshmen and four sophomores. And their vision was for a Physics First curriculum that integrated the learning of mathematics and science. So if you teach ninth grade physics, you teach algebra, you can't get around it. In fact, there was a little presentation as I was leaving the school at the final assembly. The math department actually gave me a little certificate that gave me permission to teach slope-intercept form prior to November, which is when they taught it. I would teach it in the second week of September and they would always fuss at me because that's a topic that they weren't supposed to get to in algebra until November. And I felt like I was doing them a favor. There, there it is. You don't have to worry about that. They've already got that. You can just move right along. But it took them years to get over it. They finally did. And then when I, when I left and went to this school in Phoenix, I had an opportunity to design a curriculum where what you learned in one subject supported and aligned perfectly with what you were learning in the other. And so I had a two hour block of time with my students, every day. And, um, we did physics and algebra together and students would occasionally come in and they'd say, "So what are we doing today? Physics or math?" And I'd say, "Yep."

Mark Royce:	15:04	Yep. Do you think other modelers are adopting that idea of the integration of the two in their classrooms? Is that, how is that? Is it propagating, you know?
Colleen Megowan:	15:15	I think there have been a few that have done it, but the biggest barrier really is scheduling. You almost have to be at a school that has embraced this as a plan either for a year. So maybe you just do it in freshman year and you integrate the algebra and the science course that they're taking. And that's doable schedule wise. Or you can, you could do it across several years. But, if you don't have an administration that is going to manage the scheduling problem,, it's gonna be rare.
Mark Royce:	15:52	It seems like it might challenge cause I know in one year you've got a lot of content to get through with the kids and by integrating another set of coursework, if you will, does it interfere with getting all the physics stuff taken care of?
Colleen Megowan:	16:09	Um, no it doesn't. Um, actually if you are learning a concept that is useful in both subjects, you don't have to learn it twice. You learn it once. And one of the nice things about learning algebraic functions in physics is that it's less of an abstraction than it is in mathematics. Functions are something that we learn f of x equals x squared plus five or whatever. And you learn to write it, but you don't know what it is. But when you write that function in physics, x of t equals v t plus x, not every one of those things has a conceptual identity. So it's more concrete. I taught calculus and AP physics together as well. So that's another place where it works out really well. Um, but I did not have them in the same class period for two hours the way I did with the ninth graders. I had first period calculus, and then I had, I think, fourth period physics or something. But since I have the same kids, I think they learned their calculus better because they had something 'visualizable' to attach these mathematical expressions to.
Mark Royce:	17:31	You had a little bit of a unique experience because, now did you ever teach in a public school or were both the girls school and the Jewish school, they were private schools, I assume?
Colleen Megowan:	17:44	Right, right. They were. I taught in a public school in Minot, North Dakota in the late 70s. And I taught in a public school in Bridgeport, California, and that was a middle school. So here's the, you know, here's the big reveal. In those days I was a biology teacher.
Mark Royce:	18:01	Ah, interesting.

Colleen Megowan:	18:03	I mean, you, if you teach in a small enough school, you're gonna teach just about anything. And at the Bridgeport elementary school, the town of Bridgeport had 300 people. And so the school, which served two towns actually, had a total of a hundred students in k through eight. I taught sixth, seventh and eighth grade math, sixth, seventh and eighth grade science, and music.
Mark Royce:	18:30	Huh. So I guess my question is there's a lot of people who are working in the modeling approach. Do you have any advice for how they can deal with administrators that just don't quite get it?
Colleen Megowan:	18:46	I think actually the very best way to deal with administrators is to get them to come and be in your classroom because when they can spend some time there and just watch the kids, and listen to the kids, and just soak up the energy in the room, and see the affect of those students, they will be completely sold. Today, so many administrators dip in and out of classrooms. They watch for five or ten minutes and they don't get a real sense of what's going on. They're busy ticking boxes on a checklist of standards or performance expectations. And it's really a shame that they don't know what kind of learning is happening in their classrooms. It's so focused on accountability. If they could relax, and take a breath, and listen, or even sit down at a table with kids, and ask them what's going on. Every, in every case where that has happened that I know of, the administrators have become huge fans.
Mark Royce:	19:59	If a teacher is going to invite an administrator to come in and observe, is there a certain part of the week or the, you know, you have your labs and you have not lectures, but you have different, uh, learning sessions. Is there one that you think is good with influencing an administrator?
Colleen Megowan:	20:19	Okay. Um, well, don't come in on test day. You know, that's going to be pretty boring. But, anytime they're doing a lab you can. Anytime they're doing whiteboarding, whether they're doing whiteboarding in small groups or whether they're having a whole group board meeting and just everyone's talking. I was a big proponent of the open door policy. Anybody could come into my classroom at any time and listen and watch and interact if they wanted to, as long as they weren't disruptive. I had parents, I had administrators, it was fine. And I think there's almost no bad time to come into a modeling classroom because you don't have, you don't lecture, you don't have them sitting there doing seat work. The only time they do seat work is when they're taking a test. So pretty much any time, but biggest bang

for the buck small group, whiteboarding. When kids are working on something with their little team and you can walk around and you can listen to their conversations. That's my favorite time. Yeah. I would think that an administrator would derive some satisfaction from that.

Mark Royce: 21:32 So you're out and about and you get on an elevator and you have 30 seconds, you know, the elevator speech idea. What would you say to somebody who just goes, oh, you're a teacher and they hear about modeling and they say, "Well, what is modeling?" Or "What's modeling instruction?" What's your, what's your elevator speech for that?

Colleen Megowan: 21:52 You know, this is something that I teach, a leader training seminar every summer and I make my leader training participants work up an elevator speech, and yet I never give them mine. So you've got on the spot now. Modeling instruction is an extremely effective method of helping students learn science, or any other subject, by building, testing, refining, and applying the fundamental conceptual models of that discipline. There is no lecture. It's all activity, lab, task driven. It's all collaborative sense-making. It's teacher as 'guide on the side' not 'sage on the stage.'

Mark Royce: 22:43 Hmm. Hmm. I like that. It's good.

Colleen Megowan: 22:47 Well, that last bit is Larry's. So stolen from Larry Dukerich, 'guide on the side' not 'sage on the stage.'

Mark Royce: 22:53 That's awesome. Pretty brilliant actually. Well, uh, I'm going to switch gears a little bit because you've been deeply involved with AMTA for some time now. And in your introduction you mentioned that you were the original charter member of AMTA. So tell us a little bit of the history of how it came to be.

Colleen Megowan: 23:13 Well, I was not there at dinner the night that AMTA was created by about a dozen modelers at Los Dos Amigos restaurant in Phoenix, at the foot of South Mountain. And they worked well into the night around the table figuring out how they would keep modeling alive now that the last of the grants was expiring. There were four big grants that David Hestenes got to support the construction and the refinement and the dissemination of modeling instruction. And the last of those expired in 2005. A lot of teachers that were there that summer felt, um, anxiety, I think, and a little bit of sadness that this was probably going to go away. Modeling instruction was going to go away in the same way that many other wonderful reform programs had gone away because there was no more National

Science Foundation funding. And one thing that NSF does not do for programs that it launches is require them to become self sustaining and perhaps even support the development of a business model that is sustainable. So here are a bunch of teachers thinking, "Oh no, there's no more money for modeling instruction. I guess that's it for workshops." But a few said, "No way. We're not gonna let this happen." And they decided, we'll just take it on. You know, we're smart teachers, we've got a network, we know each other. We're willing to put in some sweat equity. Let's figure out what it's going to take to create a professional association. So they borrowed and revised the bylaws from AAPT and they settled on a dues structure and they went around the table and said, well, you know, I'll be secretary, I'll be treasurer, I'll the president, whatever, and volunteered for offices. And they came back very excited the next day to my class, I had a class called Leadership Workshop.

Mark Royce: 25:24 At ASU?

Colleen Megowan: 25:24 At ASU, a one unit class that everybody in the Master's program, the Master of Natural Science in Physics Teaching, had to take in order to plan their action research and they just could barely contain themselves. They were so excited, um, and bleary-eyed from staying up 'til all hours of the morning. But, um, it just sounded so great. I pulled out my checkbook and I wrote my check for $25, which is what they were charging for, that was their special deal for life membership in that first year. Um, it was, $25 for membership, for any membership. And if you joined in the first year, if you were a charter member, you got it for $25 life membership. I wrote my $25 check.

Mark Royce: 26:06 So what is it today?

Colleen Megowan: 26:07 It's $400 today. Yeah.

Mark Royce: 26:11 For a lifetime membership?

Colleen Megowan: 26:12 For a lifetime membership. It's a steal of a deal when you consider what it would cost for life membership in AAPT or some of the other organizations for teachers. So it's, it's a, it's a great deal, but it's a great community.

Mark Royce: 26:27 When I introduced you at the beginning of this episode, uh, I mentioned that you became the first executive officer with AMTA in 2011. I believe.

Colleen Megowan: 26:39

I did. It was May of 2011 and it coincided with a moment in my professional life in which I felt that I really needed to make a change. After I graduated, I got a tenure track position at Arizona State, um, in one of the four education colleges. At the time, there were four education schools at ASU. It's a, it's a really big college. It has 75,000 students. So they had a special school that was just STEM education, STEM secondary stem education. So I was there with my other Science Ed. Folks and Math Ed. Folks. And they closed our college because of the recession. They disestablished it. I remember learning the word antidisestablishmentarianism when I was young, like the longest word in the dictionary. And I did not know what disestablishment was until my college was established. So we were folded into one big college. And the dean of our college had no use for secondary science and math education. She felt it was a niche market and that elementary Ed. Was where the money is and that's where she wanted to focus her time and attention. But she was an early education person and that was, that was her, her thing. I, in the short time that I was in that, the science and math teacher prep college and the short time I was there, I got a grant to create a Master of Natural Science program for middle school STEM. That was, no big surprise, based on modeling instruction. The difference in this program was that it integrated the teaching of science and math in all of its courses. And half of the teachers in the program were math teachers and the other half were science teachers. So she had no use for this program. And I finally decided I just don't want to play politics here. And my husband, God bless him, said to me, "Do makes you happy." So I said, well, I think what would make me happy is giving AMTA the launch that it really needs to make itself sustainable. I think I would like to resign my tenure track and just be a research scientist. That's, that's code for, I'm not on hard money at the university, I'm just on grant funding. And just do that work and spend the rest of my time trying to build up AMTA. So he said, well, then go for it. So I went to the board meeting, which was I think maybe a few days later, and I offered my services as executive officer for up to five years or until AMTA could afford to pay me a salary. And they said yes.

Mark Royce: 29:25

Awesome. Did we ever explain that AMTA is American Modeling Teachers Association?

Colleen Megowan: 29:31

We may not have said that, but AMTA is American Modeling Teachers Association. It's something that people that is occasionally misunderstood unless you tell someone you're a science teacher and then tell them you work for AMTA. They think that the modeling you're talking about is like fashion.

Mark Royce:	29:52	Yup. On a runway.
Colleen Megowan:	29:54	Yeah. So if they know you're, I mean, if you lead with, I'm a physics teacher and I work at the American Modeling Teachers Association, they assume then that it has something to do with science education.
Mark Royce:	30:06	Well, this podcast is designed to support the efforts of AMTA, but that's why I call the podcast Science Modeling Talks.
Colleen Megowan:	30:19	Mm-hmm. Very good.
Mark Royce:	30:19	Gives a little clue there, you know. So, how many members are there today with AMTA?
Colleen Megowan:	30:25	Um, there are about 2,500 members of AMTA and, um, once somebody was answering the telephone, minding the store, and we put up a new website, everybody got involved and membership grew pretty rapidly for, I'd say four years, four or five years, something like that. It is beginning to level off now and we have an inkling of why that may be. Um, it's sorta like public television, you don't have to donate in order to benefit from it. I mean, there's a million reasons that people can't make a donation or renew their membership. Membership is $75 now, and maybe you don't have $75 when the month your membership expires. And maybe you don't need to go to the website, download anything or register for anything. And so you're just going to wait until you need to do something before you pay that membership fee.
Mark Royce:	31:26	Sure. Just fiscal realities.
Colleen Megowan:	31:27	Right. And we don't cut people off. We don't stop talking to them. We don't unsubscribe them from the listserv. Um, we're, we're a community. There's 12,500 people on the listserv and there's only 2,500 members. So, you know, do the math.
Mark Royce:	31:46	Where did, where did those 12,000 come from?
Colleen Megowan:	31:49	Um, workshops. We've had in excess of 12,500 teachers go through modeling workshops in the course of 20 years. We have about a thousand every summer now. There are a number of people who come back for new workshops. We're counting on that because, we just launched a new one, astronomy modeling. It's going to be new this summer. And it's going to be in Louisville and I think the people who come will probably already have attended a chemistry or physics workshop, but

they also teach astronomy and they want to see how to do it the modeling way.

Mark Royce: 32:20 Awesome. So tell me what keeps you going, what your motivation is for your investment of time and effort with AMTA?

Colleen Megowan: 32:29 I think my motivation at this point in time is to make sure that modeling instruction is sustainable for the long term. We still struggle, we continue to grow, new things have happened. We got a National Science Foundation grant this year. It took us 12 years to get a National Science Foundation grant. You have to meet certain accounting worthiness tests. We got it. And so now that we have one, it will be easier to get the next one. But they don't just give you money. You make a proposal and then you have to do what it was that you proposed, which is a lot of work and that's what you spend the money on. So there's a little bit of overhead for AMTA in that, but, you know, we're not business people. We're teachers and, you know, we learn a lot of business stuff. I've learned a tremendous amount of business stuff by, being the executive officer for AMTA, and now being the senior fellow. But I think my current role as senior fellow is nominally research and development. And my personal goal is to make AMTA sturdy and sustainable.

Mark Royce: 33:46 That's really wonderful to hear. And I know that's going to encourage others to stand alongside because especially those who recognize how powerful it is and how meaningful it has been in their lives as teachers and also how meaningful it is in the lives of the students that are being taught. Yes, that's really great.

Colleen Megowan: 34:09 It's, you know, it's about community. It really is mostly about community. And I think we know from studying how modeling instruction works, that collaborative aspect of learning really makes it happen. AMTA has three pillars. One is professional development, one is curriculum resources that support the teaching of modeling instruction. And the third is community. And I really think the community pillar is probably the most important. It's the most significant in terms of the persistence of modeling as a method of teaching. Plenty of other programs have come and gone. Modeling has stuck. What makes it sticky? It's the community.

Mark Royce: 34:59 That's awesome.

Colleen Megowan: 34:59 We take care of each other.

Mark Royce:	35:01	So if there are listeners to this podcast that have not been exposed to AMTA or to science modeling instruction, what would you say to encourage them to investigate the world of science modeling?
Colleen Megowan:	35:18	I think anyone who is committed to the profession of teaching, and teaching science in particular, is also committed to being a better teacher and modeling instruction is a way of teaching that will help you be the very best teacher you can be. Wouldn't you like to be able to hear your students think? Maybe you can already do that. Wouldn't you like to give them really powerful thinking tools? That's what models are. Imagine we're all tool users. We all use tools all the time. Most of the tools we use are tools that we bought and we sort of know how to use. Very few of us are really expert users of all the tools we own. Now, think about models. If you build it yourself, you really know how to use that tool. You know how it works. You know what it's good for. You know how to apply it to situations. You know when it's the right tool for the job. If you want to give your students tools for thinking, really powerful tools for thinking, then modeling is your ticket.
Mark Royce:	36:29	Wow. That was awesome. It was a joy talking with you too.
Colleen Megowan:	36:32	Well, thank you very much. That it was, it was not hard or scary.
Mark Royce:	36:36	No, you're just talking from your heart. I mean, it's not like preparing some dissertation. Right.
Colleen Megowan:	36:42	Don't talk to me about that! Oh my gosh!