Mark Royce (01:40):

Hey, Scott, how are you doing?

Scott Milam (01:42):

I'm good, Mark. Thanks for having me on.

Mark Royce (01:44):

I'm glad you're here. I've been looking forward to talking with you. You have quite a lot to share with our listeners, I think. And we're gonna dig in right now, and I just wanna ask you to begin with, I saw that you've spent quite a bit of time looking at the historical progression of chemistry as it has unfolded over the years. And I just wanted to ask you what you've learned from that area of study, insights that you could share with us a little bit.

Scott Milam (02:16):

Yeah. I started reading about chemical history just a little bit informally, and then when I wrote my book, I put a little bit of effort going into really trying to get a sense of what happened, and I was surprised at how that impacted my teaching. There's things in the modeling chemistry resources and curriculum that you don't really get until you've seen kind of what that looked like in the 1800s. And what I found is that the 1800s of chemistry was kind of a mess. And so it's really hard to go back into it because there's different language used how they describe chemicals. And there's a lot of models that they're using that we don't really use anymore. And so I found it really fascinating to go through and the more I read, the more I kind of felt like I would wanna really go through and see what I could pull into the classroom and, and see what I could use.

Scott Milam (03:12):

There's two main books. JR Partington wrote A Brief History of Chemistry, and then Aaron Eid, from University of Wisconsin, later wrote. And so I've read both of theirs, and it's been, it's been kind of fun because all the little fun books that you like, Disappearing Spoon, or Caesar's Last Breath, or some of the books by Deborah Blum, all of those stories are in these kind of tales. And Partington was a student of Nerst. And then Eid was just a student at the University of Wisconsin who wanted to study chemical history. But I find that me being able to add stories of the smartest people in the world at this time, having these thoughts that were incorrect into my instruction is really powerful for students in that it shows them it's okay to not be at perfection, that as long as you're progressing and moving up, that you're doing something useful and productive.

Mark Royce (04:11):

Right.

Scott Milam (04:11):

And so it kind of aligns nicely with that growth mindset kind of a objective that I want.

Mark Royce (04:17):

Okay. Now, you were studying this historical development of chemistry over the years before you were introduced to modeling, or after you were introduced to modeling methods?

Scott Milam (04:29):

I would say after. I took my first modeling workshop in 2015, under Gary Abud. And I would say that I probably started to read nonfiction, chemical history stuff pretty intensely in 2018, 2019, 2020. So that was, that was something that kind of just by chance kind of gradually got into it. And then the more I read, the more I read.

Mark Royce (04:55):

That's interesting. So how do you see how the historical development of chemistry interacts with the modeling approach? Is that involved in the modeling approach? I mean the view to the historical development of chemistry?

Scott Milam (05:16):

That's a great question that I would love to ask at some point to whoever made the resources, what I find is that it aligns really nicely. For instance, there's a new Lego activity that we started doing about five years ago, in the materials. And if you go back to Liebig, who was an organic chemist in the 1820s through the 1850s, 1860s, and Kekule, August Kekule, that they used similar structures to what we do in that Lego activity. So there's an idea of valence, not valence electrons, but just carbon connects to about four things usually. And oxygen connects to about two things. And we represent that with Lego bricks. Well, if you look at the chemists at that time who don't really work in any kind of bonding model, they use that as their particulate representation.

Scott Milam (06:06):

And there's a professor in Ohio, Alan Rock, I believe is his name. And he talks about how the ability to imagine particles opened up the door for chemists to really be able to explore new ideas. So since most of what we're doing is abstract and cognitive in nature, having an image is really a big deal. There's actually a chemist, I can't remember the name, I wanna say Copp, but I might be wrong, who complained about it as like, in the kids these days with their fancy pictures in their heads of going through the different chemicals. And if they really just stuck to the quantitative proportional reasoning, like the experts did, they would really grow up and be able to do the harsh chemistry, which is always mildly amusing to see that back 150 years ago.

Mark Royce (06:54):

Yeah. Interesting.

Scott Milam (06:56):

Another one that I really like is there's a book by Jane Marcet, and this is from the late 17 hundreds and it's conversations on chemistry. And what she did was she did a thing where she was instructing two female students, which one is very rare at the time, right? So her husband was a chemist and they were both well off. And so that afforded her some things that weren't available to most people. So she writes this book, and I believe initially she put it under a different name, but later put her own name on it. And that book was revolutionary because it's kind of like modeling if you read it through and you can kind of dissect some of the ways that they describe chemicals in it. But she has the students asking questions like, why, when I observe this, does this happen?

Scott Milam (07:42):

And so you can see the students kind of saying, here's the limitation of what I'm seeing when I do this. And then she goes through and offers some feedback on that. And that book was actually the inspiration for Michael Faraday to go into science. He read that book and was just absolutely blown away by, what's this thing that I can't see and what, what could be happening? And how can I develop ideas and models of how that works so that I can kind of understand and be able to predict and do all the things that we want our students to do.

Mark Royce (08:10):

So you have already mentioned a few books in the short time we've been talking here. And I know you're an avid reader, so I think I saw that you have a Twitter feed that talks about your book reading and you review books and that kind of thing. My question is, what would be like the top couple of books that you would recommend that modeling instructors read? Is there, are there a couple that pop out and, you know, Hey, modelers really should read this one?

Scott Milam (08:45):

I could probably name 30. I'm gonna put a couple different spins on there. I'm gonna put some rare ones that aren't normally talked about. So one is, there's a book by Edward Frankland, I'm not sure the exact name on it, but it's something to the effect of how to teach chemistry or lessons in chemistry or something like that. And this would've been mid 18 hundreds. And it's, it's him going through and saying, basically, when you learn chemistry, we waste so much time copying down notes and writing what the instructor says, that you're not listening and thinking. So this book is an attempt to be able to share with you what you should be pulling out of these things. And for the instructor, how do you show students things? And what's really interesting about it that I think is one component we take out of a modeling workshop for chemistry is that everything he's doing is trying to convince the student that this is real.

Scott Milam (09:40):

So he's going through and saying, here's a lesson on how to show that the composition of nitric oxide contains nitrogen. And you want to take these chemicals and, and show the student this. And when you see this, that's your evidence that they can kind of connect that there's this thing. And what he does is he kind of presents this, I'm gonna assume the student won't believe what you have to say unless you can really convince them by showing them. Right? And it's so different from where we've kind of ended up in education, like when I was in high school at the tail end of the nineties, going into the two thousands, it was so dictated by an authority of the teacher saying, this is what this is. Let me show you this. And it wasn't evidence-based. And I remember the first time I took the workshop, that was one of my big takeaways was, everything I'm doing in chemistry, I should be able to show or provide some type of phenomena or evidence that this is why we believe this particular thing.

Scott Milam (10:35):

And obviously sometimes that's harder than others, but in this text, you kind of see an insight into what that looks like. I also really like Jane Marcet's book. I thought it was really interesting. It is hard to read some of the older ones 'cause they will use different nomenclature, right? So the current nomenclature we use came in the 1930s by IUPAC, but now you're going back to Lavoisier's nomenclature. And so they'll call carbonic acid is CO_2, right? And, and some of them will use different things. Some of them will use waters formula as ho instead of H_2O. So you have to kind of be able to root through some of those. But otherwise it's pretty good. It's something you would find value in as a teacher. I think.

Mark Royce (11:16):

You said that you like to tie quantum chemistry into real world situations or scenarios in your classroom. Can you talk to me a little bit what that means? Like an example of how you would do that in your classroom?

Scott Milam (11:35):

The first thing that comes to mind when you bring that up is that I know teachers struggle with what to do with electron configurations. It's a common question I see. Should we be teaching this? And I think teachers are stuck on what exactly is an orbital and what am I telling a student in orbital is that has very limited understanding and maybe even, you know, what am I telling myself that an orbital is, which is a tricky idea. And I think one of the things that I would wanna try and push to teachers is when you're teaching electron configurations, it's not about the mechanics of writing out the one S two, two S two, but you're really trying to communicate. One of the biggest ideas in chemistry that we've ever discovered is that electrons behave differently than what all the objects that we experience work, like in terms of kinematics and and motion.

Scott Milam (12:23):

And so you're trying to develop that there's this completely other world that these electrons exist in that explain a substantial amount of chemistry. And so the idea of quantum to me is trying to build a little bit of spark and curiosity. And one of the ways I describe it to my students is that there is no way to understand it. There is no analogy for this because you don't have any experience like this. It's not like a ladder. People wanna say it's like this where you can jump from this thing to this thing, but, but it's not, we can't see it and we don't know exactly what it's, we can only kind of construct these analogies that partially describe it. But I think that's a really fascinating topic. So I like to really get into that with the students.

Scott Milam (13:10):

And I've kind of developed for unit 10 for chemistry, I kind of developed a, let's start with the emission spectra and get into some questions of why is there no orange light? Why is there no green light, yellow light coming off of hydrogen spectra? And why am I seeing this red and this teal and these two purple lines and what exactly is going on with the chemical itself when I see light either emitted or absorbed or interacting with these chemicals? And then from there, I then like to eventually tie it into real world stuff. So we look at UV light and fluorescence, which is a little more complex. We're no longer talking about single atoms, now we're talking about molecules. But similar ideas that we have some kind of incident light coming in. There's some very unusual interaction with the electron that changes how it moves.

Scott Milam (13:59):

And then we get some different kind of light back. And I think that that's a really important idea for students to be able to have good understanding of. Because if you talk about, for instance, climate change, the entire premise is that we have this visible light coming through the atmosphere, hitting something, and then changing into these lower energy types of light where we have infrared and other things that aren't gonna escape back out. So this greenhouse effect is a very critical piece to kind of being able to understand why as the CO2 levels rise, why this temperature range is gonna go up. And that we've experienced that when we get into a car on a sunny day, that the inside of our car is quite warm as we have energy and light moving into the car, but not coming back out at the same rate.

Mark Royce (14:44):

Yeah,

Scott Milam (14:45):

I find that there's a lot of really cool things you can do with that fluorescence piece. You can look at a little bit of photoelectric effect, but you can also look at like your driver's license has encoded encryption stuff on it that always show up when they fluorescent under the UV light. And you might see that in an airport when you check in for your flight. Or that if you look at currency from different countries, and you can look at scorpions and banana spots and all kinds of other things. But I like to showcase a little bit of what's going on with light with the students and when is that dangerous is the question that they wanna know. 'cause they see a lot of stuff on, are cell phones bad, dangerous for me? And no, 'cause it's a radio wave, there's no mechanism for that to cause you harm. It's like, you know, the people in the generation above me were scared of microwaves 'cause they were new, but, but there's not really any sense of ability for that to do anything harmful. And you can kind of show the kids well, it's like being scared of a light bulb, you know, like, is it gonna harm you? No, because the light is not doing anything that can damage DNA barring some very unusual application of that light bulb.

Mark Royce (15:53):

Yeah. That's great. Share a little bit more about your approach in the classroom. As a teacher, what are some things that you've discovered that would be helpful, especially to newer modelers? Like maybe your top tips for people who are just getting into modeling and what you've learned in the classroom.

Scott Milam (16:18):

One thing that I'm working on lately that I've really taken to is I'm trying to look at what happens in the minds of my top students. So my students that just seem to understand things, most people ignore them to a degree. They kind of go, this student's good, I'm gonna worry about these others. And I try and look and go, how does this make sense to them? For example, one of the things that I've loved the last two years is the new quantitative reasoning approach that Brenda and Ariel have kind of put out there. Because to me that's something that my top students, even if I were to show them dimensional analysis or show them some kind of algorithm, that's what they're doing that makes them successful in applying that algorithm. So what I want to do is then go, okay, what are the verbal understandings and what are the components of that?

Scott Milam (17:06):

And then how can I get my mid-level and and bottom-tier students to be doing that level of thinking? I don't just want to give them more practice where they're kind of doing these things that aren't helping them. I want them to think like those other students are. Because to me, that's how they're gonna get to the level of success that I want for them. And so what I try and do is listen very carefully to what my top students are doing that's getting them to make sense of these different things, share that with all of the students. So not really kind of looking at how I make sense of it, but how does a new student who's having success think this through? One of the ways I do that is I'll have the students write, I'll do written reflections on some of the more complicated topics like a quantum chemistry or like specific heat capacity.

Scott Milam (17:57):

And as they do that, I'll take little snippets of those and share them with the group and say, I want you to look at how this student addresses this idea. Or here's an example of a student who doesn't think they understand multi-step calculations with specific heat capacity constants. Here's a student who does. What are the differences you notice between them? What's going on metacognitively and what's going on in terms of the actual chemistry itself? How are they approaching this? So I kind of wanna reveal that curtain for them and show the students like, you can do this, you can do this really, really well, but you have to change how you approach it. And so I have found that that in particular has been a really big boost for me, to get students to move up in a way that I normally hadn't seen them do.

Mark Royce (18:45):

Mm-Hmm. That's great.

Scott Milam (18:46):

The other piece that I would say that I've been working hard on is how is my assessment? Some of the modeling instruction stuff you said new teachers, it's hard, it's hard to teach unit four in chemistry. It's kind of like when you get started, I remember the first time I went, I was like, what did I even do in the workshop? And I'm going through the worksheets, but I'm not really clear on what my theme is or what I'm trying to get the students to do. And one of the things that's helpful is having an assessment that takes you in the right spot. For example, in unit four when I first did it, I'm working on that picture of just, I've got these different particles and they're a compound when I have two different elements stuck together.

Scott Milam (19:26):

And so I have this picture of what that looks like and that's what students go to right away, 'cause they've seen those pictures in middle school or in a textbook somewhere. And I find that unit four works best when you're looking at it from a perspective of what's the difference between a compound and a mixture in terms of composition, not bonding where the particles are stuck, but rather if it's a compound, it's always the same stuff in the exact same proportions. So I wanna look at a proportion perspective and a mass ratio. So students understand H2O is water great, but do they understand that eight grams of oxygen for every one gram of hydrogen is that proportion and that's different. And, and I wanna push them into that realm first. Get them to think like that, and then go to the H2O, to kind of connect that back to their prior knowledge.

Scott Milam (20:17):

And so when I set up my assessment, I need to set that up so that I get that value across. So I wanna write questions that then look at compositional data and have students doing that analysis, even if it might not be that challenging. I want them to see that that's what I want them to value, and that's what I value. And so I kind of have been working hard at going, how do I assess whether a student really understands this idea? What are the ideas that I want them to understand and to cycle through that. I happen to have another brilliant teacher next to me, and she and I have been working really hard on rewriting all of our assessments this year and adding some of those structures and thought into the modeling process. We sat down at the start of the year and kind of said, we're really good at getting kids to think hard in a discussion, but then they lose it, you know, the next day some of them are drifting off and by two weeks they're not remembering the stuff from that discussion. So we've been working hard at trying to make our assessments align back to our discussions and then providing students with structures for notes during this discussion and structures for tying in the worksheets to those, and having a set of standards that that kind of give coherency and structure to that so that the student is continually thinking about that stuff we did in the initial data collection and phenomena. And then also in our discussion and whiteboarding process.

Mark Royce (21:37):

You've kind of touched on this as you've been talking here. The classroom today is very diverse. There are students that have a stronger background and have had stronger opportunities coming into the science world, into the chemistry classroom. So talk a little bit more about how you deal with such a diverse set of students in your classroom. What are some of the tips and lessons that you've learned about dealing with the differences in your students?

Scott Milam (22:14):

I think that's a huge challenge. I think that most things in education, often when we reduce research down into this is what works, we have to almost ignore the fact that we're starting with this distribution of students. And that's a really big thing. For me, I found the most effective thing for dealing with diversity in student thought and where they're starting is to have reassessments on their assessment. So in 2015 when I did my modeling training under Gary Abud, I had switched to standards-based grading, but it wasn't until 2018, I believe, that I added in the reassessment component. And what that does is some big things. One, it changes the messaging to the students on your assessment from punitive to feedback. Right? And I know that many teachers are like me and that you have highly stressed out students where it seems like every point they lose is gonna cost them a university admission somewhere.

Scott Milam (23:13):

I know I carried a lot of that stress with me when I would grade, and when I went to reassessments, that opened up a lot of health for me to kind of feel comfortable giving honest, critical feedback and knowing that it would be okay, that it wasn't ruining their life and taking them from, you know, this place to this place, but rather me saying, this isn't there yet and you need to think about this differently. And so I think that that also then sets up the student that they're not taking a bad score at the beginning, first unit or two, and then being on a track where there's not really any positive way for them to grow forward. They're just gonna work hard and continue to struggle. It instead says, look, I am teaching you these things because they're important and we're gonna use them and I need you to learn 'em.

Scott Milam (23:58):

And so if you can reassess and go through and do it again, you can get that learning. I teach you naming 'cause I need you to name chemicals for when we do reactions. So if you didn't learn it, the response to that should be you go through and learn it. That's the consequence of that. Whereas what prior to that, it really was just kind of a mess. No matter what I did, we're always dealing with that distribution. It's not until I give them multiple opportunities that all of a sudden I see more and more students able to shift upward, if that makes sense. But I think also that's a beauty of teaching. It's super difficult. Even I have a pretty good situation going on in terms of I have wonderful students and we all do, but you know, I do appreciate them quite a bit and, I get to teach them really fun stuff that we all love.

Scott Milam (24:47):

And yet it is very difficult. No matter what I do, there's always things that could go better. There's always students who struggle and I'm always trying to figure that out. And I think that that's one of the beautiful things about teaching is that it is, I think, the best field to be in right now. When we look at medicine and law and legal professions, we've already figured that out. We know how to do engineering nearly perfectly. We're at the sixth decimal place to go back to whoever said that. But in teaching, we're all over the place. There are ideas out there that are abjectly terrible and are being propagated. I think one of the beautiful things in the modeling community is that we feel like we've had these struggles with teaching and then we found this kind of cornerstone piece of like, Hey, we can solve a lot of these problems here by taking these different approaches.

Scott Milam (25:39):

And so I love that about that. I like that it's difficult and I like being in a situation where I feel like I can match that challenge of being able to maybe not solve the problem, but make a good amount of progress toward how do you do teaching really, really well and how do you get students to learn? And so to me, I think that's fantastic. I think that teachers who kind of get into that point where they've had the support and they've had the connections and mentors and they're in a school environment that they can do it and have that autonomy that it's a beautiful job to be able to teach chemistry. I have fun every day. I'm so excited to go into work.

Mark Royce (26:18):

That's awesome. That's really great, Scott. I read that you have, and correct me if I'm wrong, but you've got over 500 videos posted on YouTube related to chemistry.

Scott Milam (26:33):

I started doing YouTube I think before it was cool. And so, they're not always the highest level, but that was a trip to get involved in that when I did. And then I think for a while there I tried to increase my quality and now I'm just being outclassed by people who are better at that than me. But I actually found that to be a great preparation to kind of sit there and go, all right, if I'm gonna talk about acid bases, what do I want to communicate to students and teachers in 10 minutes? And to really truncate, you know, what are the key features and how do I show that? What examples do I pick? It was a really big thing because one of the pieces that's important to teaching is being able to do reflection.

Scott Milam (27:15):

Right? What am I doing and why? Is it working and why or why not, and what should I change? And in the YouTube setting, because you're putting that out there for everyone, there's a little bit more pressure to really reflect on what exactly am I doing when I do this? And I think that's something that's hard for a lot of people to come to grips with, is that the content piece of it is really critical. When we look at chemistry content, you can approach the same topic in a lot of different ways, and some of them aren't really that good. The ones that in particular, I think that we're off the mark on are that we sometimes develop these abstract things that don't really connect back to anything real. So when we talk about abstraction, there's a group called the Learning Scientists who produce great cognitive science stuff, and they kind of explain abstraction as saying, I'm gonna give you two concrete examples.

Scott Milam (28:07):

So they use the example of scarcity, and you could have a water scarcity and a drought, and you could have a ticket scarcity for a big sporting event. And so the cost of the tickets goes up and the cost of the water goes up and all these consequences. And so the student can then take these two different scenarios and abstract the idea that's common to both, right? What's happened instead in a lot of chemical education is because it's so hard to teach chemistry that they're, giving you abstract algorithms and asking you to abstract from abstractions. So they're saying, here's how I process this thing. Now you take the idea out of it. And what we want to do in modeling instead is say, no, we need to have some type of concrete experience and we wanna showcase that to students and give them different representations of it so they can abstract the relationships that we see and describe from that, from that nature.

Scott Milam (28:59):

Right? So I'm gonna show you mass volume data and we're gonna graph it. We're gonna look at a line of best fit, and we're gonna draw a particle representation, and then I'm gonna abstract this idea of a relationship between mass and volume. And at the end we're gonna throw a term on there to be able to retrieve all those ideas. We're gonna call this density, right? And I think that that approach is really cool at being able to do that versus, alright, I'm gonna show you dimensional analysis and I'm gonna show you how to get to a gram to gram connection. I could show the steps of that. Then if I come back to an earlier point, what we're saying is that the top students are doing some of those connections that the other students are just treating this like it's a numbers on a page, and they're trying to find some abstract pattern in those without really any deep understanding.

Scott Milam (29:46):

There's a book, I think it's called How We Learn by Stanislas Dehaene. And they're doing a book talk on it right now, with AMTA. And his point is that human learning is better than AI, or at least for now, because humans develop these mental models. And one of the big pieces of that is being able to ignore the right piece of information. And I think that some of the times in education, we look at training students as though they were computers, we're teaching them as though they were AI. And that's not the appropriate way to do it. You're missing this cornerstone of why humans learn better than anything else that's ever existed, potentially. And instead you're trying to kind of take these other things. And I don't say that with judgment, it's hard to teach chemistry. Like I've done those things, but now I've found this new thing that I'm like, oh, now I see how I can do this even better than what I was doing before.

Mark Royce (30:39):

Just to make a point for our listeners, after when we post this episode on our website, I'll also be including links to like your Twitter feed with your book reviews and your YouTube channel, you know, and all the different, your website, the different things that you have made available publicly. There will be links to all that on our website, under this episode. So people who are listening can go and find all that stuff, later after listening there.

Scott Milam (31:13):

There's a lot out there.

Mark Royce (31:14):

Yeah.I know, I noticed that.

Scott Milam (31:17):

Life in the public eye.

Mark Royce (31:18):

Yeah. So you wrote a book, a couple of them, but you wrote one more recently called Teaching Introductory Chemistry. Do you wanna give us a brief description of what that book is about so people can go out and try to find it?

Scott Milam (31:33):

I would love to. There's a quote I put somewhere in the book from Toni Morrison that says, if you want to read a book and it doesn't exist, you must write that book.

Mark Royce (31:44):

Ah, <laugh>.

Scott Milam (31:45):

So, I used to teach physics way back in the day back in 2010 through 2012, which is actually how I got into modeling. And I remember when I started teaching that I was gifted this book called Teaching Introductory Physics by Arnold Aarons. And it was great. It's a book that goes through and it would interview college physics students, college physics professors, maybe high school students occasionally. And it would ask them questions like, if a ball keeps rolling, what's going on? And the kids would say, inertia. And then the book would say, so what we did was we tried to figure out what do I need to do to actually figure out if they know what that means or if they just know to say the word inertia there. So it came up with what questions do you ask?

Scott Milam (32:30):

What content, what twists and turns can you put in there to really get at, does the student understand? So I read that book and it was phenomenally helpful for teaching physics. I'm gonna do a brief diversion here. So fun note for me is that there's another physics teacher at my school who was the first at our school to do modeling. And he came to me early in my teaching there and said, Hey, I really think you would like this, I think you should try it. And back then I was a little more arrogant and I was like, oh no, that's for teachers who need that stuff, you know, not me. I got this, I can explain it so well, but you, you should see me. It's, it's, it's crazy. I should have a YouTube channel.

Scott Milam ([33:13]()):

And so he said, oh, great, we should take this pre- post-test thing and you could look and you could see how you do. And so I gave this concept inventory before and after, and I remember putting it in and kind of going, oh, they didn't really, they did a little better, but you know, some kids really didn't even get better at all. So I got my results and I went down to show him and, and he's like, oh yeah, those are really good for a traditional teacher. I think that's what I said. He, he didn't mean it with any tote either. And, uh, and so I look and I'm like, well, what did you get? And he's like, oh, here's my scores. We did the hate gain analysis, so, which is how many questions more that you could have gotten right. Per student.

Scott Milam ([33:53]()):

And I think I had a 0.28, so a 28% increase in correct answers of those available. And his average was like 0.5, 0.6. I was just like, what, how on earth did I lose that bad? Like, maybe I didn't teach perfectly, you know, but I was like, I feel like I did a decent job. So then I started to look, I was like, what are you doing? And I remember looking, this is Jim Gel, who who teaches at Portmouth High School with me. And I remember looking at his worksheets and just kind of thinking, I don't even know how I would instruct this. Like, and I just became curious. And so a couple summers later I finally did the workshop and kind of started things. So anyway, I had read this book Teaching Introductory Physics, and I really wanted to read Teaching Introductory Chemistry.

Scott Milam ([34:35]()):

And I waited for a while and it was not out there. And there really wasn't a book like it, I mean, I guess there's the Edward Franklin 1860s version, but there really wasn't a book on how do you get whether or not a student understands chemistry. And so, during Covid, I really disciplined and focused and wrote a lot and edited a lot. And everything that I knew about teaching that I had ever learned all went into that book. And I already have many things that I wish I had put in there. But it was great to write. It was something where it was very challenging and I constantly wanted help. I remember just kind of reaching out to anyone, my English teachers, I was going like, Hey, how do I write a book?

Scott Milam ([35:27]()):

And they're like, well, you have to practice writing. And I'm like, okay, I'm gonna practice writing. And so I do all these different things and I tried to read a lot, to research, and it just kind of to write and then think, and then reflect and go back and go, okay, what was I communicating when I was hoping to? And so it's a book, it's intended to be written for teachers. It's intended to be written for new teachers as well as experienced teachers. It's got a mix of high-level and basic stuff of how to do different things. It's got some focus on cognitive science and learning how the brain works, how we can optimize that. But primarily it's intended to be a focus on how do you actually get across chemistry content. So for me, an example that comes to mind is reaction energy diagrams is something I remember my first couple years just putting up there and kind of going, do you see how the bar ends up lower so there's less energy at the end?

Scott Milam ([36:17]()):

That means energy must have left? That's an exothermic reaction. And I would take the students down this chain of phrases that they were able to follow what I was saying and repeat it. And they would go, oh yeah, if it exits, it's exothermic. You know? And they even had a little bit of that kind of connection linguistically. And then later me going, they don't know anything. Like I didn't teach them anything. I just kind of trained them to repeat this one sentence or to identify this one feature. But they don't know what the energy is. They don't know whether it's chemical or some other type. You know, they don't really know what that means. Like if I were to say, draw what that means, you know. So I started to really get down into like, okay, what what should that look like?

Scott Milam (36:58):

And I found that in order for students to understand a reaction energy diagram, they need to look at force, position, and motion. And they need to look a little bit at what's happening when bonds break. Now chemist, teachers go nuts over bond breaking, and they blame everything on biology teachers, which is just completely unfair. It's not biology teacher's fault, even if the biology teacher says it wrong to the student. This is not where this misconception arises from. It's a physics misconception. And in order to break it, you have to build across the idea that when we're breaking a bond, that the particles are moving away from each other, but being pulled toward each other. And so if it's a podcast, so I'm pointing my thumbs inward and outward as I do this, but one of the examples I say with the students, if I'm running this way and the wind is also blowing this way, what's gonna happen to my speed?

Scott Milam (37:47):

And they're like, well, you're gonna speed up 'cause you're going with the wind. I'm like, great. And if I'm running this way and the wind's blowing the other way, what's gonna happen to my speed? Well, it's gonna slow down. So we look at the particle motion and say, Hey, the particles are speeding up or slowing down when they're, when they're moving apart and the bond is breaking, they're slowing down. And so we're seeing a decrease in kinetic energy, but there's not anything causing that other than the particle motion. So therefore we must be seeing an increase in chemical potential energy. And we look at that on the reaction energy diagram. And then when they come together, now they're speeding up. And so the kinetic energy's going up, it's our chemical potential or positional energy must be decreasing. And, and when we do things that way, we get a better sense that, hey, when I mix vinegar and baking soda, the particles slow down.

Scott Milam (38:32):

That means that the slowing down part happened more than the speeding up. So we call this endothermic, but the student has a better picture now of what the particles are doing as they're doing this, and also what the purpose of this diagram is showing them. And so I tried to look at what are the examples and the questions, and those things, and to put that together into a very informal, not bogged down with research and terminology, but just simple thing for a teacher to read, to be able to think about how do I teach energy in reactions? How do I teach stoichiometry? How do I teach quantum chemistry? And, and to have a baseline as well as some advanced components so that teachers could do thinking on it. And then in each chapter, I start with a chemical history, what's the relevant history in chemistry?

Scott Milam (39:21):

And then I do a digression into the typical teaching of those materials. And then at the end I look at, here are some common student struggles, just like in Aaron's book, you know, like when a student says this, here's what they're actually meaning. Because students are not great at communicating how they need help in chemistry. And so we go through and look at, when a student struggling with this calculation, here's how you want to remedy that. And then there's a set of flashcards. So we can do a little retrieval and, and teachers can look at what would flashcards look like in a chemistry sense, not in a single word into a symbol, but rather, you know, here's a diagram of a voltaic cell. What thing is doing this? And, and get that high level thinking into retrieval practice. And then at the end, there's also, oh my God, I wrote the book and I can't even remember. I have phenomenon. So I have kind of a list along with a little safety disclaimer that you're on your own. I have a list of, you know, these are some fun things that you could try that would illustrate this. And often they're not always these really elaborate demos or labs, but really simple things that get students thinking.

Mark Royce (40:37):

Cool.

Scott Milam (40:37):

I do wanna say, 'cause there's people who've probably read the book that I had the most fun year last year publishing that book. And if you wrote an Amazon review, I've probably read that like 50 times and sent it to my mother. And every time I get a new book sale, I get excited still. I'm so glad that people were able to get value out of that. And I care deeply about the field of teaching and teachers. You know, at one point, my wife and I were talking and she kind of broke my glass and something. She says, well, yeah, but all your friends are teachers. And I was like, no, they're not. And I looked through my phone and every single person on there was either teacher or married to a teacher. And I was like, I do, I really enjoy talking with other teachers and I don't know, my mom's a teacher and my wife's a teacher. I'm a teacher. And to be helpful in some sense of that is wonderful. I hope at some point that someone will help me edit that book and add to that book and we'll produce a new version that's even better. But I'm super excited with how it turned out and the fact that people actually read it and find it valuable.

Mark Royce (41:51):

That's awesome, Scott. That's really great. I'm glad you've contributed that. People can find that book where?

Scott Milam (41:59):

It's available on Amazon. It's self-published at the moment. But if anyone's interested in, you know,

Mark Royce (42:07):

Teaching Introductory Chemistry is the title, and the author is Scott Milam, M-I-L-A-M. And, so if you're gonna go find it, that's where you can find it on Amazon. Awesome. Well, we're running out of time, unfortunately. Man, it's just flown by. Is there anything we didn't talk about that you were really hoping to get to?

Scott Milam (42:31):

No, I enjoyed thoroughly being on here and I just wanna say that it's been wonderful being a part of the community. I know I got the Malcolm Wells Award this year, and that was really nice, nominated by Christian Drewry. But I know that working with like Ariel Serkin and Jeremy, we ran the intro to modeling class the last few years together. And it's been really nice to connect with all the teachers. And so if you hear this and are

Mark Royce (42:59):

You teaching any AMTA workshops coming up?

Scott Milam (43:03):

I'm doing a summer workshop in Ogden, Utah, that's in person. So yes, I'm doing that one. And who knows what will come after that. I just taught the post- workshop for Chem one. I believe it was the first ever run. So that was really cool. It was a mix of teachers that were brand new and also very experienced. And so we kind of did a mix of doing, you know, remediation, here's some basic help into here's some really advanced stuff. And so that was really cool and we had a good time on that. That's the only one I have scheduled at the moment, but who knows?

Mark Royce (43:41):

Well if, for those of you who are listening, if you'd like to find out more about workshops that are available, and up and coming, you can go to modeling instruction.org, which is the AMTA, American Modeling Teachers Association website. And just look up workshops and you'll be able to find not only that, but a lot of other resources. If you haven't been there, you need to check it out. 'cause it is a very, very good website that has a lot of helpful things on it. And I say one of the most important things is the workshops because they're critical and very, very informative. So if you haven't been to a workshop, you want to try to get into one. Well, Scott, it has been a real pleasure talking with you. And I really appreciate what you're doing for the community and in your own backyard teaching. That's wonderful stuff. And I always appreciate teachers that are conscientious and really focused on helping their students, and you are definitely one of those kind of teachers, and I'm just grateful for that and all of you out there who are doing that stuff. So I just wanna say thank you for taking this time outta your busy schedule to talk with us.

Scott Milam (45:08):

Well you're welcome. I'm absolutely thrilled to be on here. There was some running smack talk in the intro workshop where I was the only one who had not been on the podcast, so

Mark Royce (45:18):

Well, that's funny. Well, good. Well, at least that tells me a little, some people are listening. That's good. <laugh> <laugh>. Okay, man. We'll, we'll talk soon, I hope.

Scott Milam (45:32):

All right. Thanks so much. Bye.