Mark Royce (00:00):

Hi, Brant. Hey, thanks for joining me today. How are you?

Brant Hinrichs (00:04):

Hi, Mark. Nice to meet you. I'm doing all right. Just fine, thanks.

Mark Royce (00:07):

Awesome.

Brant Hinrichs (00:08):

Happy to be here.

Mark Royce (00:09):

Yeah, I'm really glad you're here. As I've researched a little bit about you, it's been very intriguing and I'm excited for our conversation today. And I'm looking forward to what you have to share with our listeners as well. It's gonna be a good one. I noticed in your bio that at one point you lived in Japan, and before we dig into all the science stuff, I wanted to ask you, how did you end up going to Japan?

Brant Hinrichs (00:39):

I had a lot of international students as friends in graduate school, and I wanted that experience for myself. And I found out about a program through the National Science Foundation. You would apply through them and they would do all the appropriate vetting. And then you would find somebody in Japan who would be willing to take you and agree to sort of the subject matter and such. And then you would apply through the National Science Foundation. There was a program set up, I don't know if you remember back in the late eighties, the first Bush was trying to press Japan to get more sort of exchanges going between America-Japan. And one of these was to try to encourage--there are a lot of Japanese that come to America, but not so many go to Japan. So this program was set up through those negotiations. So I was vetted through the National Science Foundation, but fully paid by the equivalent Japanese society -- Japanese Foundation for the promotion of science. I think it was called. Fully funded by them to go there to do a postdoc. So I went to Japan to do a postdoc for one year, and then it renewed for a second year.

Mark Royce (02:05):

Cool. And that's where you met your wife?

Brant Hinrichs (02:09):

Actually, not. I met my wife in graduate school at Illinois. We both ended up being members of graduate InterVarsity Christian Fellowship there at Illinois. And we met through doing social activities and things through that group.

Mark Royce (02:24):

Cool. So when you went to Japan, that was in the eighties?

Brant Hinrichs (02:32):

'95 was when I [went]. So the program started late eighties, and then it went on for five to 10 years after that. So I went '95 to '97.

Mark Royce (02:44):

So at what point did you get introduced to modeling instruction?

Brant Hinrichs (02:49):

That came much later. My first workshop in modeling instruction was 2001. So I came back from Japan. It's very difficult to get a sort of a long-term job from overseas. Most people don't wanna fly you back to interview. And this is late nineties, right? Zoom doesn't exist. The internet's just, you know, I like, I was using Netscape browser, you know, and stuff like that. So I came back, I lived at home with my folks and there was a university nearby, and I applied and got a visiting professorship there. And then there, there was a--this is a long story, but I promise it's getting there. There was a person there, Beth Ann Thacker, who's now at Texas Tech, who was a physics education researcher. And she got me introduced to physics education research.

Brant Hinrichs (03:45):

She was doing physics by inquiry, University of Washington tutorials and those kinds of materials. And I learned about the Force Concept Inventory and started reading about those things. And she was kind of my early mentor. So then I started exploring different physics education, research-based curriculum, and I learned about workshop physics and real time physics and things. And then, through reading about the Force Concept Inventory, I started learning about modeling. And so in 2001, there was a group that did university modeling. It was called Remodeled University Physics, RUP. And it was organized by Dwain Desbien, Eric Brewe, and Mike Politano, who were all graduate students at Arizona State University at the time. So they organized from their university perspective, which is not to say it's better or worse, but it's just from their perspective, what they were doing, like in community colleges and colleges, it might be a little different or tweaked from the high school.

Brant Hinrichs (04:46):

So I did three weeks of that, and then I was a glutton for punishment and came back the next summer and did three more weeks, <laugh>. And that was my official introduction. So I'm not quite sure how the RUP, Remodeled University Physics workshops compare and contrast to the sort of more standard two- to three-week high school summer modeling workshops. 'Cause I've never personally experienced one of those. I've been doing what I do based on that. And then in addition, I spent a sabbatical in 2009 with Dwain shadowing him at Estrella Mountain Community College and his introductory sequence courses, watching him every day to see how it worked and trying to learn better the subtleties and intricacies and things of that nature that go on from day-to-day.

Mark Royce (05:33):

Right. Interesting. What have you discovered about the differences between modeling in a university setting versus modeling in a high school setting? Have you discovered anything talking with other high school modelers or in your research?

Brant Hinrichs (05:52):

Mostly what I've discovered is through looking at worksheets and handouts that I've seen that people have had, that people have shown me. I haven't personally experienced one, so I'm not quite exactly sure. I've heard things so for example, I've heard high schools tend to do more, single groups present and other groups watch, whereas I tend to do more the so-called board meeting. Modeling discourse management, that Dwain Desbien wrote his thesis on. Though I understand many high school groups or teachers are going to that model. I think what I've heard again, maybe this changed is that in high schools there tends to be a lot of curve-fitting and linearization of data. And we basically didn't learn or do any of that in the university setting. I think the general sequence of taking data, the modeling sequence of taking data, making a model, deploying it, and then refining it, et cetera.

Brant Hinrichs (06:59):

I think that's, in my experience, what I do in the classroom, again, I'm not exactly sure how the high school folks do that in detail, but the general cycle sounds similar. One of the things I've tried to do in my research is to try to find evidence to show the effectiveness of the different aspects of modeling. The first thing I did, I wrote a paper in 2004 about the system schema. And what I discovered when I was writing that paper is there's basically two papers on the system schema. Lou Turner wrote one in The Physics Teacher, in maybe 1997 or '98. And then I wrote one in 2004 for the Physics Education Research Conference. And so the system schema actually differs pretty significantly, between the high school approach as Lou showed it, and the way I learned it and use it in the university setting. So you want me to go into details of that, or we can do that?

Mark Royce (08:04):

I would like to know more about the term "system schema." A lot of our listeners may know about that, but that's not something I'm familiar with. Maybe you could help me understand now.

Brant Hinrichs (08:14):

Sure. Happy to. So I'm kind of a system schema evangelist, as it were, <laugh>. It's one of my favorite representational tools. I think of it as sort of the first level of abstraction after drawing a physical picture. So maybe I have a book on a block on a table. And I could just draw a physical picture of that scenario. And then the next step that I use, that I learned from RUP was to think about what are the objects I care about and what are the interactions they're experiencing? So the objects in this case are a book, a brick, the table, and then maybe hidden there is earth, is also an important object. And then the interactions are at least most of mechanics is just a contact interaction or a gravitational interaction.

Brant Hinrichs (09:11):

So in the RUP framework, we don't distinguish between tension, for example, or normal or friction or things of that nature. We talk about contact forces, and then we resolve the contact force into a normal part, which is perpendicular to the two surfaces interacting, and the friction part, which is parallel to that interface. So that's a first blush at that. Once you've identified what objects and interactions you care about, then you can think about what your system is for forces. Systems are usually just a single object, like maybe I'd be interested in the block or the book, and then I could look at the interactions and using a definition. So this is something, I don't know about how high school folks think about it, but at the university level, the definition we typically use for force is one way to describe an interaction between two objects.

Brant Hinrichs (10:17):

So that's one way to describe an interaction between two objects. That's a very powerful definition. It implies lots of things like there's other ways and such, but the idea is force is very complicated and it's best described as an interaction, and we want to emphasize that throughout the entire pedagogy. So you would circle an object like the book, and then look at the objects interacting with it, and are they a contact interaction or a gravitational interaction? And then each one of those interactions would be represented by a force arrow of some relative length and labeled appropriately

Mark Royce (11:00):

System schema. What are some of the things that you try to promote when you're talking to others about the system schema?

Brant Hinrichs (11:12):

So what's really great is I use it at all levels. So there's a lot of different things to say. I use it at all levels of my class, from introductory physics all the way up to quantum mechanics and modern physics. I use it when we're talking about the two slit experiment with light or with things like electrons or protons or neutrons. So it's very good at getting at the idea of object interaction and helping students start to think what's the interaction, and then how am I gonna think about or model the interaction? So I can use it in quantum mechanics that way too. And it's holistic that way, even though, in general, I'm not doing any force kind of things in quantum mechanics. So that's the first thing. It expands kind of all the possible curriculum, upper level courses as well.

Brant Hinrichs (12:06):

It's useful for thinking about forces. It's useful for thinking about energy, for helping to make sense of work. I think there's been a lot of debate and not a lot of consensus in even the physics teaching community about how to think and talk about energy. I think modeling has really brought that forward with a lot of the work that Gregg Swackhamer did. I think textbooks talk about system, but actually visualizing it and seeing what's inside the system and what's outside, and thinking explicitly about where energy is stored... System schema is very useful for visualizing that. And when everything's inside your system, so another way to model interactions is as energy transfers. So if all your objects are inside your system, then there's nothing outside the system and nothing outside the system interacting.

Brant Hinrichs (13:08):

So that means all the energy stays constant. Now, it might change forms, right? Going to kinetic to potential or thermal or something, but the total stays the same. And so the representation I learned, one of the representations I learned to use for that is energy pie charts. So I do that a fair amount. But then using the idea of contrasting cases that Andrew Heckler has researched and discussed a lot, he's at a PER person at Ohio State. The idea of it's, the way I know something is by also thinking about what it's not. So I will also put in occasionally, ask students to leave some object outside the system, but still interacting with it. So maybe a hand pushing a book across the floor or something, I could put everything inside the system, the hand, or I could put the hand outside.

Brant Hinrichs (14:02):

And how does that change the pie chart? And then that naturally leads into the idea of working, which is objects outside the system interacting with the system. And it's a great way to visualize it and coordinate it and think about it in that level. And then from making pie chart representations, then you can write equations straight from the pie charts and what you visualize. So it's all holistic. You can teach each step separately as a concept, but then at the end, you can get out quantitative equations that you can then calculate with. So it's all sort of seamless and holistic and flows from one thing to the next, if that makes any sense.

Mark Royce (14:45):

Yeah, it does. In all physics instruction and even in chemistry instruction, the idea of how to help students understand the role and the properties of energy and its exchange is always a very important part of the classroom. You've talked to us about energy and pie charts and that kind of thing. What have you learned also about instruction around the idea of energy? Talk to us a little bit about that.

Brant Hinrichs (15:17):

Yeah, that's a really good question. I'd say a lot I learned from reading Gregg Swackhamer's papers and thinking about energy. We used to say energy's not a substance, but it turns out that if you look at the way people talk about it, it's useful to model it as a substance. We talk about energy as neither created nor destroyed. It's just transferred by interactions. So thinking about it that way, as it's a conserved quantity that can be changed, transferred by interactions has been, I think, extremely helpful. Another important question I learned to ask and think about is "where is energy stored?" So we can think about, it gets a little technical at some points, but kinetic energy is stored in the energy of motion.

Brant Hinrichs (16:09):

So if a train's speeding up, then the energy is stored in the train itself. A long time ago, back in the 17, 18 hundreds people wanted to store energy, they would spin up a flywheel, right? And the energy would be, like from a falling waterfall or something, and then energy would be stored in the motion of the flywheel. But also the more challenging one is to think about like where potential energy is stored. And this is subtle, and it comes out in modeling by thinking about it's stored in the interaction itself, gravitational potential. So it's easier to see than to talk about. But the idea is that neither a box nor the floor and earth has potential energy, but only the system together that it's stored in the interaction itself.

Brant Hinrichs (17:02):

And you need both of those inside your system in order to say it exists. And that's a very challenging concept for students. And instructors and teaching and books often use the language of what's the potential energy of the book if it's two feet off the floor? Right? Professionals understand the point, but it confuses the issue. And confuses students and leads to challenging questions and concepts, it gets carried over into like atoms, right? So electrons don't have potential energy. The atom has this energy, right? There's an interaction, the electrical interaction between the electron orbiting and the proton in the nucleus. So that's another place where it shows up. So the same exact representations can be exactly carried over into modern physics where we model the hydrogen atom just as a uniform circular motion kind of problem. Like Neils Bohr first proposed, a fixed orbit. "Where is energy stored" has been a fundamental question to ask students and have them think about, and help them to coordinate with all their representations.

Mark Royce (18:23):

That's good. In your research, you mentioned, or I read a little bit, you talked about the importance of paying attention to social positioning in the classroom and the idea of promoting consensus building. Talk to us a little bit about what you've learned in your research about that stuff.

Brant Hinrichs (18:44):

Sure. Can I say one more thing about the system schema and then come back to that?

Mark Royce (18:48):

Sure, sure.

Brant Hinrichs (18:49):

Would that be okay? I have another paper that came out and it was just an empirical paper and it was really fascinating. So I do board meetings, I have students work in small groups, and then they circle up and they have a whole class discussion, and they work to try to reach consensus. So this builds into your question about consensus building. I record those large group conversations. So I have some kind of data, and then of course I sit there and listen to what they're saying, but then I can go back later and listen to the audio and maybe analyze it for different things. Students are taught to write force symbols a certain way and taught to say them a certain way. It's hard to put into words, but, if you have a contact interaction between a book and a brick, then you might, the symbol would be F for force, and then it would be a c for a contact interaction, and it would be by brick on book, for example.

Brant Hinrichs (19:46):

So there would be two subscripts and a super script. And what I was finding is that some of my good students who really love physics and were working hard, tripped over the language of saying that, instead of saying contact force by book on brick, they would say force contact, or they would say contact, or they would say gravitational for a gravitational force because the C superscript or the G superscript was on the right side of the F. If that makes any sense. So they were reading the symbol left to right. So one time, I don't have a textbook for the class, so I can change things, if I want. And so I just did. The next year, I just changed the symbol and I put the C for the contact force or the g for the gravitational force on the left side.

Brant Hinrichs (20:38):

So if you read the symbol from left to right, you would literally read contact force by book on brick or gravitational first force by earth on brick. And I just had a student, Dana Swanson, listen to 600 minutes of audio and go through problems that were the same from the two years. And what I discovered in this empirical study was that moving that super script from the right side of the force to the left completely eliminated the problem. Like there were no instances. Students didn't say force contact or contact or gravitational, or they might say force of contact, right? Or force of gravitational. And it's a kind of a subtle problem. And it's not conclusive, but it could be, when students say things like that, they're thinking that the contact has the force, or the gravitation has the force, when what we wanna say is no, it's objects, earth, brick book that exert force.

Brant Hinrichs (21:45):

So just refining the language so that what they say is as clear and precise as possible, and just giving them one less thing that they have to trip over, right. If they can read it. So it turns out students, at least for force, naturally read force symbols left to right, even if you put them differently. So, the question is what about energy? And it seems like they're less picky about energy. They'll read energy always in a way that makes sense. Like they'll say kinetic energy or they'll say energy kinetic. And both those cases are probably okay. They don't say energy of kinetic, for example. So they seem to be more flexible with energy, which is a scaler reading those symbols that they do with force, which is a vector. So there's a paper and I guess, you'll link the paper into the podcast.

Mark Royce ([22:36]):

I have a few of your papers, and we're gonna put links for them on the website. So if you go to science modeling talks.com, as a listener, you can actually read some of the papers that Brant has produced. And, and they're quite fascinating and I think they might be very informative for you in your classroom. So let me just put that plug in and now let's get back to what you are saying there.

Brant Hinrichs ([23:04]):

Oh, thank you. I appreciate that. I think the title of that paper is something like, "Changing the Way a Force is Written, changes the Way Students Say It." The other paper I was talking about, about system schema is, "Using the System Schema to Help Develop Conceptual Understanding of Newton's Third Law," roughly that's the title. And then you asked about social positioning. So social positioning is an idea. So I'm now changing and getting back to your original question, social positioning is an idea and concept that was, I don't know if it was invented by, but it was developed and refined by David Brooks, who does physics educational research. He worked with Eugenia Etkinna, at Rutgers on ISLE and then is now at Chico State. So, this is the idea that people position themselves.

Brant Hinrichs ([23:58]):

This is not about content understanding, it's about social understanding, and it's about how people position themselves socially as experts or not. It has nothing to do with whether I actually know what I'm talking about. It's kind of a level of confidence. So if I say, well, the answer is of course, 42, that's a very confident answer, right? But if I hedge, if I say I, I think the answer might be 42, or I'm thinking the answer is 42, or we got the answer is 42, but what do you guys have, right? So kind of a hedging or a hesitation. Things like Socratic questioning is also an example of this, that kind of lowers the social barrier. And his working hypothesis was that if people position themselves not as experts, but as intermediate experts, then that opens up the space for conversation and people feel more free to jump in and disagree and have a conversation.

Brant Hinrichs ([25:04]):

So that was his model of student interaction. He was looking at it in the small groups, but I don't have small group data. All I have is large group or board meeting data. So once I heard his talk and I said, oh, that seems like it's perfect for analyzing some large group board meeting audio that I had. So I picked out two large group board meetings from my introductory calculus-based physics class. And one I thought was amazing. They talked and they worked on a really hard problem and they came to a consensus and they were very happy about it. That was the first problem. And then the second problem, which was a different problem, actually a different class, too, they talked and talked and talked, and they just, they couldn't get a consensus.

Brant Hinrichs ([25:52]):

They went around and around and around. And so, we looked at that audio and we analyzed it using his idea of social positioning. And we showed that there was empirical support to this idea that in the first case where they came to consensus, we had a lot more people positioning themselves as intermediate experts asking questions of others hedging, saying, I think, or I might, or those kinds of things compared to the second problem where students tended to more position themselves as experts, made sort of more declarative statements as facts. And so that was some initial empirical support for the idea that the way people-- the key is they're in really hard problems where you need everybody on board. And if you have, you know, the more people, the more brains the sort of group intelligence goes up if people are communicating clearly. So that was some empirical support for that idea that if people tend to hedge or sort of don't position themselves as experts that that can tend to lead to forming consensus more productively in really hard problems.

Mark Royce (27:06):

You know, your research is pretty fascinating, and I think the things you've been learning through it have a lot of potential to help teachers in their pursuit of excellence in their classroom. Can you share from what you've learned in your research, what would be your best modeling tip for modeling instructors? What would be the thing that you would say, boy, this is really important as a modeling instructor for you to know about? Just share with us what you would say would be your best teaching or modeling instruction tip?

Brant Hinrichs (27:45):

Yes, can I give two?

Mark Royce (27:49):

Sure. Yeah. You can share as much as you want.

Brant Hinrichs (27:53):

So I'm kind of a nerd, an egghead. I live in my own head and I'm very conceptual and it's taken me a long time to learn to pay attention to my students' emotions and their social aspects in the classroom. I get so wrapped up in are the ideas kind of flowing and making sense that I don't always track how they're interacting and what the dynamic of the social is. And that's my flaw. I think lots of other people are way better at that. So in regards to the social positioning, one of the things I've taken to doing, and this also I get from a guy named Dewey Dykstra, who taught inquiry physics at Boise State for many years. This is the idea that I start basically the first day of class talking about when we first circle up and we're working on a problem, and it's a whole class board meeting.

Brant Hinrichs (28:51):

I talk about the goal is not to be right. The goal is not to win. I ask, does anybody do debate in high school? Sometimes I get those kinds of students, and the goal in high school debate is to win. And you actually prepare both sides of the argument, and there's a coin flip the day of the competition and they say, okay, you have the negative. Defend the negative, or you have the positive. Defend the positive. So those people are really good at arguing, and that's not the goal. I tell them explicitly the goal is not to win. The goal is to understand first, right? So can I understand what the other person's saying first and maybe ask questions and really get at why what they said is different from mine or bothers me, or I find confusing and I use something from Dewey Dykstra, I call it the four dispositions.

Brant Hinrichs (29:48):

But one of those is basically respecting other people's ideas. Do I first take the other idea and treat it with respect and say, what does that mean? Do I really understand it? And get really confident of that rather than out and out, just challenging and saying, no, you're wrong, or That makes no sense, or that's stupid. And I think in my experience, physics culture can be very aggressive. One of my favorite ever

AAPT talks was, I think maybe in 2019 or or so I think at the Washington AAPT meeting, they invited this wonderful experimentalist who was working on the radius of the proton problem. And the beginning of her talk was, well, I just got back from my annual meeting and I think I've pretty much recovered from all the cuts and bruises and broken bones.

Brant Hinrichs (30:47):

And she was talking about how in the morning the experimentalists would share their latest data and then, the theorists would fight it out kind of a fight club in the afternoon about whose model was better. And in my experience, colloquial physics departments can be very, very aggressive. And I think, like engineering students can be very confident and be a little aggressive too. And in a mixed class like I have where I have biology folks and chemistry folks, pre-engineers and physics majors, they have very different personalities. So all that's to say is when I explicitly, at the front, "the goal is not to win. The goal is to understand," and then we do some writing and debrief, and I try to monitor that and correct it in the moment when I see it in the classroom in a gentle way, so that we get used to listening and sharing and understanding first.

Brant Hinrichs (31:44):

So that would be my first tip. And then I guess the second tip I would say is, starting with data first, and I always try to start with data first and build a model or a pattern from the data, even in things like modern physics where we're trying to make sense of phenomena that we can't see, right? No one's seen an electron, no one's seen the proton, or in quantum mechanics. So what's the data that I can bring to bear in a modern physics class, either actual data that people ran experiments on or simulated data that this is what it would look like if you were able to do the experiment in quantum mechanics as much as possible so that the models are always being built out of real phenomena that have been observed.

Brant Hinrichs (32:31):

And then from that you can represent many different ways and talk about it and build what models make sense. You can make a system schema, talk about the objects and the interaction. So I had to learn that, especially in modern physics and quantum mechanics because typically people run experiments and then do data out of it, rather than starting with experiments and saying what models we can produce from that. So when you turn it on your head, sometimes the data has to be different or thought about differently, I guess. I guess the last thing I'll say -- one more tip. So ISLE, Investigative Science Learning Environment, research developed by Eugenia Etkinna's Group at Rutgers overlaps really strongly I think with modeling. And it has some affordances that I think modeling doesn't, but this is not a modeling thing, but one of the things I learned from Eugenia and her work when they're doing modeling is that predictions only ever happen after students have some subset of models from which to grab a prediction and apply.

Brant Hinrichs (33:41):

So I used to learn, I used to early on really, really into the elicit, confront, and resolve model of teaching, which is, there's a difficulty that students have, like when you drop two objects, which is gonna hit the ground first? They're the same size with different mass, and you give them a prediction problem, you know, they're gonna get it wrong, and then you do the experiment, show it to 'em, shock them, and then that puts 'em in a place where maybe they're ready to resolve, or think about different ways of thinking about it. But what I found is that that was so emotionally damaging to students. And after we'd been doing that kind of teaching for a while, students would say, oh, I think the answer's C but I'm always wrong and A doesn't make sense to me.

Brant Hinrichs (34:30):

So it's probably A. I heard a student say that out loud and I'm just like, oh, that's like exactly teaching the opposite epistemology, right? We want students to think science makes sense and they can understand it and they can think about it in, clear and thoughtful ways. So that's not a modeling thing that didn't come from modeling, but that was something I brought into my teaching and it could be used in modeling. So I learned from Eugenia to back away from that a lot. I use it rarely, sort of like for the third law or something, but very, very rarely. And most of the time it's, let's describe and build a model and get a suite of models. And then I can look at, for example, the two slit experiment. And now that my students understand a particle model and understand a wave model, I can show them the two slit experiment and say, here's the data, what's the best model that fits that data? And they have those two models already in their back pocket, right? They don't have to develop them. They can look at the data and pull one of those out 'cause they're already familiar and comfortable. Does that kinda make sense?

Mark Royce (35:36):

It does. Those are good tips. So Brent, you had a paper, or a couple of papers, but one was about the integration of math in these science courses, and I'd like you to share with us what you've learned about that. And then, there was another paper called Conceptual Resources that I'd like you to just share briefly about that as well. So can you dive into those two things?

Brant Hinrichs (36:04):

Sure. So one of the great things about being at a small place like Drury is that I teach everything. I teach general courses for non-science majors all the way up to senior-level quantum mechanics. So it's really nice, you know, if you're in a bigger place, you maybe only get to teach an upper-level class once every five years, maybe, or maybe never if a senior person has it and doesn't wanna let it go. So I've been looking at math and one of the things I've been looking at is non-Cartesian unit vectors. So not X hat, Y hat, Z hat, or not i hat j hat, k hat, but looking at r hat, theta hat and phi hat in the spherical unit vectors and how challenging that is to think about for students, even in pretty simple problems. Cartesian unit vectors are fixed and always point in the same direction, but non-Cartesian unit vectors, like spherical unit vectors r hat, theta hat, and phi hat, directions change depending where you are in space.

Brant Hinrichs (37:11):

So I've explored a little of that. I sort of identified the problem with a simple conceptual pretest, and then I've been working on materials to try to help students better grasp and understand and apply those concepts. So that might be of interest to folks who like the mathematization of physics. 'Cause that works even if you just have a current that's on a really long wire along the Z-axis and it's a constant current. Then the magnetic field is concentric circles, with the centers at the Z-axis. And you would describe that magnetic field, B field with phi hat everywhere in space. So phi hat is the same symbol, but it points in a different direction everywhere in space. And that's pretty mind blowing if you've been doing Cartesian unit vectors, which always point the same direction anywhere in space.

Brant Hinrichs (38:07):

So then out of that paper, with a colleague here at Drury, who has a expertise in resources-- resources also goes by knowledge and pieces. It was developed resource and developed by David Hammer and then also Joe Reddish at the University of Maryland. It's the idea that resources are little bits of knowledge or ideas to get activated that people bring to bear in the moment to try to make sense of something in the moment. So examples might be like closer is more so if I'm closer to a light, it's brighter, or if I'm closer to a speaker, it's louder. And those kinds of things, some of these resources developed just because we're humans, brains and bodies living in the world. We have the experience, right, that if I get closer to a light bulb, it's brighter, or if I get closer to a speaker, it gets louder.

Brant Hinrichs (39:02):

So these are little pieces that we might develop because of our experience in the world, but also we might just learn like the right-hand rule, right? I might learn that in a physics class. That's another sort of conceptual resource. There are also epistemological resources, which I won't get into. So, with my colleague Eng, we studied how were students working together to solve a problem looking at these spherical unit vectors. And, um, we were trying to understand, was there a framework to understand how they work together to solve the problem. And what we proposed is an idea called shared resources. And this is the idea that one student activates a resource. So they might, for example, draw spherical coordinates in a Cartesian reference frame and say, Hey, could we use this? And, um, the other student or students in their small group working on a problem could either say yes and they pick it up or just, no, and they go on.

Brant Hinrichs (40:00):

And so we followed students where students would pick up this resource. So one student would say, Hey, what about spherical coordinates? Could we use that to make sense of spherical unit vectors? And the other student picked it up and said, oh, okay, that kind of makes sense, but what about this? And they kind of go back and forth thinking about it and applying it and using it and making sense and interrogating each other and seeing how it does and doesn't apply. And so we call that a shared resource because one student thought of it, activated and said it, and the other agreed that that was a useful idea to bring to bear to solve the problem. And then they worked together with it in that context. And then also changing context. So this is all to say that I like resources as a very nice model for what students have inside their brain.

Brant Hinrichs (40:50):

And trying to identify what are productive resources that students have that they could, can I write a problem that will bring those resources out? Or can I be paying attention and listening and saying, oh, what are those little bits of ideas that they said that are really helpful that I wanna support and reinforce so that they get competence, that they can make sense of things and also build on what they already have as much as possible. Having to always have students change their mind or start from scratch is mentally taxing for them and the instructor. So the more we can sort of grab and use what people already and students already bring with them from inside their head, maybe the more effective or more productive their work might be, either as individuals or even in groups.

Mark Royce (41:44):

Wow. That's really good stuff. This has been a really fascinating talk and our conversation has been really interesting. I think, um, our listeners are gonna enjoy it. I want to thank you so much for taking the time outta your busy schedule and spending this time with me. It's been really great.

Brant Hinrichs (42:10):

I wanna thank you. I wanna thank you for the opportunity. It's been an honor and humbling to be invited to be on, 'cause a lot of my heroes and mentors I've heard and seen on here. So I don't think I can be included in the same breath with them, but...

Mark Royce (42:26):

Oh my goodness.

Brant Hinrichs (42:27):

I'm so thankful that you invited me in.

Mark Royce (42:29):

Well, I think the whole modeling community is so important and it's great how everybody who's involved contributes to the joint knowledge of the entire community. And it's really great to have you be a part of it too.

Brant Hinrichs (42:45):

Absolutely. Crowdsourcing. Just to be clear if people weren't clear, is that I'm at a small private liberal arts university. I don't know if I made that clear or not. So, we have about 1500 students or so. Maybe you'll do that in your introduction that it'll be really clear. I just wanna make people understand the context that I'm working in.

Mark Royce (43:03):

Well, it's great and it's very fascinating to bring in the perspective from a university professor. It's really great. So thank you again so much for being here and taking the time to do this and my very best wishes for you and your endeavors ahead.

Brant Hinrichs (43:21):

Thank you. Really appreciate it. You've been great. It was wonderful talking with you.

Mark Royce (43:25):

Yeah, you take care.