Richmann: Welcome to professors talk pedagogy, a podcast from the Academy for Teaching and Learning at Baylor University. I'm your host, Christopher Richmann. Professors talk Pedagogy presents discussions with great professors about pedagogy, curriculum and learning in order to propel the virtuous cycle of teaching. As we frankly and critically investigate our teaching, we open new lines of inquiry. We engage in conversation with colleagues, and we attune to students and experiences, all of which not only improves our teaching, but enriches and motivates ongoing investigation. And so the cycle continues. Today, our guest is Dr. Trey Cade, director of the Institute for air science at Baylor University. Dr. Cade came to academia after serving in the US Air Force, specializing in weather and space. In 2015, Dr. Cade was selected as a baler fellow, a program recognizing gifted teachers and devoted to pedagogical experimentation. We are delighted to have Dr. Cade on the show to discuss teaching complex science to non-science majors, using history to teach science concepts, and more.

Richmann: Trey Cade, welcome to the show.

Cade: Thank you.

Richmann: We're so glad to have you here to talk to us primarily about a particular course that you have taught here at Baylor, a space weather course for non-majors. And you've presented about your pedagogical approach to this course, and you've also written about it in our collection called to teach. But first of all, I just wondered if you could kind of give us some perspective on what this course is and what it tries to accomplish sort of within the curriculum that you're teaching.

Cade: Sure. So the course, It's, introduction of space weather. And the idea is to, to teach space weather to students but with a different focus than you would normally see from a course of this type. You certainly see space weather, space physics type courses taught at other places. But they tend to be more for the physic students, to engineering students. That's, the audience. I've always been very interested in kind of community outreach, public education. And so kind of bringing that element into my, my focus and my goal for teaching this class. The idea was to open up this class to anybody at Baylor, to any student of any major, regardless of backgrounds. So assuming no special background knowledge, any prerequisites coming into this class and teach it very much more from a qualitative perspective rather than kind of the typical quantitative perspective that you'd see a lot of science classes where you know, you're sitting there and it's formulas and doing calculations and that kind of thing. I wanted to take a very different approach for more of a general audience. And a part of the reason for that is because I think there's a general lack of knowledge and understanding about what space weather even is among the general population beyond scientists who were involved in it. Because I get that question all the time when I just talking to people, when I tell them that, you know, my background and a lot of what I have done as a scientist, as an aerospace, whether, you know, the first question I get is “There's weather in space?”

Richmann: That's exactly what I was going to say.

Cade: Well, I have no idea what that even means and what that's referring to. And so the goal of this class is to broaden the exposure of space weather as knowledge to, to a greater population.

Richmann: Have you had experience teaching non majors this this specific of material in the past?

Cade: So my background has prepared me for this not exactly in that way, but I before coming to Baylor, I was in the Air Force for 22 years as a space weather scientist. That's mostly what I did so but throughout my entire career from very early on, I was in positions where I would have to present information, give presentations to an audience that was not, didn't have the scientific background to say general officers, generals who wouldn't necessarily have the scientific expertise to understand things at a scientific level. So I had to present to that audience. I would have to present in more of a general big picture qualitative manner. And so those experiences that I had felt my Air Force career and the fact that I already had an interest in kind of public education, public outreach on the topic of space weather. I would go to schools and present to, to schools in scouting groups and various kind of public type layman audiences. And so all those experiences prepared me coming into this class for how I wanted to, to approach it.

Richmann: So let's talk a little bit more about this particular approach that you took for this class. You write that you teach the first third of the class as a mystery novel? Can you explain what that means and how you decided to use that approach?

Cade: Yes. So the influences for that approach started when I came to Baylor and my faculty orientation, when I first got here, a couple of people that talked to my faculty orientation group. One of them was Chuck Weaver. And one of the things that stuck out when he was talking to us about the science of learning. He, one of the things that he said that stuck with me, he said, “People remember best what they create.” And so the, the, the, the idea that, you know, you don't, you don't want people to study answers. You want them to create their own answers. So that was kind of one influence that stuck with me from that orientation. The other one was listening to Ed Burger, one of the prior Cherry Award winners that was that was here when I when I first started working at Baylor. And he talked a lot about education as being inspirational and sparking interest and changing lives. And we ask the question, in 10 years, what are you, what are your students going to remember? And I took that, and I thought back to the classes that I had as an undergrad, and I really don't remember a lot of the things from my classes when I was an undergrad students. So that led me kind of along a path of thinking about doing things differently. Sparking that interest, sparking their imagination in a way that maybe can connect to them more and maybe be a little bit more memorable. And Ed Burger also talked about learning should be joyful. And so I wanted to have more of a, more of a community type environment in the class as opposed to the traditional lecture approach was sent up there and I talk for an hour and then they listen.

Richmann: Or not listen.

Cade: Yeah, which is usually what happens. So to try to make the class more interactive and get more hands-on with some of the material. And so those are the influences kinda led me into this line of thinking of, okay, I'm gonna be teaching students. You know, if I'm opening it up to all majors, I'm going to be bringing in students with very little math and science background. So I'm going to have to teach this in a different way than, than would normally be done. And so that led me to the thought of while. Okay, here's an interesting approach I could take. I could basically, my students can learn space weather, the way humanity learns space weather. And there are some advantages. And as I've thought about that more and kind of fleshed out that idea a little bit more and actually sat down with Ed Burger and kinda talked about my ideas and the approach I wanted to take. And he gave me some, some good insights and things to think about. But the advantages are that approach. And there's a fascinating story to tell that covers hundreds of years, brings in all kinds of very interesting characters. With interesting stories. There's a lot of intrigue. There's potential there to spark their interest and to get them thinking about the material in a different way and in a unique way that may be a little more engaging for them. It also allows for kind of a scaffolding approach to teaching. Taking students that don't have any background in the subject area. I'm teaching it kind of from a historical perspective and kind of, you know, them learning the way humanity learned it. In our early understanding of things like the Aurora, geomagnetic storms, the sun, we're all very simplistic. And so we start from a very simple basis of understanding. You gain—And as the story progresses, we make some discoveries, you gain some new insights. But then that brings up more questions than that. You've got to try to answer with more investigations and gradually so the sophistication of your understanding gradually grows over time as the story progresses until eventually we get to modern times. And so at that point they're ready to, again at a very qualitative big picture level, but be able to understand some basic concepts that can be somewhat complex like plasma physics, for example. But they, they're able to understand it at a very basic level. Because we kind of follow this scaffolding and storytelling approach where the learning kind of grows naturally as humanity learned it, the sophistication of our understanding grew so that, that's an advantage. I think the other one is— And this wasn't, this wasn't a goal that I had in mind when I decided to take this approach. But it was a benefit that came about as I started actually teaching it. And over the first few years of actually teaching this class, that the storytelling approach, the historical storytelling approach. It's kinda starts to unfold as I said, like a mystery novel, or as some students have describe it maybe even better as kind of a series of TV. But the TV episodes where and each episode and, and it's, it's kinda developed to where now each episode, and I call them episodes instead of lessons now. So that's something that I've changed recently. And so episodes with episode titles. So each episode now ends on a cliffhanger. So we're making discoveries, learning some things, but then that brings up new questions that need to be answered. And so that's kinda the cliffhanger that each class ends with. So that leaves them wanting more and coming back to find out, okay, what's going to happen next? Because with this kind of cliffhanger approach, so all those I think are, are, are advantages of using this.

Richmann: This approach seems to me that what you're getting at is really like a picture of the scientific process as it actually is. Think that, you know, I'm, I'm not a science person by any

stretch of the imagination, but I remember being taught at, at various stages in middle school, high school, college, the quote unquote scientific method.

Cade: Yes.

Richmann: And it seems like such a such a simple static checklists kind of thing. But where you're talking about is the actual process, which is a lot messier than the checklists of hypothesis and test and recheck hypothesis and all of that kind of thing. So, how do students react to kinda like the messiness, the uncertainty that, that you're putting before them?

Cade: That is absolutely true. One of the things that they learn and what one the things I tell them at the beginning is they're going to see how science actually works. They're not going to get this, this pristine view of science where we always have all the right answers. The, as you said, the scientific method that is presented in school as, you know, this rigorous step-by-step process. And I'm sorry, most of the time science does not follow that scientific method that we present in schools, at least in my discipline. It doesn't it's, you know, it's trial and error and people just trying to figure things out and trying things and see if seeing if they work. Making measurements, collecting data, and then trying to figure out what it means without any preconceived idea of, here's the hypothesis I'm going for is just, these are measurements I made and now I've got a, I'm trying to figure out what they mean. It's people getting it wrong. And when they see people that we— esteemed scientists like Edmund Halley, Galileo, even, even Einstein who features a little bit in our, in our story. But I mean big name scientists getting things wrong. I think that brings the science down to a more human level and a more relatable level. Because I think it's very easy for students to get in their mind that these scien— and you know, the, the, the great man thing, right, where the scientists were great people. And beyond our ability to draw on another level, beyond what we could possibly do and brilliant people and figure things out well, well, yes, they were smart and some of them were brilliant, but they also got things terribly, terribly wrong. And they see that. So everybody makes mistakes. There are failures everywhere. And that was another thing that I remember Ed Burger talking about is failure and how failure should be, should be celebrated. Because failure, failure means that you're trying, it means that you're learning and sometimes that failure is necessary. Especially when we look at the history of science. Some of those failures are necessary to enable the next step in learning to where you get the answer right? And I don't think that message is presented very often in the sciences.

Richmann: Yeah, it seems to me like there was, there was, there was and is a perfect opportunity in the midst of the pandemic to think about the scientific method. And that the typical way, I think that in popular culture science is presented as having answers, that its job is to have the answers, really has done a disservice in a lot of ways to how people are interpreting the messages that they get from the CDC and that kind of thing where we have in real time like no, this is a messy process.

Cade: That's a good example.

Richmann: And the best scientists are always just making the best recommendations with the little information that they have at any given time. And it's always open-ended. It's always open to trying to change right?

Cade: Right. The basics of science is you're trying to figure out how nature works and that process never stops.

Richmann: Yeah.

Cade: And, you know, it's a continual process. Yes. and it evolves and changes over time. Absolutely. It's never static.

Richmann: So you write also about how much of the course is also a problem based pedagogy. So once you've kind of set the scene of the episodes in the cliff hangers and the historical narrative of it, you get into hands-on activities, right? So how do you, how do you find or create problems that are really aimed at driving your particular learning objectives forward?

Cade: So as I was kinda first putting this course together, NASA was actually a great resource for me. They have kind of a set of websites devoted to space science education. They had tons of exercises basically designed for schools to use in kind of illustrating space science related concepts. And so I was able to take many of those and adapt them to my class. So NASA was a great, great resource for that. One of the things that I wanted to do with the historical approach was as we're telling a story. Actually, I'll give my students the actual data that some of the scientists were working with to try to figure things out. And so I could get my hands on the actual data, give those out to the students and say, okay, here's, here's, here's some measurements, are some data that the scientists collected. What can you glean from this information? So try to make them come to conclusions on their own from the data. As opposed to me just telling them what the answers are. Again, this idea of creating your own answers, right, goes back to what, to what, what Chuck Weaver said. So some of that using, using historical data and I was able to, to, to find and use some of that pretty easily. Reconstructing experiments that were done in the past. Some very simple experiments that can be done in class. Oersted's experiment where he shows that electricity running through a wire deflects a compass needle and makes a compass needle move when you hold that wire next to a campus. And so we do that experiment in class and I make them figure out, okay, what does this mean? What's going on here? And it leads then to the realization that an electric current creates a magnetic field that deflects the compass. And so you're getting some hands-on with experiments, some simple experiments like that is really useful and very memorable for the students. And then there have been cases where I've had to create my own problems and, and, and scenarios based on the needs of the class. As I develop a class, develop a lesson or an episode. I say I really, I need something to illustrate this concept. And so sometimes it's me figuring out how to do that and whether it's creating my own dataset or going out and finding data that can support it or whatever I can find. And that has kinda been a continual process over time. As I've gone through the years, you know, occasionally I'll say, I need an exercise to illustrate this. And I'll just have to spend some time to figure out how to do it.

Richmann: Yeah. There's some conflicting, might not be the right word, but some conflicting evidence about how students react to these kinds of different learning learning environments. Where on one hand, we can see like a rise in motivation when students get to support each other and get to discuss and get excited about the hands-on nature of it. On the other hand, sometimes these kinds of courses don't meet their expectation of the teacher should just tell me the right answers. So how do your students react to a really kind of different way of learning science?

Cade: Well, I can tell you that just at the big picture on this is, it's my highest rated class for the four classes that I teach. But digging a little bit deeper, looking at the student comments that I get from, from the course evaluations. They talk about, I mean, in the, in the comments that I get on the class, they talk about how they couldn't wait to come to class to figure out what happens next.

Richmann: That should just blow everybody's mind.

Cade: That's exactly what, that's exactly the mindset you want your students to have. You want them to come to class, to be motivated to come to class to find out what's going to happen. If I actually had very, you know, had one student kinda just express that to me after class one time and kinda in frustration. Like I'm frustrated because now I have to come back to class to find out what happens.

Richmann: It's like we're gonna have to wait for your episodes to drop on Netflix, right?

Cade: And I'm sitting there going, that's exactly the way I want you to feel that he was complaining, but yeah, that's what I want. That's all I want them to. A lot of the comments really express appreciation, especially for the hands-on. It seems like the hands-on things that we do, like the Oersted experiment that I talked about. We do another one with, I mean, it's kind of a and always thought of as a kind of a very almost too easy, kinda cheesy experiment that we do with rubber bands and binder clips to, to try to illustrate the, the process that creates the energy behind a solar flare. And I thought that one is probably too simple, you know, and they're probably gonna think this is dumb. But the comments I get about that they talk about how they remember that that's one of the things that they remember. And really it connects to this— one thing about teaching is you always trying to connect a prior learning and prior knowledge. And that's what it does. It takes a potentially very complex concept, a solar flare and the powering mechanism of a solar flare, which is my magnetic reconnection. But by relating it to the very simple act of, of cutting, clipping a rubber band together and cutting it in half. It makes a connection, and it makes them understand it. And that's something that's, that that sticks with them. And I've had comments specifically talk about kind of the TV episode aspect of it. And that's something I think especially now where we're all binge watching TV show or something so much now, I think that actually that approach, I think kind of connects to them as well and actually enjoy it and like it. Well.

Richmann: And as you've talked about how you've sort of embraced that and even begun to label the class session, right, as episodes.

Cade: Yeah, that's something I've recently done just in the past couple of years.

Yeah. I mean, I wouldn't, I would not discount the positive psychological effect such kind of labeling can have. I think of our Baylor colleague, Kevin Doherty in sociology. He doesn't have tests anymore in his class. He has celebrations of learning, right? And, and students bring food and, and balloons and they play upbeat music, and then they take a test. But it's a celebration of learning.

Cade: That relabeling, yeah, can just bring a different mindset, right? And they, you know, my students are very engaged in class because, you know, we discuss, I mean, there, there is a lecture element where I'm presenting information but present a little bit. We do hands-on exercises, problem-solving present. So it kind of alternates, so it chunks of the information. But it also again creates more of an interactive atmosphere, and they definitely are more interactive in the class overall, which is again, is something that you want.

Richmann: I'm assuming that this has also really affected your assessment strategies for this type of class. You know, you can't probably give a type of exam where it's like plug and chug these formulas and equations and that kind of thing. So can you talk a little bit about how you assess student learning?

Cade: Yes. So so the, the tests during the course of the semester are more—because the approach that we're taking—more qualitative question. So, you know, while we will do some math and some of the problems that we do in class. Just by nature of, we have to do, we have to be able to do some math. But it's, it's, it's very basic. You know, we're not doing calculus or anything. But I also make it very clear while we are using math in class to, to address some of these problems, there will be no math on the test. So that immediately makes it a low stakes.

Richmann: Yeah.

Cade: So it lowers a lot of their— because a lot of the students, especially, you know, non-science majors, some of them are going to come in with a lot of anxiety about math, and that's definitely something that I've seen. So it lowers the stakes for that first of all, so they know they're not going to have to do this on tests. So the tests are very qualitative questions. So it's more, you know, about what, you know, what was the significance of this event or tell me about, you know, what is what is the process that powers a solar flare? And you know, what was the significance of the, the, the discovery of the telescope in early 1600s? And how did that influence what we learned about the sun? So questions kind of along those lines that I will ask. But then when we get to the final, the final exam is very much a nontraditional final exam. And I've tried a few different approaches for the final exam, and I've tried some different things. The, the one that, that I've enjoyed the most is where basically I give them a scenario where they are a part of a, they are a member of a space weather consulting firm. And Congress is

considering cutting the budget for the Space Weather Prediction Center under the National Weather Service. And so they are testifying before Congress to explain why the funding should not be cut and what the significance of the services that the Space Weather Prediction Center provides. And of course, to be able to do that, they have to understand space weather processes, how they work, how we measure them, how their forecasts, they have to be able to understand more importantly, what are the impacts of space weather? How does that affect our society? How does it affect our technology? Whether a potential ramifications, if we're not able to provide warnings and forecasts of these events for the various technology sectors that can be impacted? And so I've done this before in the final exam when I had smaller classes. So I would actually simulate testifying before Congress would be a senator and who knows absolutely nothing about space weather, right? So there would be kind of lined up there and I would go down the line just ask, alternate asking them questions related to this topic and related to space weather and why is it important and how does it impact us? And, and some of those. And so they have to be able to basically kind of synthesize all of the information that they've learned through the course of the semester to be able to articulate those answers. So there's kind of an oral exam part, yeah, that simulates testifying to Congress. And then there's a written part where they have to write a letter to Congress so they have more time to think about and articulate or a written response to Congress to justify their argument for why the funding should not be cut. So I've played around with variations of that and done some different things too with that kind of final exam, testing environment and got to change things up.

Richmann: I love that rhetorical situation of testifying to Congress because as you say, I don't think it's going out on a limb to say they're not going to be space weather expert, right? And so automatically you've set the expectation of what kind of language ought to be used. And I think it's a common frustration, especially in, in humanities, where we assign some kind of student writing, and no matter how much we asked students to avoid using jargon and things like that and so that we can better understand what they actually know and they're not just hiding it in jargon, we get these papers that are just incomprehensible four-syllable words, one after another after another because they think that's what sounding smart means. You know? So creating that rhetorical situation where the expectation is no, you've gotta, you've gotta use short words.

Cade: You have to dumb it down. I have to explain it in simple terms and in layman's terms.

Richmann: Yeah. And as any teacher knows, that's when you cut to the quick of whether or not a student understand writes something, right?

Cade: Right. Right.

Richmann: Well, how has this, this approach to this class affected your own thinking about, about your own discipline? We've talked about the relative importance of math skills.

Cade: Yeah. So it's— I don't know that it's changed my thinking because as I said, I've I've

always been kind of, uh, of that mindset of community outreach and public education. So it fits very, very naturally with that mindset of always kind of wanting to be able to take this complex concept and explain it in an easily understandable way. That's something I've just kind of always done, and I guess to some degree come comes naturally because of that, because I've always done it. And so it fits very nicely with that so I don't know that it's changed my thinking in that regard, but it has changed my thinking in some ways. And again, a lot of it because of the discussions I had with Ed Burger as a mathematician. But he talks about math very differently. And so looking at it as, yes, we use math to solve problems, but it's not about the math, right? It's, it's about critical thinking and problem-solving skills. And that was something that Ed Burger really got me to thinking about that. Thinking about it in terms of you're using and honing problem-solving skills. You know, you're given, you know, it's a situation where okay, here's the information that I know. Here are the tools I have to figure out what I need to know. One of those tools may be a math equation, but it's not again, it's not about the math, that the math is a tool to try to figure out to you, take the information, you know, use the tools you have to figure something out or to answer a question or to, to, to solve a problem. As Ed Burger said, it's not about the answer. It's about the process.

Richmann: Yeah.

Cade: And so emphasizing that it's about the process, that it's not about the answers but about giving an effort in using your problem-solving skills. So that's what I focused on. It's not about getting the right answer when I give them a problem solving class, especially using math. But it's about giving it an effort. And, you know, using, using the problem-solving skills. One great comment that actually got this semester just a few weeks ago from one of my students who was a very kind of math averse student. And because their work, because I was kinda addressing the issue in class a little bit because some of the students were kind of struggling with the math a little bit. I was kinda talking about the the math. And now you may not like, a lot of you may not like math, but again, it's a tool that you use to problem-solve sometimes. But she spoke up and she said, and this again is a student that self-proclaimed doesn't like mad. She said, she said, I actually liked the problems we're doing in this class because their practical, we're actually trying to solve a problem. There's a problem, it needs to be answered. And we're using the math to get an answer to a problem that needs to be solved. She said, I like that. I like using math that way. Yeah, and I never quite thought about it that way, but that was a really cool response. I thought, yeah, that's what we're doing. Yeah. And and to get that and, you know, if I can get them to think about math differently, That's, That's a real benefit.

Richmann: Yeah, rather than, I think, implicitly anyways, students get the impression in a lot of math courses that math has is its own end.

Cade: Right.

Richmann: Which is, what I don't think any math instructor would actually want, you know. We— it's just like a language instructor, like, yeah, you're not learning the language just to learn

a language. You're learning the language so that you can communicate and broaden who you can speak to and interact with, right?

Cade: Right. Right.

Richmann: So with all of these hands-on and problem focused approaches, do you have any problems or activities that you've been wanting to implement that you just haven't had the time or haven't quite found the right angle or place for it yet.

Cade: Yeah, I've always got new ideas. So with this being my, what I call my experimental class, you know, I'm always trying out new things and some things work and some things in here if they don't work, I don't do them again and, but I'm always willing to try new things out and you have had some ideas for some things I've wanted to try that I haven't quite figured out how to do yet. Maybe doing some kind of larger kind of whole class, kind of using the entire class and using the entire class period to have them address kind of a larger problem. Like maybe you're planning a mission to Mars, and so on. You'll spend the class as a group taking about, thinking about, talking about coming up with, okay, what do you need to do to plan for the space weather hazards that are going to be presented on a, on a human mission to Mars. That would take a whole class period to do something like that. Giving them data and you know, basic measurements and having them write their own space weather forecast. Things that take a little more time. So I haven't, mostly, and I guess the reason I mostly haven't done things like that is because of the time issue. Yeah, takes a whole class to do that. And so just finding the time in the schedule of the course to, to, to kinda these, these bigger things I'm talking about. I've thought, I've thought about smaller things, like instead of giving them the cliffhanger, them have them kind of work in small groups and discuss with each other what would be kind of the next natural question to ask and have them come up with their own cliffhanger at the end of the class. I've thought about that, I haven't done it, but that's something I've thought about that too.

Richmann: Back to that, "you remember what you create."

Cade: Exactly. Yeah, exactly. So yeah. I've got a I have ideas out there for things that I've thought about trying but haven't yet.

Richmann: Well, we'll stay tuned for the mission to Mars. Alright, Trey Cade, thank you so much for joining the show today.

Cade: You bet. Glad I could be here.

Richmann: Our thanks again to Dr. Cade for joining the show. In this episode's show notes you'll find links to the Called to Teach collection, which includes Dr. Cade's essay on this class, and an online profile of Ed Burger and NASA and space weather educational resources. If you're enjoying the show, we'd love to have your five-star review on Apple podcasts, which helps bring

our show to the top of search results. And that's our show. Thanks for listening and join us next time for Professors Talk Pedagogy.