Community for Advancing Discovery Research in Education

TRANSCRIPT of "STORIES AND PERSPECTIVES" PODCAST: The Power of Story in STEM Education

National Science Foundation Principal Investigators Roy Gould and Jackie Miller met up in January to talk about story. Specifically, what makes a story effective? And how could or should story be used in STEM education?

During their discussion, they agreed that a good story that captures your attention should be a mix of interesting content and good storytelling. Or something that speaks to you personally.

For the purposes of this podcast, Roy and Jackie are talking about stories used in the classroom to interweave content and concepts, rather than stories told just for the sake of entertainment.

So let's join Roy and Jackie, jumping right into their discussion on the power of using story to frame and explain scientific concepts…

…Roy: Can I be radical here? Is that okay?

Jackie: Of course! Please...

Roy: I love science, and I love the concepts of science, but we put so much focus on concepts, they're holding us back from the stories that could really interest us in science. And a good example, I think, is the concept of entropy, where in the previous version of the science standards, there's a mandate there—it said, all students shall know that entropy is a measure of disorder. They don't use the word entropy; they say that all things tend towards greater disorder. And in any natural process, energy is redistributed so that everything becomes more uniform.

And it turns out that's not actually correct—entropy is a measure of two different things, only one of which is disorder. But over the last century, people got rid of that other thing that it measures and they just focused on disorder. And if you go and look at textbooks, you'll see that, systematically, they eliminate all examples that would contradict this notion of entropy as disorder. So people talk about, oh, an example of entropy would be a gas that expands…well if a gas expands it doesn't just naturally go back into the bottle. It comes out of the bottle. It expands. But in fact that's not true. In my field, in astronomy, outer space is filled with these huge clouds of gas that just collapse under their own gravity, and they do go back. Now, why does that matter? Well it matters to me because we get phone calls from teachers who say, I'd like to teach about the big bang and the evolution of the universe, but I'm really confused because the Big Bang was supposed to be this state where everything was the same temperature and uniform in composition, so how did it happen to suddenly become more ordered and

so forth…and, that's a fabulous story. But it's one where the concept that we teach actually holds us back from it because we're not willing to go into the subtleties of it, so...

Jackie: But isn't it interesting that that kind of story can show that it's counterintuitive.

One of the problems that seems to be happening, that we suffer from, is if we use story and science, people think it's not rigorous, it's watered-down. Have you run into that?

Roy: Absolutely. And I think there are at least two reasons in my mind that I've seen. One is this idea that stories are subject to interpretation and therefore it's not clear what the student is getting out of it. You know, it seems wishy-washy in some way. I think the other reason is that it's difficult to assess learning through a story. Very often people consider story synonymous with history and then there's a focus on just the historical unfolding of events rather than the underlying concepts. It really gets at the question of what the purpose of education is…what do you want to happen in the classroom? Is it about developing young people who are going to go on to become the kinds of citizens that we would want to share citizenship with? Or is it about doing well on a test? And maybe it's not an either/or. Maybe it really is a question of both. It's about developing the person and that's independent of how they do on tests, I think. But I really like the idea—it's a huge challenge—to see what can we tell about how people learn through stories.

It's interesting. We're so comfortable talking about misconceptions. There's the right conception and there's the misconception. But we're not comfortable talking about misinterpretations because everyone can interpret things in their own way and as you say they can tell stories in their own way and you're not quite sure what they're making of the stories.

Jackie: One of the stories we use is about genetically modified organisms. And we give them this whole tale about how potatoes are being destroyed. And they have to come back and tell a story in a poster (which is one way to do it). But some of the kids manage to get around the concepts totally. You know, they start talking about the political, or the ethical—which is important—but they also need to weave in the science.

Roy: Yes, really, I think stories have meaning, in a sense, only if you get the underlying concepts. I keep thinking back again to the Aesop's fables, and so forth. I mean, the whole point of the story is that there is a concept underneath that really resonates with you. It's not the story that's the end in itself.

Jackie: No, I mean…you know, the stupid fox, what's that have to do with me?

Roy: Right.

Jackie: But then I remember some time when I didn't get an award, or I didn't get something I wanted…and I didn't want it anyway. You know, so yeah, it moves on to your own sphere.

Roy: Teachers tell us, you know, I'm a physics teacher and I'm aware that only one percent, if that, of the students in my classroom are going to go into a physics-related profession. The other ninety-nine percent are wondering why am I studying angular momentum and why do I have to do this equation,

and so forth. And yet, when we talk to parents and we say that, they say, Oh, I don't want my child to have a watered down curriculum. I want them to get exactly what the one percent are going to get, because they see Physics for Poets, as it used to be called derisively, as something that's watered down.

Jackie: Or Rocks for Jocks.

Roy: Yeah, Rocks for Jocks….

Jackie: Yeah, and it's not! It's…let's get you excited, and let's…I mean if you were to ask the goal of education from me…I want people, when they've left school ten years later, to watch NOVA or to not be afraid to pick up Discover magazine because they see something really interesting and know that they can understand it—that it's not this esoteric subject matter. The one percent? Well, they'll be fine. You know, they'll go on and maybe even excited themselves. I mean, when I started this business coming out of research, and I would go to my colleagues and talk about how I wanted to create this curriculum. I said, you don't have to make a story, you don't need to make it engaging…science IS engaging in of itself. They said, maybe for you, you egg-heady, nerdy friend of mine. But for the ninety nine percent they need another vehicle to see that. You saw through the memorization and junk that we had to do in our education because you saw some nugget that grabbed you. And people need to be grabbed in different ways. Not everybody gets that.

So I don't know how you get that message across though—that it's not watered down, that it's not second-rate science.

Roy: In San Diego, a curriculum actually tried to move in the direction of making the physics curriculum more relevant to students. And parents looked at the text and saw that it had cartoons in it and they went to the school board and said, this doesn't look hard enough, it's not difficult enough, it has cartoons in it. (They were cartoons of Einstein). It was actually a fabulously successful curriculum for the schools that used it, but it didn't go over well with the parents and the schools finally stopped using it. So that's an example of this perception of, that if it doesn't look like what I suffered through, it's…

Jackie: Isn't that an irony though? I don't do science because it was too hard but I want my kid to have the same misery, almost.

Roy: Yes, we've all had these moments in our careers where we suddenly think, oh my goodness, what are we doing and why are we doing it. And this gets to the idea of concepts and how they've really taken over the teaching of science. A number of years ago, in the space of one year, I had three friends in different parts of the country, call me to ask me to give their child help with their physics problem. And what struck me was that they were all doing the same physics problem. They were all over the country, but it was the same physics problem. And it had to do with putting a block of warm iron into a glass of water and calculating the final temperature. So I helped them with the problem, and I said…are you interested in this? And they said, are you kidding? I mean each kid, said: are you kidding? And you know, if you're going to talk about warm objects in cold water, tell the story of whales and why they have to migrate from the Arctic down to the Caribbean when they give birth because their babies are relatively small and they need warm water so they don't freeze to death in the cold water. But the adults are too

big and they would get too hot in the warm water so they have to migrate back…I mean, it's just such a wonderful story of how animals adapt to their environment and it uses that concept. So maybe, one way to do this is to say, well, if less is more in the classroom (and there is a growing consensus that that's the case), maybe we should look for those concepts that both leverage future learning and can be the seeds for telling wonderful stories about nature. I mean maybe one way to do it is to identify some of the concepts that we know are boring. I think of isotopes as being an example of something that could be made very boring. But the examples…

Jackie: Oh, but it's so exciting.

Roy: Yes.

Jackie: There's so much to say about isotopes. I mean, it's…alchemy…you know, they're turning one thing…fission turns one element into another element. I mean, isn't that amazing. And talk about the alchemists. Why were they so excited about what they were doing…other than they were trying to turn everything into gold.

Roy: Yes.

Jackie: But, I mean that's one of the funniest stories—the discovery of phosphorus. This man was trying to convert something into gold, and he decided urine's yellow, gold is yellow, I'll work on urine! And he isolated a phosphorus out of that. The thing that I think comes up and maybe we don't ever articulate—stories should be funny also.

Roy: Isaac Asimov wrote a book about what makes a story funny. He was very interested in this idea of whether a machine could tell jokes. Could you get artificial intelligence to do so…so he was trying to analyze jokes and he told one—it's the one that you've all heard about prisoners who amuse themselves by telling stories and of course, they've heard them all, over and over again—so they just call out the number of the story…31! And somebody laughs.

And in one version of it another prisoner doesn't laugh. And he asks, how come nobody's laughing. He says, oh, you just don't know how to tell a story. So, what makes that story funny is that we all know that what makes a joke is the context and the telling of it. And so, that's a story that itself, points out the meaning of stories. You can't just reduce them to a simple one-liner. It doesn't work that way.

Jackie: It gets back to what we were talking about…what makes an effective story? It'll make you laugh, it'll make you think, it'll make you cry—whatever it does—and it can do all those things at once. But again, it can encompass things that you can't get across any other way. You can't talk about the human side of scientists without telling stories.

Roy: Jackie you mentioned that a story has a beginning, a middle, and an end…or not, you said. And I was thinking, I wonder if stories can also be an entrée to this idea of unanswered questions in science, a great way of introducing students to current science, or the frontiers of science—questions that they themselves might have.

Jackie: Yeah, I think it really could be because…science—certainly the way it's taught—it always has an answer. And that's not real science. I mean it doesn't neces…, it shouldn't have an end. Your story should end with another question, or in another story. And who knows? The end of your story today won't be the end of your story tomorrow because of new discoveries.

Science is very complicated and that's in a way another reason that story is good. Because story is complex. Generally, stories should be simple in the telling but not simple in what they're trying to do. And science is just like that.

Gerry Wheeler, who was head of NSTA, came up with a phrase that I use all the time. And he said, well we teach science with the idea in mind that its truth versus clarity. That is constantly in conflict because if you tell the true story…you could start saying, well this…but, but, but…you know, all the exceptions. I think you have to let students know that you're telling them something but it's more complicated. But right now you just have to understand the basic fundamental.

Roy: And the stories can help us get, I think, to that boundary line between the truth and the clarity.

Jackie: Yeah. In the conflict with Lamarck and the idea that environment can give you characteristics that can then be passed on? Well, that was total nonsense, everybody thought Lamarck…you know, you weren't allowed to mention Lamarck in classrooms. I was told when we were doing *Insights in Biology*—don't mention Lamarck, it just confuses the kids. (And there's this wonderful book *The Case of the Midwife Toad* that goes into all of that.) Well, now… people are saying, hmm, he may have actually been onto something with epigenetics. So again, that's just saying, let's not not talk about things, let's really say, scientists don't know a lot about what they're talking about, but what's amazing about them, particularly when you look at Mendel—is he didn't know about genes, he didn't know about DNA, he didn't know about meiosis…but his three principles hold til today! How did he do that?

You don't have to be right all the time. I mean Linus Pauling won 2 nobel prizes and he thought protein was a genetic material.

Roy: There's another reason we haven't touched on why stories are so critical for learning. Because they provide a context even at the level of perception. For example, if I say, oh I can't get together at lunch today because I'm eating [sounds like meeting] my friend for lunch downtown. You hear that as saying, I'm going to get together with my friend, but what I said was, I'm eating my friend for lunch. I'm a cannibal. I'm eating my friend for lunch with a knife and fork. You don't hear that at all because you know the context and you instantly surround it with a story about meeting somebody for lunch. You don't hear what I actually said.

Jackie: That's right.

Roy: And that carries over into the classroom. Without a context, without a story in which to put some of these strange new ideas that teachers bring up in science, we often don't even hear what the teacher is saying.

Jackie: I think that the other feature that I was thinking about was exercising imagination, which is what stories also allow you to do. Imagination and scientific concepts are not incompatible. And scientists use their imagination alot, they just use it in the context of prior knowledge and understanding some of the laws of nature.

Roy: Just 10 or 15 years ago, the whole idea of finding life on other planets and gee, are there other planets outside our own solar system was considered science fiction, and astronomers really didn't like to talk about it. And two things I've discovered since then, one is, if you ask astronomers how did you get interested in science, so many of them say, don't tell anyone, but it's really from reading science fiction stories when I was younger or seeing movies if they were younger scientists—they'd see the Star Wars or the Star Trek series. The other thing that's happened is that it's now become legitimate because they've actually discovered thousands of other worlds out there and we really are on the verge of detecting some signs of life on one or more of these other planets. The hope is that that will happen within the next decade, but certainly within the next couple of decades because we now have the technology to do it and we know where to look. So, it's an incredibly exciting field and it's interesting how the whole ethos of what you're allowed to talk about and tell stories about has changed.

But, I think that storytelling is so important, because as you were saying, stories give meaning to facts.

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Thank you for joining us for this Stories and Perspectives podcast. CADRE is the National Science Foundation's DR K-12 resource network. Please visit our website at cadrek12.org for more information about Roy and Jackie's work, as well as related National Science Foundation projects.