Why and How Can We Promote Science in Early Childhood
Front Porch Series: Broadcast Calls

Dr. Ilene Schwartz: My name is Ilene Schwartz, and I'm here today representing the National Center on Quality Teaching and Learning, which is funded by the Office of Head Start. The purpose of the National Center on Quality Teaching and Learning is to help ensure that every child in Head Start receives a world-class education and leaves Head Start ready to be successful and happy in kindergarten. To do that, we want to ensure that Head Start teachers – that we're able to put into the hands of Head Start teachers the very best research-based teaching tools and techniques, and give them the support that they need in order to use those techniques with children and families.

To do that, we've developed the house framework; and the house framework guides our work. So the house framework has four components, and these components are interactive. And they – so they work together in order to build the synergy that we need in order to help children learn. The first part of the house framework is the foundation. And as we all know – that foundations are the most important. You can't build a house – have a sturdy house, or a sturdy relationship, without a strong foundation.

The foundation of our house is Engaging Interactions and Environments. We want to ensure that all classrooms – all places where children spend time – have engaging interactions between – between adults and children, among the children, and between the parents and other caregivers and the teachers in the environment. We also want to make sure that the environment has interesting activities for the children and are culturally responsive and respectful.

We then have two – our house has two pillars. The first pillar is Research-Based Curriculum and Teaching Practices. This pillar is to ensure that all Head Start teachers have in their hands the very best information on what to teach children and how to teach children. The second pillar is very related, and that's Ongoing Assessment. So, we need to make sure that we're using frequent child progress measures so that we can ensure that children are learning what we're trying to teach them.

Finally, the roof of the house is made up of Highly Individualized Teaching and Learning strategies. So we want to ensure that children who need a little extra support receive that support. Some children need some support because they may not be learning as quickly as other children. Some children need more support because they're learning more quickly than other children, and we want to keep those children engaged as well.

So all of the talks that we're going to be doing today – in this series, all of the activities that we do at NCQTL, are related to bringing – making this house come alive. We want to make sure that the strategies that we talk about in the research are translated into ways that teachers and families can use them and that ultimately children benefit from them.

Now, let me introduce our speakers today. We're very lucky to have two experts in the area of early childhood science education. Dr. Andrew Shouse, who is the associate director of the UW Institute for

Science and Math Education, is here; as well as Ximena Dominguez, who is an child – early childhood researcher at SRI International in California. So at this point I'm going to turn it over to Dr. Shouse, and he will take it from here.

Dr. Andrew Shouse: Hello, everyone. Thank you for joining us. This is a – it's an honor to – to be a part of this series, and I appreciate the – the nice framing and introduction that Ilene has provided. As she mentioned, we're – we're going to be talking about early childhood science education, in particular how to promote that. My colleague, Ximena at SRI, and I will be splitting duties.

I will start by providing some overview of the research basis on early proficiency in science learning. In other words, what are the things that young children can do – they arrive at our doorsteps able to do – that then science education can take advantage of to promote their interests and skills in science. And then Ximena will take over and focus more on the practices of what – what educators and parents can do to support early science development.

So as Ilene mentioned, we are working within the house framework, and I won't say more other than to point out that we're really focusing on that pillar on the left, Research-Based Curriculum and Teaching Practices. We're going to provide some foundational research on learning and – and – and some ideas about practice.

So to begin: What is science? On your screen you should see an image of a scientist which I think of as kind of the canonical view, or the typical view, we see in media, particularly media focused on children. He's kind of a wild-eyed, crazy-haired experimentalist in a dark, gloomy setting, doing something that looks dangerous, and he's doing it all by himself. This is not the image of a suitor for one of my children nor someone who I would like to have mentoring people in the field. And in fact that's a good thing, because this is not what science is or what it looks like, although we do see this in how children represent what they think about science because of this image.

Now contrast this image with some real images of scientists at work. You should see on your screen now four different images – four quadrants on the slide – in which scientists are at work. In the top, they're in research groups. People – men, women, people of color, people who are Caucasian – working together to solve problems. They're looking at data on the left-hand side in a model.

On the right, someone is providing an – an early presentation on their work to get feedback before they write it up. If you look at the bottom, we see scientists in the field collecting data, getting dirty, laughing, having fun. On the right, we have the – you know, the classic example of a lecture: folks sitting in a room and preparing to make remarks that they hope will persuade their colleagues that they've seen the world in an accurate way, and that through peer review, their work will be – will pass muster and become a product of science.

So these are better images of science. They're more representative of what goes on. Of course, we could – we could make this a more diverse, interesting depiction of science if we had kids in there, because

kids do science as well and contribute to science, not only in their classroom, but the actual practice of science.

So from that, let's move from what is science to what is science learning. Now on your screen you should see a summary of what we call the Six Strands of Scientific Proficiency. These come from consensus studies, or sort of what the field of researchers on science and science learning believe to be the best that we currently know.

So, this is the best that we currently know of what it looks like and feels like when young people learn science. And there are six dimensions. If you look to two and three, those are where we've typically focused our energies in education Pre-K-12. "Understanding scientific explanations:" what is photosynthesis; tell me about the rock cycle; that kind of thing. And then the other, "Generating scientific evidence," and – which is often reduced to just sort of simplistic experiments. And this is probably what most of us would reflect on when we think about our own experiences in Pre-K-12 education.

But I'm here to tell you there's a lot more to this, and that the research suggests we should be doing a lot of other things in science education. I'll just read down the list and return to the beginning. Look at "Generating scientific evidence." Kids should be out collecting data, coming up with questions that like – they'd like to investigate. "Reflecting on scientific knowledge." We do science because we have a belief, and we test that belief. Kids need opportunities to test their ideas against their prior ideas. "Participating productively in science" means doing it, engaging with others, asking questions, using the tools of science.

Now the bookends of the strands, which I've highlighted in red – "Developing interest in science" and "Identifying with the scientific enterprise" – are of critical importance for young learners. Developing interest is, of course, finding this stuff fascinating; and for us as educators, it means situating the curriculum and our experiences in ways that students can connect with them. It's very clear that kids find the natural world interesting.

They're very interested in animals, in plants, in what happens. They ask questions about why the sky is blue. These things happen. Anyone who has spent time with young children and listened to them know that. Our job as educators: how can we tether our experience and their experiences to that natural interest? And then identifying with science is something that evolves over longer periods of time.

It's sort of the mature version of interest. It means that young learners come to see themselves as part and parcel of science, and they start to imagine their futures as – as scientists, or at least as consumers of science, people who would not turn their nose up at an article on climate change or who might actually watch a "NOVA" program. Those are the kinds of things that we'd like to think of as outcomes in the long term for young learners.

A quick reference to a study here that helps make this case... I've just flashed Robert Tai of the University of Virginia – his study in science on what are the – he was exploring what are the factors that produce scientists. And he was trying to explore the earlier – the earlier development in upper elementary grades and middle grades, and what he found was that the strongest predictor of people who entered science was early interest. It was stronger than grades. It was stronger than course-taking patterns. And this is just the earliest we've done this study.

There have been a series of these looking at high school students and college students. And he got back into elementary and middle school students. But my sense, and I think a lot of folks would agree, is that if we did that study with younger children, we'd find the same result. So what I'm – what I'm trying to convey to you is that promoting interest and finding ways for kids to explore science is probably the – the most fundamental thing we can do to support their learning in the early development phase, in early grades.

So now I'm going to shift to make a few comments about what the literature says about children's competence. There has been a lot written about this for many, many years, and the story has changed in the last couple decades. And there's – early on, we talked a lot about what young children can't do, and now we have better evidence of what they actually can do. So let me start with this. Children starting school are surprisingly competent. They already have a lot of knowledge about the natural world. So that Strand 2 I was pointing to as the place that we focus most of our attention in K-12 education, they know a lot of that stuff already.

Some examples from the research that I find very compelling is – one of which is – is niche-fitting – or niche-fitting, some may say – and that is about what niche – or niche – is where an organism fits in its environment. How does it have its needs met? What does it do for shelter, food, protecting its – its offspring, and so forth? And children have a very strong intuitive grasp of this. They can explain to you why a particular animal thrives in a particular environment. They won't have all the details; they won't necessarily have the right details, but they have a sense of this. And this is – and I'm making comments about kids – really, anyone who doesn't have a severe cognitive developmental issue is going to develop in this way.

Similarly, mechanics and bounded objects, young children have a sense of how physical objects work in space. One of the most interesting studies I've found is that young kids, even pre-verbal kids, know that two objects traveling in space coming upon a common point will not interpenetrate; they won't go through each other as they might in – in "Star Trek." They'll actually collide and won't occupy the same space at the same time. That – that is a foundational idea in physics, something that we can build upon.

To give you a little example from my own home, these are pictures of my kiddos playing a game they used to love to play. These are two years old now. The kids – my kids are a little older now. They – this is when they were five and about two, playing groundhogs. And you can see the pillow placed over the – the seat and the – the leg rest provides cover for the groundhogs to go underground. And what they'd do is they'd go about the living room foraging for, you know, what they called seeds, and then they'd

come back and somehow fit both of their bodies in that little space and keep each other warm, behaving just as groundhogs might. So this is just an illustration of the kinds of things that kids do naturally, the kinds of play they engage in that can support their development of scientific reasoning.

Moving on, another dimension of their competence is what I would call abstract reasoning, processes that are critical to – to – to their development of scientific skills and knowledge. They are not concrete and simplistic thinkers. So, there's a series of studies that I – I think is most illustrative of this insight into children's use of models in which researchers have children work with little dollhouses that represent scale models of actual houses. And the researcher will place something like a box of chocolates in a particular place in the model, and they'll ask the child to go into the real house and find that box of chocolates. And lo and behold, the children will do it.

Now, what does that say? To me, that says that the children are able to use models to solve problems, much as those scientists depicted earlier on the slide were using the graph of an actual scenario on a smaller scale to think about what that represented and solve problems. So this is a fundamental part of science that happens in all – all domains, of – of the sciences and which young children can do. Again, it's an emergent new thing. They need help; they need support to do it well, but they have the fundamental resources to pull this off.

So I'm going to draw another example here of – of what I would call theorizing, or explaining, coming up with explanations of observations. This is from our colleague here at the University of Washington, Leslie Rupert Herrenkohl. Leslie was working with a first-grade classroom, and the kids had observed that they had a critter, or what they thought was a critter, come into their classroom. It was in the fall, they'd been doing some stuff with pumpkin seeds, and their pumpkin seeds they thought were disappearing. So they devised a system to sort of catch and observe what was happening when they weren't present.

They laid out a trap – I won't read it to you because I have a feeling time is – is limited. But you can see in the slide they – they laid out pumpkin seeds and counted them, they sprinkled powder on the ground around this "trap," and they had an idea of what they would – if they saw footprints, if they saw scratches, if they saw fewer pumpkin seeds, that would tell them what had happened. So young children, again, engaging in sophisticated reasoning about the natural world that I would say approximates science and is – is a good guide for how we should think about young children's capabilities.

Finally, there are a couple observations I want to share with you from my world. I'm slightly ashamed of this, but in science education, K-12, we have been very bad about depictions of young children. And I'm just going to quickly quote these. At – at the top line – this is from the National Science Education Standards, which are fortunately being revised as we speak, "Young children think concretely about individual organisms." I think that's not true. I think they think in sophisticated ways about the relationships among organisms and with the natural world, and I think there's a lot of evidence that we now know supports that view.

Similarly, from the AAAS – that's the American Association for the Advancement of Sciences – they're calling for theory to wait because theory won't be right. Kids won't have the accurate scientific explanation. I think that's the wrong message. We need to be thinking about kids generating theory, theorizing. Let's not worry about whether it's scientifically accurate. Let's support their meaning-making processes and help them along the way, because it's a lifelong venture that we're launching them on.

Finally, I want to close with a bit of levity and a little bit of popular culture. I received an email on November first from several of my friends saying, "Look at this video of kids. Can you believe how they're – they're engaging in argument?" They know that I like argument and how kids construct their meaning through argument. This is from "Jimmy Kimmel Live," in which he did a little – a little project with his viewers and asked them to do something that I would never ask anyone to do with children, but I found him using nonetheless.

He asked them to – to tell their children the day after Halloween that they'd eaten all of their – their Halloween candy. And most of the children reacted by screaming and crying in ways that, frankly, made a lot of sense to me. But one little boy and his brother responded in a much different way. And I think it's illustrative of what kids can do, so let me play this very short clip for you and – and debrief with you. The little boy you're looking at, I'm guessing, is about five or six years old, and he has a little brother who's not in the image who's significantly younger. So here we go.

[Audio clip begins] Younger Brother: What?
Older Brother: She ate it. What the heck?
Younger Brother: Mom!
Mom: Don't you guys think you ate enough candy last night?

Older Brother: No, I only had like one bite of candy. Are you serious? [Laughter] And you ate the rest! Oh, good for you. Now you're probably going to get a bellyache. [Laughter] That's why you shouldn't eat so much candy. Mom, there's two.

Mom: Two what?
Older Brother: Two bags of candy.
Younger Brother: 2 + 2 is – equals 5. [Laughter]
Older Brother: It's really four. You were so close. [Audio clip ends]

Dr. Shouse: So the – the point of that one, I think, is – is that, you know, young kids will engage in argumentation, which is sort of a fundamental thing we do in science. We represent our ideas and we support them to the best of our abilities. And that little boy's doing it. Of course, it's about candy, right? And we know kids will do certain things for certain things that motivate them.

Let's look – what we need to do is think about how we tap into it and support that in other domains. So the other interesting insight in that is that the – the big brother is being extremely supportive of the

little brother. You know, he tells him that 2 + 2 = 5 is really close, so it makes me think there's a lot of facilitation or mediation going on in that household. What – the question for us is what can we do to see more of that kind of engagement with peers, with – with siblings that would support the development. With that, I'm going to hand the baton to Ximena, who will share some insights into practice.

Dr. Ximena Dominguez: Well, that was a great presentation, Andy, and I wanted just to echo some of the things that you've said. I think, you know, my – my work has been mostly in – in – in preschool and mostly in Head Start, and some of the things that Andy said I think deserve to be further highlighted. I think it's – the – the focus on science has been relatively newer. And those of us who have been doing research, like with – with the early ages have noticed that, unfortunately, even though we know that this is – that it is really important – like you were saying, Andy, that we need to be promoting interest in science early on, that this has been actually the school readiness domain that has seen less gains across the preschool year. And so I think that that has created a lot of attention and has highlighted some of the importance of – of really being very conscious about – about promoting science – science early on.

So after – after Andy's presentation, what I wanted to do was talk a little bit about why we should be teaching science early on and how it makes sense in the preschool context, and how we can go about promoting science early on. So, one of – one of my favorite things to see when I go into a preschool classroom and I see science being promoted is that it really capitalizes on children's natural curiosity and initiative.

So like Andy was saying, you know, kids come into the classroom with questions, wanting to know about the world around them, wanting to know why things happen and how things happen. And when you see science, and – and hopefully you all can see images on your screen right now – you see kids being naturally curious, wanting to know, wanting to take the initiative to engage in an activity.

So you can see the girl on your left really thinking about, you know, how the plant has grown. You can see the girls in the middle seeing how – how things move, and maybe what car is moving faster and how you can change – how you can change motion. And you can see the little kid on – on the right really engrossed in thinking about the fish in the classroom and maybe – maybe they fed him and – or what's happened or how he's grown. So, it really captures, you know, the – the – the engagement that kids have at this early age.

Teaching science can also promote really important cognitive skills that we're all interested in – in early childhood. So, it can promote things like reasoning and critical thinking and problem solving. So if you see the kid on the screen right now, you can really think about how that child may be thinking about important things such as cause and effect and, you know, knowing and understanding what happens when he manipulates the object in a certain way. And all of these things we consider really important skills that can really help children learn throughout their – their educational career. And one of my favorite things about why I say teaching science can be really beneficial in addition to being really important is that it really helps foster readiness in other domains.

So, there are different teams of – of science researchers that have noted, for example, that science is very closely tied to mathematics. And you'll probably have read from Rochelle Gelman and Kim Brenneman; they've done a lot of work integrating math and science. And you can think of certain things like measuring, which we traditionally have thought about when we think about mathematics, being really important also for science. You see the girl on the screen measuring the plant and maybe keeping a record of how the plant is – is growing or changing across time.

Another really important skill that I think we – we see in – in classrooms a lot is being able to sort things; so, being able to observe things and compare them based on characteristics or different features. So for example, here you would see that actually the kids are sorting different kinds of insects, And you can see that there is multiple characteristics they may be sorting by. They may be sorting by colors, or they may be sorting by features, how many legs or things like that.

Science is also very closely tied with language and literacy. And so, scientific experiments like Andy was describing give children the opportunity to really think out loud and explain their thought process, and theorize and be able to say what they think would happen, and be able to then test what – what their hypothesis was and see what actually did happen, and then engage in some – some process in which they can better understand the phenomena or something – something they were experimenting about. And this gives them the opportunity to really develop their vocabulary, their reasoning. It also gives them an activity that they're really interested in; and they can then go, for example, into a science journal and also do some writing and some documenting or recording of some of the observations.

And finally, science can also help promote approaches to learning, which we all know that is a really important and understudied domain of early – of early readiness. And when you – when you engage children in really meaningful experiences, children are more likely to be engaged. They're more likely to pay attention. They're more likely to persist at a given task. And so, science activities give them that opportunity to really captivate and – and motivate them to engage in learning.

But what – what really is teaching science early on? And so when we think about teaching science, I think we – we often think about the scientific method. And – and you think about later in elementary school and you think about high school, and you think about this process of being able to ask a question and – and conduct some research, and being able to state hypotheses, test them, analyze data, and then report the results. And often I think those words make folks think, you know, this is something that we can't do in preschool, you know. Some – for some people, thinking about data seems like a loaded word, or "researching" seems like a loaded word, for a preschool classroom. But like Andy was saying, it's actually what we engage children on an everyday basis.

So we're thinking about this similar process, being able to engage children in what we call process skills, or inquiry skills. So, you all have seen children conducting observations, being able to observe what's going on around them. When they go out into their recess time, when they go out to the outside area, they're observing everything around there. When you're actually introducing an activity in the classroom, they're observing how you're engaging that activity.

Children are able to compare and contrast and see how things are different or how things are the same. And then like Andy was saying, they're able to see things and – and pose questions, and say, you know, why the sky is blue or why did that car move faster than the other, and really come up with questions that then you can take into an activity so that they can experiment and see what happens when – when – when you do something – what happens if you do two things differently, and then be able to record their findings to be able to draw conclusions.

So even though the scientific method seems, like, a little bit more complex, it's really what we engage children when we teach science. And in preschool, we can do this in developmentally appropriate ways by engaging children in – in activities that tap into life sciences. So for example, living versus non-living things, being able to understand how – what – what humans need to live, how humans are different from animals.

We also can teach them really important earth science topics; so being able to understand weather patterns, being able to understand soil, and being able to understand other components of the earth. And also, physical science content. Like Andy was saying, you know, kids really come to preschool ready with understandings about their physical environment. And so being able to understand about how things move, for example, is something that they're – they're very good at and they have a lot of really important questions about.

And we'll be, you know – we – along with some researchers at the University of Miami, we conducted a review of all of the early childhood standards, so any standard in any state or nationwide that had – that had any component of science in it. And some – some states have science separate; so they have science, math, language, and literacy.

And some states actually have it embedded within their cognitive readiness domain. And we – we took a look at that. We took a look at all of the early childhood curriculum, and what we saw is that in – in using different language, everyone is really interested in trying to promote both these process skills, and also some develop – developmentally appropriate content in preschool so that then kids could actually move on to kindergarten with a better understanding of both math and science.

So what – what is really important? I know we – we don't have too much time and we want to leave some time for – for questions, but what is really important for us to keep in mind as early childhood educators is – is setting up the stage. And, you know, we've done a really good job of thinking about what are appropriate areas in the classroom to promote; for example, language and literacy. And we – we know that we need a really cozy book area in classrooms where kids can go and do some – some reading or engage in collaborative reading with others.

In similar ways, we know about our block area and how that's important for mathematics, and the same – the same is true for science. We – we need to make sure that kids have an area in the classroom or opportunities in the classroom to engage in scientific activities and experiments and – and

collaborations with peers. And so, a lot of the materials that become really important, for example, are being able to have a water table or a sand table; being able to have manipulatives or – or – or tools like rulers and measuring cups; being able to have magnets, magnifying glasses that kids can actually take outside as well. So a lot of these things actually invite children to engage in – in scientific exploration.

We also want to be very conscious about planning activities – so planning scientific activities. So these could be very simple things, and a lot of – a lot of preschool classrooms are already engaging children in these activities naturally. So, you know, a lot of classrooms that I've been to have already engaged in doing some activities around plants and inviting kids to understand what plants need to live, and what are the different parts of a plant and what are they useful for, then understanding what – what happens when you don't give a plant something it needs to live.

And so, for example, one kid – I remember being in a classroom and a kid asking, you know, "If a plant needs light, what happens if I don't put a plant in a place where – where – where there is enough light?" And, you know, I remember the teacher putting that plant close to the closet and then putting one in the window and kids being able to record the growth of both plants in their journals. So, for example, you can do an activity with – with plants but really be tapping into this bigger idea or – or bigger concept of how things grow and how things change; and then you can connect that to how children are growing themselves, or how other things around them grow.

In a similar way, I've seen a lot of classrooms engage in – in cooking activities. I was just doing a workshop this past week, and – and I had a group with an excellent idea about... They – they made applesauce in – in the classroom, and it really introduced this bigger idea of transformation and – you know, and how things – how things change and how things transform. And they were talking about touching the apple and using kids' senses to really describe what the apple was like before they used it to make the applesauce. And what happens to things when you heat them? What happens when they cook the applesauce? And they had already gone through this – this process and how it looked at the end.

Another common science activity that I've seen is really engage learners' ideas about weather; you know, the – the changing of seasons or weather on a daily basis. I think a lot of classrooms really discuss with children, you know, what they're wearing, why they're wearing certain clothes, what the weather looks like outside. Most people have the opportunity to take children outside. Being able to grasp things or – or, you know, having a better understanding of patterns is – is really important.

Dr. Schwartz: Okay, so this is Ilene Schwartz again, and I'm going to end our call today. We had almost 500 people on this call today, so I thank you so much. And once again, I want to give a big round of silent applause to our speakers. They really got us thinking about how do we introduce young children to science. Thank you so much.