

## Science and Math in Preschool Curriculum: Can All Young Children Benefit?

Gail Joseph: Well, good morning or good afternoon, depending on where you're joining us from. It is the fourth Monday of the month, and so this means it is time to welcome you to the Front Porch series. I'm Gail Joseph. I'm co-director of the National Center on Quality Teaching and Learning, and our Front Porch series is a collection of broadcast conference calls that take place on the fourth Monday of every month, where we gather around, like on a front porch, to hear a national expert on a topic related to quality teaching and learning in young children.

So, on behalf of my colleagues and I at NCQTL, I'd like to welcome all of you to our broadcast call today. Today, we focus on a topic that is of great interest to many of us in early learning, and that is STEM: Science, Technology, Engineering, and Math in early learning. So, STEM is getting a lot of focus in K-12, especially with the Common Core math standards making their way to each state and school district, as well as, the recent publication of the Next Generation Science Standards adopted now by dozens of states.

So, now, in Head Start and in other early learning settings, we're wondering how best to prepare our young children to be successful in math and science in school. But at the same time, early childhood educators don't always feel as well prepared in these areas as they do in other domains.

So I'm absolutely thrilled to introduce our speaker today, who will address STEM in early learning. And I'm going to give you a little bio of her, before I turn it over to her. Our speaker today is just the most wonderful, Dr. Eva Horn. So, Dr. Eva Horn is a professor in the Department of Special Education and an investigator for the Life Span Institute for Developmental Disabilities at the University of Kansas. One of the great things about Dr. Horn, among many, is that she was a classroom teacher of young children with disabilities, for over 10 years, which I think is one of the reasons why her work is always so applied and relevant. Her research interests focus on effective instructional techniques for infants, toddlers, and preschool children with developmental delays or at risk for disabilities and their families. She has directed numerous externally funded grants -- many, many, many -- including personal prep, doctoral leadership, et cetera. But she's currently the PI for a multisite IES project called Children's School Success Plus, addressing high expectations, early childhood curriculum for all preschool children, including those identified with developmental delays and disabilities, which I'm very excited we will hear more about today. And so now, without further ado, I'm turning the mike over to our presenter, Dr. Eva Horn.

Dr. Eva Horn: Thank you, Gail. That was quite an introduction. So, I am excited to talk to you about science and math, in particular today. And -- but I'd like to just start off with just kind of giving you an overview of what we're going -- what I'm going to talk about today, or share with you today. And so first of all, just a little bit of kind of getting us all on common grounds and a basic understanding -- and Gail did a nice job of doing that, talking about some of that in the introduction, but this notion of STEM and how it relates to early childhood or our young children.

And, then moving more specifically into two areas of STEM -- two really important components of STEM, The math and science, and looking at the -- you know the key concepts, the content that we should be teaching that's age-appropriate for preschool, and then, some thoughts about teaching strategies that we would use across those two. And then I'd like to end with, as Gail mentioned, our Children's School Success Plus project has been working on challenging curricular content for all children. And so, I'm going to share a couple of our activity plans that include science and math being embedded into the learning opportunities for kids. So, that's kind of how this next 30 minutes or so is going to go. So, let's go ahead and get started.

The first thing is just, "Ah, what is this thing called STEM?" And, interestingly enough, as Gail said, you know, it really has become a real important issue, when we're talking high school, middle school, and even elementary school, in terms of really putting a focus on our -- making sure that our young, our newest citizens, as they move up the educational ladder are really highly skilled in these areas. And, in fact, it's been noted that, as you can see on the slide there, that these core technologies -- science, technology, engineering, and math; these core areas have really been seen as the underpinnings of an advanced society.

And so, you know, it really is seen as what's going to keep us competitive in the world. So, yeah, is it important? Definitely that's been put -- put forward for all of us. But what do you think about when you think -- when you hear the words science and math? And quite honestly, I -- you know, I think you're probably -- I certainly feel this way; it kind of makes my heart race a little bit. My memories of high school, when I think of science and math, I think of high school and I think of algebra and calculus; I think of physics, you know, topics that weren't necessarily easy for me. And yet, you know, again, we need to be thinking about laying these foundations early.

So, what does it really mean for us, in early childhood? Well, STEM actually has a real relevant place in early childhood education. And again, we're seeing lots of evidence of that. Just a quick couple of tips to kind of remember is that, you know, really, children are a lot more competent in math and science than we initially thought, and that we, as teachers, sort of gave them credit for.

Just a couple of examples from our research literature. We know that truly infants are born with kind of this intuitive math and science skills. There're ways in which we react and interpret our world, react to things in our world and interpret those things that we're experiencing. For example, there was a study showing that infants as young as 9 months have a sense of numbers. And you say, yeah, right. But actually, they do. They will move their eyes to a picture of two circles when they hear two drum beats played, instead of the picture of three circles. Seems pretty hard to imagine, but in fact, they do. They are already sifting through information and making sense of that information. We also know that, the second item there, that the gender -- male versus female -- and the socioeconomic gaps that we see in later schooling around STEM topics actually can begin in the preschool years. So, children -- females and those of lower socioeconomic status -- tend to have less exposure and less opportunities to engage in challenging curricular content around science and math.

So, again, really important that we change that trend. And then, finally, to kind of ease our minds, as early educators who may be a little nervous about science and math, we really don't need to know all of the answers. We just need to help children ask the questions set opportunities to ask questions about their world in a mathematical, scientific way.

So, let's take a look at, specifically, just narrow it for just a second back down to science and math specifically, which, again, is kind of the focus of my topic today, even though it's nested within the STEM. So, just to reiterate; we do know, in fact, we have significant evidence to show that children -- that math skills, demonstration of math skills at kindergarten entry are actually the strongest predictors of later school achievement. We've had a lot of emphasis on literacy, and that doesn't mean we should stop doing literacy, by any means, but, actually, math is one of those content domains that is even a stronger predictor than literacy skills, on par with language and communications skills.

What about science? Again, we've often thought that, you know, scientific thinking, experimenting, is really not appropriate for preschoolers, but again, we know that science -- and this isn't facts and figures around science -- but it is actually most importantly about critical thinking skills: Being able to observe, think about, understand, and then communicate things that we're trying to understand about how the world works, or doing science.

So, what are some just basic ways that we might actually, sort of, promote that science thinking or doing science and math within our preschool children that we're working with? So, a couple of -- a series here of ideas about just how to sort of generally start, and many of these you're probably already doing and you just need to sort of think more intentionally about making multiple opportunities to do this. So, always focus on understanding of concepts. So, for example: "Why doesn't the shape" -- if you're holding a rectangle -- "belong with the other shapes, triangles?"

So, again, making them understand the concepts of what's the difference between a rectangle and a triangle. Encouraging them to use analysis and reasoning skills. "Why do we need to wear a coat outside today, when we didn't need one yesterday?" A very normal conversational approach with kids, and yet really hits on those analysis and reasoning skills. Making sure that concepts go across activities, that we've linked those concepts: "Remember when we looked at and touched different types of rocks, yesterday? Today, we're going to make some guesses about how heavy or how light those rocks are." So, connecting previous experiences with the next day's experiences or the next hour's experiences. Sparking thinking: "Let's brainstorm all the ways we might get from the door to the playground." Supporting observation and evaluation: "Would you want to live in the house that one of the three pigs made out of the straw or the one out of brick? And why would you want to live in the one that you picked?" Also help think -- help them thinking about the process of thinking.

So, not just giving the answer, but -- the child giving the answer, but, "How did you know that?" or, "How did you figure that out?" So, that you really help them not only understand what they're thinking, but the child themselves thinking through that process of how they made that decision. And then, lastly, lots of applying of concepts. "Let's make a graph to show how each of us got to school today. Bring your picture up here and put it next to the bus, the car, or the walking feet." Again, lots of things that you typically do, but, again, we're talking about making sure that we're very playful about getting these things done.

So, let's move on and look just quickly at some of the ways that you might embed science and math. And again, very natural in the way that we do plan our routines and schedules of our preschool days. Math and science can be wonderfully taught in either large or small group; it can be integrated with other topic areas such as literacy. Who should be doing it? All of us should be doing it. Providing families with activities that they can also do at home that create opportunities to do math and science.

So, what are we doing? Primarily, what we're looking at, in terms, of science is we're wanting to promote vocabulary, prediction, and experiments. And we'll talk about that a little bit, as we look more closely at science. And then, in math, we have a range of kinds of things. It's not just numbers and it's not just counting, but it's graphing and recording data and shapes and patterns. And again, we'll talk more specifically about what those expectations are. And then how you really need to plan intentional opportunities through activity plans or other ways in which you systematically plan to integrate science and math in your daily schedule.

So, let's look first at math. And just a real quick example here to move us forward on math. I'm going to read you a really simple example, but there's a thing called mathematize an experience. And that's a little bit of a made-up word, but I think it's a really useful way for us to think about games and activities that children are engaged in naturally, and how we can, in a very naturalistic way, embed a math -- or mathematize that experience.

So, here's a little quick story. We've got 4-year-old Corky. He wants more cars than Eugene has. If he takes two cars from Eugene, one, we'll probably have a little bit of a social situation here, but the -- but we can also look at it as a math problem. He is adding. He notices that Eugene has more cars than he does, and he wants to have more cars. So, while he snatches the cars away from -- while Corky takes the cars away from Eugene, he's actually experiencing adding, and Eugene is experiencing subtraction. Now, obviously, it's not the right way to get more cars or to do addition, so, the teacher could just, for example, step in and say that he needs to share and simply divide the cars up, between the two boys. Or she could engage them in a conversation about how to create two equal sets of cars. So, rather than just doing it for them, she can mathematize that little example.

So, let's take a look at -- whoops, sorry, jumped ahead on myself. And again -- okay, so looking at this particular slide, basically, what we have here are all the different kinds of content that we should be addressing within mathematics. As you can see, it's not just numbers and operations. It's much more than that. Numbers and operations, how many, is definitely important. Geometry and spatial sense. So, you know, understanding shapes, absolutely, but also directions, locations, objects related to other objects become really important in that domain of mathematics. Measurements, comparing things: How much, how much they weigh, how long they are, what's longer, what's shorter. Those are all important measurement concepts that can definitely be integrated into preschool.

Patterns, algebraic thinking, displaying and analyzing data. Kids really seem to love that one; classifying, representing, and using information to answer and ask questions. And then, there's time: Sequence, day and night, morning and afternoon. Now, one quick -- and by the way, all of these content domains are part of the National Council of Teachers of Mathematics standards for preschool, and a wonderful tool to take a look at and to really understand what is developmentally appropriate and yet, really challenging, in terms of promoting mathematics thinking in preschoolers. One quick little caveat or word of caution is around time. And I know there's hardly a preschool classroom or kindergarten classroom that we go into where teachers are not engaging in calendar time. And we really do need to be cautious about that. I think we often think about that, "Oh, what a great way to teach math skills or counting skills." And actually, it isn't really the best way to teach.

We have found that -- and you can see the limits listed there on the slide: 7-day week really isn't anything like our ten-based number system. And so, that can be somewhat confusing, using 7 there. Children, typically, are simply reciting the numbers that they hear. So, it's rote counting; it is not any kind of understanding of the concepts of numbers. They frequently have mastered rote counting long before they understand the concepts of time. And so, really it's just an exercise of practicing potentially something they already know how to do, counting to 7. And then, finally, pointing to squares on the calendar really isn't -- which just reinforces the pieces above -- and not an effective way of teaching counting.

So, what should we do? Does it mean we don't do calendar? Well, of course, not. But, calendars should be used in the way that people use them in their homes: To note and plan for, anticipate, and remember significant events. It's a great way to talk about, "So, today, these are the things that are on our agenda," or, "We've got X coming up, because of -- on a particular date." Birthdays, trips, visitors coming into classrooms, et cetera. You know, we put calendars in our house and our office centers. We use them in a real way. And certainly that's an appropriate thing for preschool teachers to be doing. And to also be introducing the vocabulary around time and calendars. So, days and the names of the days of the week are certainly, helpful. And the months of the year are, again, helpful for children to start learning, as long as we don't do it in a drill kind of fashion. So, just a short -- well, relatively short caution there.

Okay, so moving on. And I'm not moving on as fast as I need to, so, I'm going to pick up the pace just a little bit. So, again, I think pretty clear that math can be embedded throughout play. There's multiple ways in which we can do that. We can do measurement weighing and comparison kinds of things in our marketplace center where children are playing. And certainly tabletop activities; we can do a lot of patterning and sequencing kinds of activity and, certainly, even book reading can be a wonderful resource.

Let's jump ahead to science. So, again, what are the primary, the critical components that we need to pay attention to in science? We've got physical science, learning about light and properties of matter, characteristics of light and sound. Really important basic ideas, and kids just have a great time with those. Life science: living things, non-living things, what makes something a living thing? What makes living things grow and change? A little bit about the human body: How are we same? How are we different? Earth and space science: Understanding about the sun, the moon, observing weather and the changes in weather, learning about mountains and oceans and the different topographies of our world. And, most importantly, learning about scientific inquiry.

Scientific inquiry in early childhood: What do we mean by that? Well, basically it's a series of thinking through logically, raising questions and thinking about things that we've seen, objects that we've seen, making predictions about answers to those questions, exploring the objects, acting upon the objects, thinking about, acting out the activity, seeing whether our predictions are going to be there, observing and recording what happens, and then, communicating those ideas through multiple different ways.

So, here, a quick example. Teacher takes a whole apple and writes down what they say. She asks the children to explore it and then, writes down what they say. It's red, round, smooth, and cold. And then, she asks the children to make a prediction, something like a guess, the teacher says, about what's inside. So, they list off some things such as: It's probably white inside; maybe, it has seeds inside, and then, they act upon it. They cut open their apples, and the children check their predictions. And again, record what they found. They found that it was white and it had seeds; ah, but it's also wet. So, they're checking up on those predictions, adding to those predictions, and then, communicating those outcomes. A really simple way to do scientific thinking and inquiry and yet such an important activity for children to do in a very systematic, planful way.

So, how do we teach -- what are some of the ways that we might teach science? So, here you see a couple of girls, and we know that children are naturally curious. So, in this photo, you see these two girls, and they're looking at a starfish in a tide pool along the ocean. And, no, we don't have oceans in Kansas, but these are actually my grandkids out on the Oregon coast and looking at this, and I just thought, you know, it's just a perfect example of the curiosity, their excitement about it. And you can just imagine their sense of wonder and questions forming in their thoughts, as they see something familiar in shape -- see the starfish laying there? -- but very different from the hard shell-like collector's item that they have seen actually in the little stores around the Oregon coast there. So, again, they start asking questions and they start thinking about that, and what a wonderful opportunity for children to observe, investigate, ask questions, make predictions, and seek answers to those predictions.

So, moving on just a little bit here; what I'd like to share with you now in the last seven or so minutes that I've got left is a little bit of the work that we've done on the Children's School Success. Hopefully, by sharing some of those components of what math skills we can be working on and the science skills that we can be working on and what fun we can have with it, I've inspired you to think about how you might incorporate this into your classrooms.

So, let me just give you a couple of examples from our curriculum that, again, make it a little bit more concrete, in terms, of the kinds of lessons and activities that you can create for young children. So, basically our curriculum is an integration of our curriculum framework, actually integrates curricula in science -- we actually use the Literasci curriculum, which formerly was called ScienceStart! -- and a literacy-based book reading format, and math, using a lot of the materials from Doug Clements' Building Blocks curriculum, and then the social-emotional skills from Carolyn Webster-Stratton's Incredible Years. So, we used a range of different kinds of activities, but integrated them together.

Show you one really important piece that actually ran through, both through the science, the math, the literacy; it really ran through all of our activities, and that was a scientific method. So, that the teachers actually used this four-step scientific method to engage in activity planning and activity implementation. It's actually adopted from the ScienceStart! curriculum. And, again, a great resource to take a look at, in terms of both developing science lesson, as well as, integrating science lessons into other kinds of activities.

So, the first thing that we have children do is to reflect and ask, and the teacher guides that. So, understanding the problem. And this could be a social competence kind of issue or a social dilemma, as well as, a science question. Then, they plan and predict; they make predictions about what we might do -- what would happen if we did X, Y, or Z. And then they actually implement that: Act and observe. And again, all of this is done as a part of the planning of the activity, and the teachers very planfully come up with strategies to engage children in each of these four steps. They act and observe, and then finally they report and reflect upon what happened through this process.

So, let's take a look at how that looks in a lesson. So, the first -- what you have here is -- it's actually a -- what we call in our curriculum an activity set. And an activity set is a series of large and small group activities that are all part of a theme, and it's essentially what you would do; it's a day's worth of activities that you can do connected to the current theme and unit. So, you can see this is what we call the discovery day. And the theme that's happening at the moment is neighborhood habitats. And the unit specifically is living things. And then it lists -- there's, you know, vocabulary being taught; there's a letter of the day. And again, these are nuances of our particular curriculum, but I wanted to kind of show you the -- how all of the pieces are really integrated in together.

So, then, as you can see, lesson plans included are individual activity plans for different kinds of focused groups. So, the first one is the large, what we call the science group on that particular day, and the large group activity is seeds. And what I really want you to pay attention to here, probably the more important thing, is the problem-solving process. So, in the description of the activity, you can see we always had a review, so we'll skip number 1. Number 2, you see the reflect and ask. So, in the large group activity, the activity, if you will, for the day, is kind of introduced and children begin reflecting and asking questions through guidance by the teacher; they plan and predict what's going to happen around the seeds, and then they're told about how they are going to now enact that, as they go into their small group activities.

Here you have the small group activity, the science small group, which is the seed planting. So, now they're acting on those predictions. They talked about seeds; they talked about different predictions about what happens with seeds; what do seeds need, and now, they are actually implementing that. So, again, there is a plan and predict, sort of reiterating what it is that they're going to do, thinking about what we need to do in order to plant our seeds. They act and observe. They actually implement that. And then they're going to report and reflect about that planting process. And again, in this case -- because, we're talking about seeds, it's going to take a while -- they actually, on the report and reflect, they make new predictions about how long and then how are they going to keep track of that.

So, how are they going to gather data, and how often, how frequently. So, again, really embedding that scientific process, in terms of developing answers to our questions. Then, just to show you how the math got integrated in that, as well. You can see that the small group activity on this day is also related to seeds and about fruits having seeds. And they do a counting activity; they do a comparison activity, as a part of this use of the seeds from the fruit that they had used in previous activities. And then, finally, the literacy activities again, integrate that same theme.

We use the book, Eric Carle's book, "The Tiny Seed." [coughs] Excuse me. And had the children integrating discussions, both from the science and math, but, as well as embedded important literacy skills within that activity. And then just as a resource, these are a number of the books that, in the CSS+ curriculum, we have integrated -- have used in really supporting math and science learning, just some fabulous ones that really help us across all of those domains of science and also, different dimensions of math.

And then what I wanted to last share with you is just a little bit of what our teachers told us. We worked with the teachers for at least three years in many cases. And these teachers were, like all early childhood teachers a bit nervous about science and math and not sure that they had all of the answers and knew all of the content in terms of science and math, and yet they gave us really positive feedback. They got -- they got sucked in by the fun of teaching science and math. They said the children loved to make predictions about what happened and I'm definitely seeing that.

And then another one that, just real quickly, that I thought was wonderful, was -- and saw so much of in classrooms -- is data analysis and graphing. Kids loved it. And they would go back to those graphs, again and again to see how things turned out. And they'd talk about, "Oh, that's what I thought it was going to be," or, "Oh, boy, I got that completely wrong." It was just really fun to watch these graphs plastered all over the classrooms and kids really having a good time. And it was a really wonderful integration of both the science and the math concepts.

So, finally, my time is up, I know. And in fact, I'm probably a couple of minutes past my time, but a list of references that I used both in this PowerPoint, but also resources that I have found incredibly important in really understanding these two important areas for young children.

Gail: Thank you, so much. It is rare that we want somebody to just keep going and going, and I was hoping you would just keep going and going. So, that was just a great wealth of information. And of course you can talk teacher-ese, so, we always appreciate that so much, Eva.

Eva: Oh, my!

Gail: Thanks to everyone for listening. We'll see you next month on the Front Porch.