TEACHING STEM IN THE PRESCHOOL CLASSROOM

EXPLORING BIG IDEAS WITH 3- TO 5-YEAR-OLDS

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What Is STEM and Why Teach It in Preschool?

At report card night I shared with a parent that her child’s science skills have shown progress based on his scores on HighScope’s COR [child observation record] assessment. Mom’s response was, “I know!” Then the student shared, “I love science!” This kind of interaction hasn’t happened in my 10+ years of teaching pre-K. I felt like I wouldn’t have mentioned this before I started participating in this study. I’m slowly overcoming that fear of not knowing all the answers when it comes to science and sometimes math, and I have this study to thank for it.

—Teacher participating in STEM professional development project

WHY THIS BOOK?

Almost certainly, you have heard adults say—or you have even said yourself—“I’m not a math person” or “Science is hard.” You will not often hear a young child say it. Children tend to express the opposite sentiment! Young children are naturally interested in the math and science that is all around them. They count how many crackers they have, they find patterns in the classroom, and they are curious about why a sunflower is so tall. Their passion for discovery can be quite strong, as illustrated by my (Alissa Lange) then 2-year-old son when he proclaimed vehemently after pouring water into his dinner (again), “Mama, I need to do it.”

Children have to be taught to believe that science, technology, engineering, and mathematics (STEM) are hard and that they cannot do them well (or that they’re for boys). Two of us (Alissa Lange and Kimberly Brenneman) did not love mathematics during school. We were successful enough students as far as grades went, but it seemed that math was just a lot of rules to memorize and apply. We only became passionate about math when we began to work with young children and their teachers and saw the many ways that very young children reason mathematically, and that great teaching can support this thinking. One of us (Alissa Lange) worked on an evaluation of a
preschool math curriculum, *Building Blocks*, and related professional development model, which sparked her excitement about math. That research showed that children whose teachers used the *Building Blocks* curriculum and the accompanying teaching practices learned more mathematics than children whose teachers did not. These children also showed stronger language skills! (See the section “Why Teach STEM in Preschool?” below for more on the power of early STEM.) This experience highlighted just how much *sense* math makes and how accessible it can be for young children, when taught in a way that is in line with children’s development and interests.

Science, technology, and engineering similarly can be exciting for children as they explore on their own and when facilitated by a thoughtful teacher. Children can really *do* science and engineering. Watch them try to balance blocks in a really tall tower, discover how worms move and burrow, or test whether their dinner will get wet (again!) and whether Mama will suggest that they experiment with something else instead (again!). Invite them to help you solve a problem. What can we do if we have a spill, but we do not have any more paper towels? What could we use instead? Which materials are good for absorbing liquids and which ones are not? How can we find out? (See Figure 1.1.)

Children can, and deserve to have chances to, *think about, talk about, read about,* and *do* STEM. STEM explorations can support critical and logical thinking, problem solving, and literacy development. Classroom explorations can build on what children are already interested in, thinking about, and doing—perhaps informally or nonverbally—from an early age. When a teacher we worked with introduced the topic of frogs, children were drawn to the library books the teacher had on frogs, tadpoles, and the life cycle.

**Figure 1.1.** Trying to soak up water with parchment paper.
They pored over the photographs in the books and wanted to know how frogs go to the bathroom, if they drink water, if they sleep, and what those little white “bubbles” (eggs) were.

To foster and further develop children’s natural interest in STEM, adults sometimes need to revisit (or overcome) their own relationships with STEM. If we learned that STEM is really hard and only a little fun, how can we join children in their understanding that it is doable and enjoyable? To do so, teachers (and families) might need to be supported to build their own confidence, knowledge, and competence in STEM so they in turn can support and empower children to be confident in their knowledge and competencies. (See Chapter 2 for more.)

Another challenge that educators face concerns children’s varied levels of experience, understanding, and skills. Linguistic differences can also present challenges and opportunities as teachers aim to help all children reach their full potential. Providing rich, accurate, exciting STEM experiences for young children is good for all children in all developmental stages (see below, “Why Teach STEM in Preschool?”).

As our culture is becoming ever more technologically focused, we need to support our children to become the next generation of thinkers, builders, scientists, mathematicians, and STEM-literate citizens. Teachers are looking for strategies to do so. Our goal in this book is to empower educators and educators-to-be with the content knowledge and skills needed to bring more STEM into the preschool classroom, an awareness of how key STEM ideas develop in young children, and strategies to engage and support each STEM learner. We also hope to foster educators’ confidence that they can engage children in meaningful STEM learning experiences and support positive attitudes and dispositions toward STEM so they can model these for children. We hope that readers will be empowered as STEM teachers, much as this educator who participated in a STEM professional development project describes:

I believe I give more thought to preliminary steps in my lessons [as a result of participating in a science and math professional learning opportunity]. I do more checking for understanding before moving on and attempt to use simpler goals for each lesson . . . breaking each goal into smaller steps.

WHAT IS STEM?

STEM stands for science, technology, engineering, and mathematics. These domains have been clustered together because they are intimately related to one another. (And, after some time using METS and SMET, we think the field has found an acronym that will last.) Science is the study of the natural
world and includes major content across life, physical, and Earth and space sciences. Science includes a body of current knowledge about the natural world as well as an understanding of the scientific practices used to obtain and build this knowledge. Chapter 3 describes science practices used in the scientific inquiry process, why science is important for young children, what are best practices in teaching science in preschool, and what are some scientific concepts and processes that children can explore at this age.

Technology includes digital media like laptops and smartphones, but technology also includes any human-made objects created to make work easier (like a spoon or a pencil). Technology is created through the engineering design process, and it can be used to explore natural phenomena (for example, using a windsock to measure the wind). Chapter 4 describes technology in the preschool classroom in more detail.

Engineering involves using science, math, and technology to solve a problem. Engineers identify a problem, think about a solution, test a possible solution (prototype), and revise the solution as needed. Chapter 5 describes the engineering design process and outlines how preschool educators can engage children in engineering explorations.

One way to think of mathematics is as a system of rules used to quantify our world. Math is often used to understand and analyze scientific phenomena (for example, measuring—using 1-inch cubes—the distance that a toy car travels after zooming down a ramp; see Figure 1.2). Chapter 6 defines
mathematics, describes how key math ideas develop in young children, and outlines high-quality math classroom activities.

We choose to focus on the ways in which each STEM discipline is unique and benefits children, but we also encourage and value connections across the STEM domains, as well as connections from STEM to other domains such as arts and literature. In each of the four content-specific chapters, we illustrate ways in which these disciplines are interconnected, sharing central concepts, practices, and dispositions. We provide examples for using art to enhance STEM learning and STEM practices, and we include links to literacy throughout, such as great children’s books related to STEM. This interconnectedness is undeniable and enriches our world and children’s understanding of it.

**WHAT ARE THE STANDARDS FOR STEM?**

I now have a much stronger base of [STEM] information and activities to pull from to help organize my day. My science center and activities were [weak] and have definitely improved. I see the children being drawn to that area much more than before. The same for my math centers.

—Teacher participating in STEM professional development project

There are many guidelines, standards, frameworks, position statements, and learning objective lists that outline what children should know and be able to do by the end of their preschool year across many domains of development and learning. Math and science tend to be included in these, but technology and engineering are much less often the focus of learning standards. Some of these include state early learning and teaching standards (e.g., New Jersey Preschool Teaching and Learning Guidelines) and others are national standards, such as the Head Start Child Development and Early Learning Framework and position statements from early childhood and STEM teaching professional organizations (e.g., National Association for the Education of Young Children [NAEYC] and National Council of Teachers of Mathematics [NCTM] joint statement on early math, 2010; National Science Teachers Association [NSTA] position statement on early childhood science, 2014).

STEM learning guidelines that start at kindergarten—the Next Generation Science Standards (NGSS), which include engineering, and the Common Core State Standards—may serve as a reference point for preschool teachers to understand where their children are headed—and where some of their children may already be—on their STEM learning pathways. Though our approach to STEM teaching and learning draws from many sources, our primary aim is not to give a full accounting of all of these. Rather, it is to explore with current and future educators the big ideas of STEM teaching and learning so that they may better make sense of the many
resources that are available. We hope that this book will serve as a guide for teachers as they navigate who they are as teachers, work within their particular educational contexts and circumstances, and consider how they may build on what they or their school districts or early childhood centers already do to support young STEM learners.

**WHY TEACH STEM IN PRESCHOOL?**

STEM in the early years makes a difference in children’s lives. Research suggests that learning rich STEM content during the preschool years is critical to later success in school—not only in the STEM domains, but in others as well (Early Childhood STEM Working Group, 2017; McClure et al., 2017).

**Math Matters**

Research has shown that children’s knowledge and skill in mathematics as they enter kindergarten relates to how well they will do in math—and in reading—in later elementary school (Duncan et al., 2007) and in high school (Watts, Duncan, Siegler, & Davis-Kean, 2014). High-quality mathematics teaching can also develop children’s executive function skills (Clements, Sarama, & Germano, 2016), which are the mental processes involved in planning, focusing attention, and switching among mental tasks. Young children are capable of doing more—and more amazing—mathematical thinking than was previously believed. We know a lot about how children develop mathematical skills and understandings and how teachers can effectively foster learning (California Department of Education, 2011; Clements & Sarama, 2014; NAEYC and NCTM, 2010). Educators can use this information to help children build the strong foundation for future learning that they deserve.

**Science Matters**

Early science matters, too! What children know about the world around them by the beginning of kindergarten is related to their later achievement in other areas, including reading and math (Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010), and the science children know in early childhood correlates with their science achievement in middle school (Morgan, Farkas, Hillemeier, & Maczuga, 2016). Science is related to executive function, too. Children with higher executive function skills also tend to learn more science over the course of preschool (Nayfeld, Fuccillo, & Greenfield, 2013). There also appears to be a bidirectional relationship between children’s science knowledge and their positive approaches to learning (such as being persistent, focused, and collaborative). Gains in one area are linked to gains in the other (Bustamante, White, & Greenfield, 2018). New research