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Connect, Deepen, Extend: Creating Meaningful Science, Technology, and Engineering Learning Experiences

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Young children are curious and highly motivated to make sense of the world around them. Beginning at birth, they behave like scientists and engineers. Preschool and kindergarten teachers can support these natural tendencies by recognizing and taking advantage of the many meaningful science, technology, and engineering (STE) learning opportunities that surround children at school, at home, and in their communities.

The Readiness through Integrative Science and Engineering (RISE) project supports Boston-area Head Start preschool educators to connect, deepen, and extend STE learning. RISE collaborates with educators to build upon young children's interests and curiosities and their families' funds of knowledge to create developmentally appropriate STE learning experiences.

In our role as principal investigators on the RISE project (funded by the National Science Foundation), we (the authors) conducted professional development with teachers. In this article, we share how two partner teachers collaborated with RISE to connect, deepen, and extend children's STE learning through lessons on pedestrian safety and hygiene practices. We also offer ways that early childhood educators can intentionally design and integrate key STE practices and concepts into their own settings.

Using Key Practices and Concepts to Support STE Learning

Ways for children to learn about STE practices and crosscutting concepts exist everywhere: within the curriculum, in response to their interests, in spontaneous or unplanned occurrences, and in daily routines and activities. Children's recurring engagement with science and engineering practices and with crosscutting concepts helps them build rich STE knowledge and skills over time. RISE uses approaches based on the Early Science Framework (ESF) to help teachers develop equity-informed principles that we refer to as connect, deepen, and extend. These

principles are flexible: educators in a variety of settings can use them to draw upon children's interests, knowledge, local contexts, and cultures. (See "Essential Foundations for STE Learning" below for more on the ESF, STE practices, and crosscutting concepts.) In this section, we explain connect, deepen, and extend and share how teachers can integrate these principles into their teaching practices.

Essential Foundations for STE Learning

Daryl Greenfield adapted the Early Science Framework (ESF) from the National Research Council's Framework for K–12 Science Education. (To learn more about the ESF, visit esi.miami.edu.) Both frameworks focus on three components:

- **science and engineering practices** (doing science) such as observing, describing, investigating, analyzing, and interpreting
- **crosscutting concepts** (key concepts that provide coherent connections across experiences and content) such as cause and effect, patterns, systems and system models, and structure and function
- **disciplinary core ideas in science** (science content) such as the properties of materials and their interactions and the needs and characteristics of living things

Educators can intentionally weave these three components together by offering hands-on, inquiry-based learning experiences that build upon children's STE practices and help them to answer questions, solve problems, and acquire concepts connected to STE content. (To learn more, see *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*.)

Connect

Children's experiences with their families and communities create funds of knowledge that provide a wealth of opportunities for building STE learning. *Connect* is an approach that invites teachers to link STE to what children already know and can do. STE concepts are embedded in many of the interests, activities, and materials that children find meaningful—a child's block structure collapsing or the sounds created when they strike a pot can be used to illustrate cause and effect. Teachers can also integrate STE into various content areas through familiar materials, stories, and music. For example, stories like *The Three Little Pigs* can be used in a literacy unit and to discuss stability and change, and songs such as "Open, Shut Them" can be used for a music-focused activity and for exploring patterns.

Teachers can create meaningful STE experiences for children when they work to strengthen home-to-school connections. During a unit on sound and music that focused on how to create sounds (the crosscutting concept of *cause and effect*), one RISE teacher brought an African percussion instrument to her class and allowed the children

to explore it. The instrument was familiar to one young girl whose family had a similar instrument at home. She and her grandmother created a book about the instrument and its origins, which the young girl brought to class. This led the teacher to reach out to all the families to ask about the instruments they had at home and the music that was important to them.

Deepen

Investigations that span days, weeks, and even months allow children sufficient time to strengthen their STE learning. To *deepen* children's knowledge and skills, teachers plan multiple experiences over time to form in-depth investigations of STE topics. This approach provides children with varied entry points and opportunities to revisit and build on STE concepts. For example, children can explore stability and change while outdoors. Teachers and children can take photos of plants, animals, and objects throughout the year and view them at regular intervals to observe differences. They can gain more awareness of their environment and strengthen their abilities to notice, describe, and document changes. They can also engage in inquiry by discussing what does and doesn't change and why and how changes occur with seasons.

Extend

Teachers can *extend* learning by integrating STE into their daily schedules and across activities. Although often confined to STEM-focused lessons or to the science center, these experiences can happen anywhere children go throughout the learning day. With intentional planning, teachers can link STE concepts and practices to children's mealtimes, in the dramatic play area, during read alouds, and so on. Further, teachers can take STE learning outside of the walls of the classroom when they encourage children to consider, explore, and investigate STE in the community. For example, a visit to a local restaurant could include a discussion about the design and use of tools used for cooking.

Integrating STE Learning into Familiar Routines

The following examples demonstrate how two RISE teachers took to heart the importance and value of collecting information about children's familiar knowledge from their homes, neighborhoods, and communities. They drew on this information to create rich STE experiences related to pedestrian safety and handwashing practices in their classrooms.



Pedestrian Safety

On a bright summer day, Grace's preschool class of 3- and 4-year-olds go on a walk in the neighborhood. At the first corner, the children prepare to cross the street. Grace draws their attention to two long, white, parallel lines on the road and tells them, "We can cross here safely when the crosswalk signal says so." The children wait for the numbers of the crosswalk signal to get to zero and for the image of the person walking to appear. Once this happens, they look for traffic and cross. While doing so, one child, Samuel, notices that his feet feel hotter on the black asphalt of the crosswalk than they do on the painted white stripes.

Grace used this neighborhood walk to **extend** the children's STE learning beyond the classroom. With Grace's prompting, the children recognized that the crosswalk was made up of patterns communicating where it was safe to walk. The children watched as the numbers displayed on the crosswalk signal counted down, which was an example of technology designed for a specific function. Once the children began crossing, Samuel noted how different the asphalt temperatures felt. Later, during future class walks, the children were able to **deepen** their understanding as they, too, noticed and discussed the various surfaces and temperatures. The children's observations would create an opening for Grace to **connect** their experiences to an investigation of how different materials absorb and reflect light. (See "Concepts to Explore During a Neighborhood Walk" below.)

Concepts to Explore During a Neighborhood Walk

STE Concepts	Example Questions to Ask Children
Patterns related to traffic signals	What do you notice about the colors and sequence of traffic signals?
Patterns related to the crosswalk signal display	What do you observe about the numbers that are displayed? What do the numbers tell you? How much time do you have to cross the street?
Cause and effect at a crosswalk	What happens when you press the button on the crosswalk signal? What sounds do you hear? What do you see?
Systems and system models of traffic	Why do cars stay on one side of the road? How do drivers know when to stop and go?
Structures and functions of pedestrian infrastructure	Why do you think there are sidewalks, stairs, curb cutouts, ramps, wheelchair lifts?

Handwashing

It's the beginning of the year, and the 3- and 4-year-olds in Tanya's Head Start class are learning handwashing techniques. Before arrival time, she writes a question on the whiteboard: What kind of soap do you use to wash your hands at home? She draws a t-chart and puts a photo of a bar of soap at the top of one column and a photo of liquid soap in the other. As the children arrive, she assists them in placing their name cards under the photo of the soap they use at home. Then, the children compare each column to determine which type of soap is more popular.

Before introducing handwashing at school, Tanya recognized that she needed to learn about the children's handwashing practices at home. Her question provided an opportunity to **extend** their STE learning through a whole-group investigation, and it allowed her to **connect** their home-based experiences with documentation, analysis, and interpreting data. The learning doesn't need to stop there; teachers can use soap as an STE material throughout the year. For example, teachers could **deepen** children's STE learning by planning an exploration of the different properties of bar, liquid, and foaming soap. (See "Concepts to Explore Related to Handwashing" below.)

Concepts to Explore Related to Handwashing

STE Concepts	Example Questions
Cause and effect of different hand drying methods	How many paper towels does it take to dry your hands? What are other ways you can dry your hands?
Cause and effect while handwashing	What happens when you push the lever on the soap dispenser? What do you notice when you add soap and water to your hands when they are dirty? What do you see and hear when you turn the faucet handles?
Systems and system models that allow for handwashing	How do you think water gets into a building? How does soap come out of the dispenser and onto your hands? Water can feel hot, warm, or cold; how can you make hot water come out? Cold water? Warm water?

Paper Towel Disposal

Continuing the focus on handwashing, the children gather together to investigate how to use and dispose of paper towels. Tanya has toilet paper, paper towels, and a bin of water on display. Tanya lifts up a paper towel. "This is a paper towel. After you wash your hands, you need to use just one to dry them. Where should you throw it away when you're done with it?"

"The trash can?" the children ask.

"Yes, the trash can! Why shouldn't we put paper towels in the toilet?"

Responding in his home language of Cantonese, Fen repeats that the paper towel should go in the trash can. Tanya asks the question again. Chen, another child, reiterates Fen's response in Toisanese.

Tanya sees that the children are unsure. "Let me show you why we can't put paper towels in the toilet." She submerges the paper towel in the water and holds it up. "When paper towels get wet, they don't dissolve and can clog up the toilet." Then she repeats the same steps with the toilet paper. "When toilet paper gets wet, it dissolves, which means that it falls apart. It can be flushed down the toilet." After the demonstration, Tanya takes the materials to the sensory table for the children to explore during center time.

Tanya used a hands-on approach to **extend** the children's STE learning. She **connected** a familiar routine, handwashing, to an exploration of stability and change and to answer why paper towels should be disposed of in the trash. By seeing what happens when toilet paper and paper towels are submerged in water, the children were able to internalize an important piece of handwashing guidance instead of just learning the classroom rule by rote. After the activity, Tanya **deepened** this experience by inviting the children to explore the materials at the sensory table on their own. (See "Practices and Concepts Related to Paper Towel Disposal" below.)

Concepts to Explore Related to Paper Towel Disposal

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Conclusion

Pedestrian safety and handwashing were topics that RISE teachers were required to cover in their curricula. Through the lens of connect, deepen, and extend, they were able to turn these requirements into meaningful STE experiences for children. We hope their stories sparked ideas about how you can support STE learning through the routines and activities you already do inside and outside your learning setting. We offer questions to consider as you begin:

- What is one required topic you teach that you'd like to enrich with the connect, deepen, and extend principles?
- What changes might you make to foster more STE knowledge sharing between home and school?
- What possibilities exist to incorporate the principles of connect, deepen, and extend within the curriculum you currently use?
- Who can you collaborate with (a program leader, coach, coteacher) as you work to apply these principles in your setting?

To learn more about RISE, read “Incorporating Knowledge from Children’s Homes and Communities: A Home-to-School Approach for Teaching STEM in Preschool” by Christine M. McWayne, Jayanthi Mistry, Sunah Hyuan, Virginia Diez, Cynthia Parker, Betty Zan, Daryl Greenfield, and Kimberly Brenneman in the December 2020 issue of *Young Children*.

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