NGSS for Our Youngest Learners: Explorations in Coding

By Alissa A. Lange

What would the *Next Generation Science Standards* (NGSS) look like for preschool? How can we link preschool learning to what happens in kindergarten and to the *NGSS*? In fact, they are already linked, but we can make the connection more explicit for teachers. When we start to describe what teaching would look like in preschool to align with this framework, we quickly notice that there is an incredibly strong alignment with what many preschool educators are already doing (find more in the NSTA position statement on Early Childhood Science; see Online Resources).

Early childhood education values hands-on, minds-on learning—focusing on what children are doing and how they construct their knowledge. The three-dimensional approach is a natural fit for children younger than kindergarten. The *NGSS* encourages K–12 science learning that supports "...communication, collaboration, inquiry, problem solving, and flexibility—that will serve them throughout their educational and professional lives" (*nextgenscience.org*). This all starts before children turn five. In this article, I outline examples of what teaching and learning in preschool can look like when grounded in the three dimensions of the *NGSS* (check out NGSS-aligned preschool standards work by The Early Science Initiative; see Online Resources).

SCIENCE AND ENGINEERING PRACTICES

We want younger children to be *engaging* in the science and engineering practices just like older learners. In fact, early childhood educators working with young children are pros at this. Let's get materials into their hands, let them discover for themselves, and engage in activities that are "...designed to help children get better at reasoning, solving problems, getting along with others, using language, and developing other skills" (NAEYC). Hoping that young children begin to identify primary and secondary colors? Facilitate an open-ended investigation of paint color mixing to let them make these discoveries. Want to encourage their problem-solving skills? Ask children to debug a robot when their codes do not lead to the robot making it through the tunnel.

DISCIPLINARY CORE IDEAS

We also want to provide opportunities for children to build accurate foundational knowledge of the disciplinary core ideas of science. This may involve direct instruction at times, while at other times, powerful science learning is possible through play and open-ended interactions with materials. Our youngest learners can form a rigorous and correct understanding—at the level that is right for them—of how worms need a damp environment to survive and thrive (life science), that the robot may not "survive" a fall off of a tall ramp (physical science), and that the Sun gives us light and heat (Earth and space science).

A girl investigates the on-off button on the robot during free exploration.

CROSSCUTTING CONCEPTS

Finally, the crosscutting concepts highlight the ways in which there are *connections across the disciplines of science*. Young children and their teachers are already thinking and working in a connected way in early childhood classrooms. Even infants and toddlers are attending to cause and effect: What happens when I drop my spoon? Papa picks it up for me (cause and effect!).

What could K–12 educators learn from preschool professionals about how to bring the three dimensions to life? Below, we describe a series of connected activities to illustrate ways to engage three- to five-year-olds in early coding and computational thinking principles that align with all three dimensions of *NGSS*.

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Playful Coding

OVERVIEW

These activities introduce the foundations of coding that are grounded in children's interests and play and connect to the three dimensions of the *NGSS*.

LEARNING OBJECTIVES

- Demonstrate understanding of the directional words *forward* and *backward*
- Identify functions of the robot's buttons
- Identify and solve a problem (debug) that arises with the robot

GETTING STARTED WITH ROBOTS

Start with the basics, you or your students' interests, or a book. When we worked with children, their own questions drove their engagement in many investigations (SEP: Planning and Carrying Out Investigations).

Consider exploring off-device coding experiences. Activities like Code the Teacher (see an example on the CRRAFT website) and using directional words (*forward*, *backward*, *left*, and *right*), are engaging and allow for discovery of the basics, such as the importance of precision in computer instructions.

Once you are ready to jump in with robots, let children play around with robots first. Possible questions to spark thinking and experimenting include *What do these buttons do? What do you observe? How does that feel? or What else could you use that for?* Children can discover for themselves what happens when each button is pressed and how to use the available functions.

Two boys work together to program a robot mouse to go through a wooden tunnel they made.

Let's Go!

As children begin to experiment with the robots, notice what questions arise. In our exploration, a child wondered out loud if the robot mouse could go up a ramp. The child looked around for materials, found a wooden ramp, and tested his idea by pushing buttons to get the robot mouse to the end (DCI: ETS1.A).

Provide children with opportunities to use and think about "If-Then" statements, which are key parts of control structures underlying coding languages (see the CRRAFT project website for more "powerful ideas" in early coding). The children we worked with noticed that if they press the right turn button many times, then the robot turned in a circle. (CCC: cause and effect).

Prompt children to deepen their work with robots. Incorporate coding vocabulary like debugging, which means "identifying and then solving problems that arise in order to achieve a goal" (CRRAFT Project). A math debugging connection happened when a child wanted the robot mouse to go all the way across the room. He first tried six presses, but it stopped short. We asked him how many more presses would it need to make it go to the end?

Offer challenges. One child was ready for a challenge, so we asked what he might do to make the robot go through the tunnel he made, and then turn right. He tried once and the robot did not make it. To debug his program, he thought about it, and then came up with another set of successful "codes" that included an extra forward button press.

These relatively unstructured experiences can lay the groundwork for structured fun, too. For example, a teacher-guided activity can be to ask if children can get the robot mouse through a block maze. Check out Creating Coding Stories, linked in Online Resources, for more playful ways to bring coding to life with young children. All of these offer opportunities to think, learn, and do science and STEM in a way that prepares children well for *NGSS*-grounded science learning ahead in kindergarten and beyond.

ONLINE RESOURCES

Creating Coding Stories
www.naeyc.org/resources/pubs/tyc/feb2017/creating-coding-stories-and-games

CRRAFT
https://crraft.org/crr-program/school

The Early Science Initiative
www.earlyscienceinitiative.org

Position Statement: Early Childhood Science Education
www.nsta.org/nstas-official-positions/early-childhood-science-education

The 10 NAEYC Program Standards
www.naeyc.org/our-work/families/10-naeyc-program-standards

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