Learning Engineering through Block Play: STEM in Preschool

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Learning Engineering through Block Play

STEM in Preschool

Zachary S. Gold, James Elicker, and Barbara A. Beaulieu

"We have to test it out," asserts Sonya. Dolly carefully releases a wooden ball down a ramp. She and Sonya watch closely as it slips off the side of the ramp and rolls away. "That did not work," says Sonya. Ms. Evans, who has been quietly observing, chimes in, "Well, what can you do to make your ball stay on the ramp?" Dolly suggests, "We need to block the side and build a wall to keep the ball on the ramp." Dolly and Sonya construct a barrier just high enough to protect the ramp, but not so high that it will topple over. This time, the ball speeds down the ramp in a straight line, through the tunnel, and across the finish line. "Ah! That is better," says Sonya. "We solved the problem!"

Young children often engage in engineering-based design to solve problems—as in the example in the opening vignette—through their language and social behavior during constructive play. However, children (and teachers) often do not know they are engineering. In recent years, science, technology, engineering, and mathematics (STEM) have been increasingly emphasized for elementary-age children, and this trend should extend into preschool too. Blocks—a fundamental material found in almost all early childhood settings—are an excellent (and fun!) means for enhancing early engineering and STEM concepts. Through our work as university scholars and educators, we developed a research-based program to assist teachers in recognizing, encouraging, and enhancing children's "engineering play."

Block play and engineering

Young children have always created, tested, revised, and expanded their ideas about the physical world through active exploration with available materials (Gold & Elicker, forthcoming). Play with blocks and other open-ended loose parts construction materials has been an important aspect of early education since at least the mid-nineteenth century and continues today (Froebel [1826] 1887; Sutton 2011). Decades of research support building with blocks as a key context for developing social language and cooperative peer relationships. In the 1980s, for example, scholars observed that preschoolers played in social groups more often when building with larger blocks compared to smaller blocks, and that group block building resulted in few problematic social behaviors (Rogers 1985).

Building with blocks is a key context for developing cooperative peer relationships.

More recently, scholars documented children's use of complex social language ("Let's build a bridge as a group!"), frequent spatial language (*above*, *below*, *near*, *around*, *through*), and a variety of creative forms to represent their ideas (using a cylinder to symbolize a tin can) during both free play and adult-guided play with blocks (Cohen & Uhry 2007; Cohen & Emmons 2017). Although play with blocks is a rich, multimodal learning experience for young children, new education perspectives are needed to understand connections between block play, learning, and children's engagement in STEM.

Engineering play has the potential to improve school readiness across multiple domains.

Along with several colleagues, we recently developed a framework for understanding block building as an engineering design process (Bairaktarova et al. 2011; Gold et al. 2015; Gold et al. 2020). The "engineering play" framework describes how children's block building parallels the way adult engineers think and work to foster innovation, exchange different viewpoints, and compare alternative solutions to solve problems. The profession of engineering is social and constructive. It involves stating a goal to be achieved or a problem to be solved through creating plans; building prototypes; evaluating results of a design through trial and error; and communicating with team members about ideas, strategies, the building process, and building solutions. While less complex and organized than the engineering processes that professionals engage in, engineering in early childhood includes essential components such as using language and actions during constructive play to set goals, brainstorm, test, and evaluate ideas to tackle problems and agree on solutions (Moore & Tank 2014).

The engineering design process is much like the classic scientific method, where scientists ask research questions, develop hypotheses, test their hypotheses in experiments, and evaluate the results. However, engineering design is different, because the goal is to create something to meet or solve a problem through discovery and testing a theory. This process is often done in cycles. Children may design and build certain engineered block constructions, make various decisions about their constructions, and then jump back to earlier steps in the process as they evaluate and make changes. For example, children may build a castle, decide that the castle is unbalanced and might fall, and then add blocks around the castle bottom to increase stability. Each engineering design process is unique!

A framework for supporting engineering play

Children's engineering design processes with blocks can be documented and understood by observing nine engineering play behaviors (Gold et al. 2017) (see table below).

There are two main educational benefits for documenting and evaluating children's engineering play behaviors. First, increasing teachers' awareness of early engineering enables them to foster children's interests in STEM activities now and in the future. There is a shortage of adult professional engineers, especially women. Our research has found no gender differences in the frequency of preschoolers' observed engineering play (Gold et al. 2015; Gold et al. 2020). Therefore, specific encouragement of girls' engineering play may build early interest and confidence in STEM-related activities.

Second, new research has found that preschoolers who engage in more engineering play perform better on assessments of mathematical knowledge (numeracy, geometry), spatial ability (mentally rotating and transforming shapes), and planning skills (tracing an accurate path over patterns on a page) (Gold 2017; Gold et al. 2020). Encouraging preschoolers' engineering play has the potential to improve school readiness across multiple domains.

With the engineering play framework, teachers can support multimodal learning during constructive play. After participating in a workshop about the framework

Engineering Play Behaviors

Behavior	Examples
Communicating goals	"Let's build a castle!" "I want to put this block on top."
Designing and constructing	Drawing blueprints, stacking or placing blocks, collecting or organizing blocks.
Explaining how things are built or work	"Let's put the block this way to hold the door open."
Solving problems and replicating solutions	"This will not work for the window; it's too big." "This square block will hold the truck—we used it yesterday."
Testing solutions and evaluating designs	Rolling a ball to test if a ramp works and suggesting reasons why it does not work.
Creating innovative ideas	Leaning two long blocks together to make a tent.
Following patterns and prototypes	Representing ideas verbally or in structures. "This tractor is just like the one mom drives at home."
Thinking logically and mathematically	Using words like *taller*, *near*, *above*, *square*, *counting*, *inside*, *around*. "If we use the square block, then we can close the tunnel!"
Using technical vocabulary	Learning about and starting to use words like *gear*, *balance*, *stability*, *satellite*, *slope*, *engine*, *factory*, *robot*.

The Enhanced Block Party: Fostering Engineering Play Behaviors in Young Children

For a free series of short videos that address each of the nine engineering play behaviors, visit https://bit.ly/2Py0vCy. Together, these videos offer teachers classroom-based, 40-minute, self-guided professional development. Developed with Kodo Kids and Purdue University Cooperative Extension, the videos feature early childhood educators engaged in engineering play with groups of preschoolers, along with tips for facilitating children's learning.

and using it in their classrooms to facilitate play with blocks and loose parts, several teachers reported on the changes they observed:

> Some of the children have begun making their creations into a game. The ball has to go through the ramps and hit the wall to score! They continue to surprise me with their creativity.
>
> —University Laboratory School Teacher

> They are beginning to troubleshoot on their own. They are standing back and looking at things to see what they could do differently. The . . . [children] are also working together more. They are taking the blocks and making them go up, down, and through something now. They are becoming more creative with their designs.
>
> —Head Start Teacher

> Our children have built bridges with the cardboard bricks on their own and walked across them. They bring other materials over to use with them. We built an obstacle course. . . . [After the teacher prompted children with this pretend play scenario, the children] used . . . weighted bags as our wheat to carry to the mill. They then carried over that play to the room using the cylinders as the container to grind the wheat and also as the oven to bake the bread.
>
> —Preschool Special Education Teacher

How can teachers enhance engineering play?

The following are examples of teachers facilitating some of the engineering play behaviors. These examples are drawn from our observations of teachers in their classrooms after they participated in a workshop about the framework.

Explaining how things are built or work

> "Ms. Evans, look at the front of the garden!" says Dolly.
>
> "That is very nice! Now can you describe what you did with the blocks?" Ms. Evans asks.
>
> "This is a little lake under here," explains Sonya, pointing to a bridge on the garden's side. "We can make it like this, right?" adds Dolly, blocking the bridge entry with a square block. Sonya agrees: "Right! We can make a water-block when it's night!"

After Dolly expresses excitement and asks Ms. Evans to view her construction, Ms. Evans enthusiastically encourages Dolly and Sonya to explain what they did to build their garden. Ms. Evans's use of open-ended and inquisitive questioning furthered Dolly's and Sonya's evaluation of the components of their garden.

Using technical vocabulary

> Daniel crosses two blocks like an *X* and gazes inquisitively at them. "Are you going to use those pieces in your construction?" asks Ms. Evans. "Yes," says Daniel, placing his *X* on the floor on-end. "This will be a platform," he explains, pointing to the *V* opening on top of his *X*. Melvin adds, "And this will be a tunnel." He points to the upside-down *V* opening between the *X* and the floor.

Here, Ms. Evans notices Daniel has fit two block pieces together with an apparent goal. Daniel could have made the *X* for a constructive purpose that he is envisioning, but Ms. Evans or Melvin are not. Ms. Evans's open-ended question about Daniel's intention to use the pieces fosters both Daniel's and Melvin's descriptions of the pieces' functions and shows that they are learning

vocabulary related to engineering (*platform*, *tunnel*). (See the photo above and on the next page for a look at the materials used for these types of block activities.)

Solving problems

> "Dolly, I found two tiny blocks that can be perfect for the water-block," says Sonya, describing her plan to block off the entrance to the bridge they had built. Dolly suggests, "How about we do this one instead?" She replaces the small square blocks with a half-circle block designed to fit perfectly under the bridge block. Sonya agrees: "Okay, I am just going to use this one then."

In this example, Ms. Evans does not intervene to support the children's problem solving. Instead, she notices that Dolly and Sonya are already engaged in problem solving together. Ms. Evans quietly observes and allows the children to troubleshoot their building problem, learn from each other, and reinforce trial-and-error evaluation until they solve the problem.

Incorporating engineering play in classrooms

In addition to using the framework to support and extend children's block play, we recommend the following:

- Introducing interesting new construction play materials and loose parts in the classroom and outdoors, including blocks, large cardboard boxes, funnels, sand, water, safe plastic pipes, balls, and wheels.
- Making your own blocks using readily available materials, such as shoeboxes, paper towel rolls, cans, and containers. (For a free guide to creating homemade blocks, visit https://bit.ly/2S73Jia.)
- Encouraging children to use loose parts materials in various classroom learning centers and to combine materials from more than one center during their play explorations.
- Hanging large posters or cards with STEM words around the block play area and in other learning centers so both children and teachers can easily learn, use, and incorporate engineering-related vocabulary as they build and play.
- Including books about building, construction, and computers in the library center. Some great books to include are *If I Built a House,* by Chris Van Dusen, *Rosie Revere, Engineer*, by Andrea Beaty, and *The Robot Book*, by Heather Brown.
- Inviting adult guests with STEM-related jobs—construction workers, architects, engineers, computer scientists—to show children what they do.
- Taking field trips to construction sites or engineering and architectural firms and building lesson plans around the visits.
- Encouraging all children to play with blocks, paying particular attention to whether there are some children (often girls) who need extra supports to feel comfortable joining in block building.

- Getting down on the floor and building with children, actively participating in their building, and asking open-ended, inquisitive questions.
- Displaying large photographs of bridges, buildings, or other interesting structures and challenging children to build what they see.

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