A PRESCHOOL INVESTIGATION: THE SKYSCRAPER PROJECT

Kelly K. McCormick
and Guinevere Twitchell

Young children are powerful mathematicians who are capable of demonstrating this power through their actions in both play and structured learning (Perry and Dockett 2008). As educators, we must create the opportunities for children to use mathematics to make sense of the world around them. Young children thrive in classrooms that allow them to explore and discover their environment and interests and also support them in this learning. Because children learn best when they are interested and excited, early-childhood educators should offer children play-based, integrated mathematical experiences (NRC 2009). In this article, we describe a meaningful project-based learning experience that intrinsically invites problem solving and mathematical thinking in a preschool classroom. Project-based learning is a learner-driven approach to teaching in which children investigate significant, real-world ideas or problems. Early-childhood, project-based learning allows children to learn through exploring their world of play and further investigate their curiosities and interests.

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This meaningful learning experience intrinsically invites problem solving and mathematical thinking that emerges during play.

The idea for the Skyscraper project emerged from observing children's spontaneous play and exploration. Our preschoolers love to build; they build with large blocks, small blocks, wooden blocks, unit blocks, magnetic building shapes, and Duplos®—sometimes all together! Block building supports children's learning of shape and shape composition and helps develop foundational spatial skills (Clements and Sarama 2009). Initially we observed that after a brief period of building out, children's interest usually turned to building upward. However, their tall structures would fall because of unstable foundations. As we observed how building skyscrapers with blocks requires eye-hand coordination, spatial awareness, size comparison, concentration, and problem solving, we realized that the study of building-block skyscrapers provides a meaningful learning experience that naturally generates problem solving and mathematical thinking. We chose the project of investigating and constructing skyscrapers to support our students' mathematical reasoning processes, such as spatial and quantitative reasoning, because these are foundational to young children's mathematical development (Mulligan and Mitchelmore 2013). Subsequently, we asked the children what they knew about skyscrapers. Some of their answers follow:

TABLE 1

Content addressed throughout the project is matched with student activities.

Content and corresponding activities

Content area	Knowledge and skills	Activities
Number and number sense	Counting sequence Cardinality Estimation Compare numbers Recognize and write numbers	Constructing the cardboard city Construction books Building skyscrapers with various materials during free play Fill the skyscraper game
Measurement	Recognize, describe, and compare measurable attributes Measure with rulers Use standard and nonstandard units of measurement	Constructing the cardboard city Building skyscrapers with various materials during free play
Geometry	Recognize and name two- and three-dimensional shapes Create, compose, and decompose two- and three-dimensional shapes Draw two- and three-dimensional shapes Model shapes in the world Spatial sense Visualization Use spatial relational words	Constructions books Constructing the cities of skyscrapers Constructing two-dimensional skyscrapers with felt shapes (activity not mentioned in article) Constructing two- and three-dimensional shapes with straws and marshmallows Building skyscrapers with various materials during free play Quick Images of skyscrapers made of two-dimension shapes (activity not mentioned in article)
Data	Create bar graphs Use bar graphs to compare data	Constructing the cardboard city

- "They're tall."
- "They have square windows."
- "It has a big round thing with a circle on top."
- "They scrape the sky. You can see the whole city. They move a little."

With these responses in mind, our Skyscraper investigation was born. We began by brainstorming activities that would undergird our integrated and emerging curriculum. As we considered our learners, we also considered the mathematics we wanted to support during the investigation (see **table 1**). Constructing skyscrapers appeared to be a natural way to support our students' numeric, geometric, and spatial reasoning while fostering their interests and recognizing and responding to the mathematics that emerged in their play. Early-childhood instruction should be rooted in play to provide the most developmentally appropriate approach and support children's growth in multiple domains (Wager 2013).

We wanted to begin the investigation with a captivating experience that would obtain and hold the children's attention. Meaningful projects powerfully activate children's need-to-know with an engaging entry event (Lamar and Mergendoller 2010). For our entry event, the children created their own large-scale cardboard skyscraper city. Research suggests that the preschool teachers should—

> provide materials, facilitate peer relationships, and time to build, and also incorporate *planned*, *systematic* block building into their curriculum. Children should have open exploratory play and solve semi-structured and well-structured problems, with intentional teaching provided for each. (Clements and Sarama 2009, p. 151)

Constructing a cardboard city presented a perfect mix of excitement and play that was more structured.

Constructing a city of skyscrapers

We collected cardboard boxes and created a construction site, which evolved into the city of skyscrapers, by cordoning off an area with

KELLY K. MCCORMICK (2)

Joshua constructed a cardboard city.

Preschoolers compared the lengths of their Unifix© towers by laying them side by side on the floor.

KELLY K. MCCORMICK (3)

Students worked alone on buildings for a small-scale city of skyscrapers.

This child added windows to her constructed skyscraper.

yellow tape wrapped around cones. We wanted to create a natural environment where the children had to communicate about the process of constructing skyscrapers, so each child worked collaboratively with a partner. The teams selected materials and designed and constructed their buildings on site. The structures were not originally taped together, so that students could dismantle and reconstruct them, an act that further supported their spatial thinking, and so that the parts could be moved easily for painting. Constructing, deconstructing, and then reconstructing the buildings with partners forced students to communicate about the spatial relationship between the boxes they had used. Working with partners created a natural situation in which the children practiced using spatial-relationship vocabulary, such as "*above, below, beside, in front of, behind,* and *next to*" (CCSSI 2010, p. 12). At the construction site, we commonly heard someone exclaim, "No, that box goes below that one" and "No, that box goes under that one because it is bigger." Every step of the process required collaboration, which meant communication, negotiation, and compromise.

We noticed that children naturally began comparing the size of the boxes, which was a perfect opportunity to discuss measurable attributes of the boxes (e.g. height, width, and even volume). We commonly responded, "I heard you say that box was bigger. What about it is bigger? Is it taller? Or is it wider?" We would then use our hands to demonstrate height and width. "Do you think it could hold more?"

As the buildings grew, the children loved discussing the height of their creations. Comparing and ordering is a natural, critical skill for children (Clements and Sarama 2007). They frequently speculated about which tower stood tallest. Phrases such as "Ours is twenty-hundred feet tall" were common. When the buildings were completed, each team measured the height of its skyscraper, one partner holding the tape measure at the bottom of the structure while the other read and recorded numbers at the top. Partners reversed positions, remeasured, and compared their results for accuracy. Because many skyscrapers were similar in height, the children could not visually ascertain which was the tallest or shortest. To help them compare, they represented the height of their structures

using Unifix® cubes, each cube representing one inch of tower height. The children laid the Unifix towers side by side on the floor for comparison. This allowed them to visually compare the height or length of the towers. After that, the exact numbers seemed less important, and conversations included such phrases as "Ours is shortest" and "Ours is shorter than Charlie's and Henry's, but taller than Nell's and Olivia's."

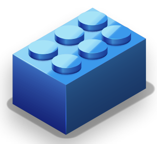
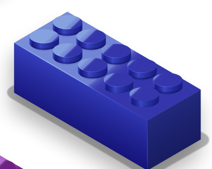
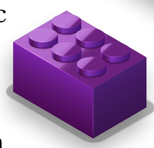
Children need a variety of experiences comparing the lengths of objects. They also need experiences that allow them to connect numbers to the lengths of objects. They need opportunities to compare the results of measuring the same object with manipulatives and rulers and to use the manipulative length units to help support the connections between number and length (Clements and Sarama 2009).

After the skyscrapers were reconstructed on site, the teams added doors and windows. We then asked each group to estimate the number of boxes, windows, and doors before counting them. Estimating was new for the class, so we asked, "About how many boxes (or windows or doors) do you think you used?" We talked about how an estimate is "a best guess." We also discussed whether their guesses were *reasonable* and what that means. We asked them to "try to predict just by looking at the skyscrapers which skyscraper you think used the most boxes. Which one do you think has the fewest boxes?" We documented their predictions and gave each team the task of figuring out and recording how many boxes, doors, and windows the team had used. This gave students the opportunity to count and record with tally marks or numerals the number of materials they had used. This also gave them the opportunity to compare their estimates and predictions and answer the question, "Which group used the most (and fewest)?" To clearly exhibit comparisons among the numbers of objects each group had used, we created graphs, each group recording its data on the appropriate chart by using stickers of boxes, windows, and doors. We spent one day comparing the number of boxes (and another day comparing windows and a third day comparing doors), each time discussing number questions about the graph, such as these:

- "Which groups used more than eight boxes?"

Students built this three-dimensional structure using magnetic triangles, squares, pentagons, and hexagons.

- "Which groups used fewer than three doors?"
- "How many fewer doors did Beckett and Ellie use than Sam and Jack?"
- "Which groups used the same number of windows?"


Discussing comparisons such as these add considerably to children's understanding of number (Van de Walle et al. 2014).

As the children finished their skyscrapers, they worked individually on a smaller-scale city of skyscrapers. Designing these required the use of fine-motor skills, other geometric shapes (e.g., cylinders), spatial visualization, and problem solving. Constructing these allowed the children to create their own three-dimensional structures and solve problems, such as deciding which materials fit in the space provided and how shapes fit together. For these structures, we asked each child to "tell us about your skyscraper. We are going to draw a picture of it without looking, and your job is to tell us what it looks like." Although

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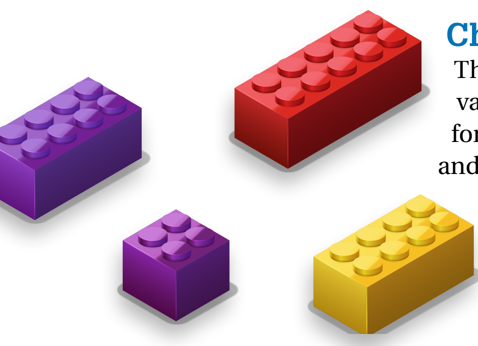
Charlie's skyscraper was taller than he was.

difficult for some, this activity required each child to communicate about the structure he or she had created and practice using new vocabulary, such as *cylinder*. Students liked this activity so much that they asked us to do it with other structures they created.



Choice-time activities

The Skyscraper project offers numerous valuable informal and formal opportunities for children to build and create with two- and three-dimensional shapes, using a wide variety of materials. For example, building skyscrapers with Duplos became a favorite choice during free play. More unstructured building offered additional opportunities where children naturally compared the height of their skyscrapers to their height and the height of other people. One child made these direct comparisons with his height, another child's height, and his skyscraper: "It is taller than Eloise, but not as tall as me." He then added, "But, we are still building." After a few minutes, he asked, "Now, is it taller than me?" We took his picture standing next to the skyscraper and showed him the photograph, and he proudly answered that question for himself. He then stated, "But, you are still taller," and kept building. The authors of the Common Core State Standards (CCSSI 2010) note that making direct comparisons between objects, with a measurable attribute in common, is a foundational kindergarten measurement standard.

The children's interest in building tall structures in the block area continued throughout the investigation. Using large wooden blocks and painter's tape to represent doors and windows, they experimented with balance, shape, and spatial awareness. Building led to more collaboration as taller children helped shorter ones add height to skyscrapers. Teamwork persisted as we challenged them to count windows and doors, giving more-experienced mathematicians an opportunity to help their less-experienced classmates count to higher numbers.

In addition to the building activities during choice time, we introduced the Fill the Skyscrapers game (see **fig. 1**), which we adapted from Van de Walle and his colleagues' (2014) Fill the Towers game. We created game boards with four "skyscrapers." Each skyscraper was a column of twelve one-inch squares. To play the game, children took turns rolling a die and placing the corresponding number of counters on one of the towers. The object was to fill all the skyscrapers with counters. We later introduced the rule that the towers had to be filled exactly, so a roll of a four could not be used to fill three empty spaces. This game created opportunities to assess the children's ability to count and their understanding of number. We often asked them, "How many counters are in that skyscraper?" or "How many more do you need to get to the top?"

Children's literature

In addition to constructing, we read numerous books about construction. *Tonka®: Building Skyscrapers* (Korman 1999) introduced us to pyramids and taught us why most beams are made of interlocking triangles. We then searched for triangles in all of our construction books. *Look at That Building: A First Book of Structures* (Ritchie 2011, p. 20) confirmed that "a triangle is the strongest shape," giving us even greater appreciation for the shape. It also showed us how to construct two- and three-dimensional shapes using craft sticks (or straws) and marshmallows. Building with these materials was another favorite choice-time activity and exemplifies how children should "model shapes in the world by building shapes from components (e.g., sticks and clay balls)" (CCSSI 2010, p. 12). We counted up and down

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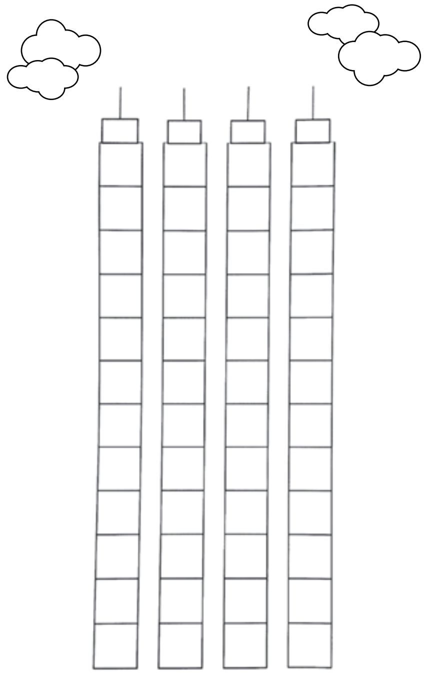
FIGURE 1

To play the Fill the Skyscraper game, students rolled a die and counted the exact number of squares.



and found examples of triangles, squares, other rectangles, circles, semicircles, and cylinders in books such as *One Big Building: A Counting Book about Construction* (Dahl 2004), *Construction Countdown* (Olson 2004), and *When I Build with Blocks* (Alling 2012). The photographs of real skyscrapers in *Amazing Buildings* (Haden 2003) engaged us; we also admired photographs of Egyptian pyramids, a dome constructed entirely of hexagons, and the sphere-like building at Epcot Center in Florida, which comprises more than 11,000 triangles. We made the books available during choice time for the children to explore; and we urged them to record, by drawing, the different shapes they found.

A powerful learning experience

We worked on the Skyscraper project for four months, which was when our preschoolers' interest waned. However, before we left our investigation, students displayed their work in our Skyscraper Museum, which was open to the public, primarily their families, for a special exhibition. Schoolwork is more meaningful when it is created for a real audience, and so presenting products publicly is a cornerstone of project-based learning (Lamar and Mergendoller 2010). When students present their work to a real audience, they care more about the quality of their work, and the experience is more authentic. Our students made invitations for the exhibit's opening using their best writing skills. We created documentation panels (i.e., presentation boards containing evidence and artifacts of the children's work), with pictures and descriptions that told the story of the children's learning, so parents could see the process, not just the product. To conclude the project, the children proudly and competently guided their families through the museum, displaying and explaining their work.

The project proved to be such a powerful learning experience because we recognized and responded to the mathematics that emerged in the children's play and built on and extended their understandings (Wager 2013). The mathematics was meaningful because it connected to their play, interests, and everyday activity of building. One of our primary roles as teachers is to observe and help children reflect on and extend the mathematics that arises in their everyday activities, conversations, and play (Clements and Sarama 2004; Parks and Blom 2013–2014; Wager 2013). Project-based learning is a powerful approach to support preschoolers' learning. Preschoolers learn through collaboration and by employing critical-thinking skills as they engage in projects (Bell 2010). Powerful projects encourage students to explore and investigate their interests and the world around them and experience learning in deep, meaningful ways, which "is the jumping off point to developing students' love of learning and nurturing their natural curiosity" (Bell 2010, p. 43). By observing our preschoolers' interests and the mathematics within their play and by creating a project on the basis of those interests and significant mathematical ideas, we helped our students work together to build a solid foundation for their mathematical thinking.

Common Core Connections

K.G.1
K.G.5
K.MD.2

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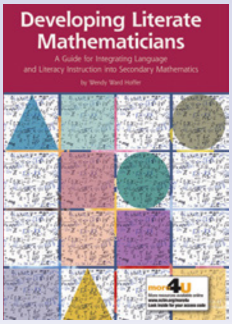

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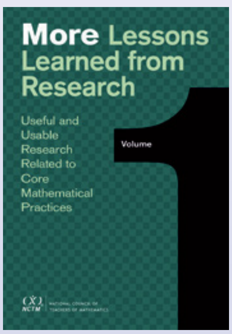

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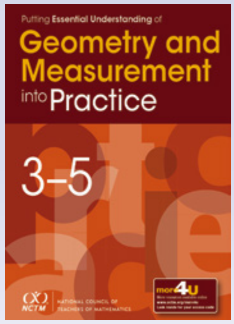

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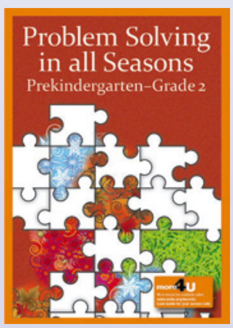

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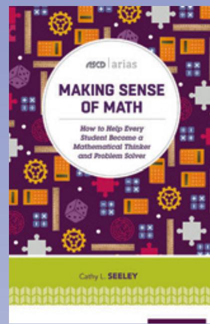

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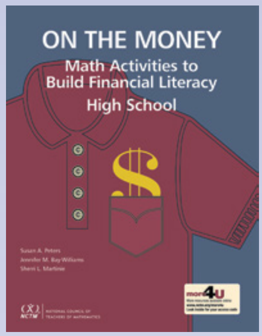

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