Asia carefully turns the handle of a handheld drill that her teacher holds in place over a piece of soft wood. Soon sawdust begins to appear. "Round and round it goes," they sing, as Asia cranks the handle. Suddenly the drill bit slips through the wood. "A hole!" exclaims Asia. "Let's do it again." The teacher replaces the drill bit with a smaller diameter bit. "You made a round hole with the big bit," he says. "Do you think this new bit will make a round hole too?" Asia shrugs. "Do you think it will make a big or a little hole?" the teacher asks. Asia shrugs again. "Well, let's find out," he says, and Asia eagerly begins to turn the crank again.

Math and science and the related technology and engineering are natural pairings. These four disciplines form the acronym STEM (Science, Technology, Engineering, and Math) and can be readily combined into an integrated curriculum for early childhood classrooms.

Many educators believe that children learn best when disciplines are interconnected. An integrated curriculum, such as STEM, is in keeping with developmentally appropriate practice in early childhood education: "Teachers plan curriculum experiences that integrate children's learning within and across ... the disciplines" (Copple & Bredekamp 2009, 21). The National Council of Teachers of Mathematics (NCTM 2000) encourages teachers to help children connect mathematics to other contexts, while the National Science Education Standards (NRC 1996) urge teachers to coordinate science and mathematics programs.

Some adults mistakenly think that STEM activities are too challenging to integrate into preschool settings, particularly if the children have special needs. Appropriate STEM activities, however, allow young children to explore materials using all their senses. As they experiment and investigate with the materials, they develop an understanding of important mathematical relationships, such as more/less, far/near, and fast/slow. We also found that the STEM curriculum helps children focus, increase their vocabulary, collaborate with one another, and create scientific relationships.

This article explores the reflective practice of a preschool early intervention teacher and a university teacher educator working to develop and incorporate a STEM-based curriculum in an inner-city, inclusive classroom. The classroom included 14 children, ages 3 through 5, of whom 12 had documented disabilities, including cognitive delays, severe language delays, cerebral palsy, autism spectrum disorder, and behavioral disorders.

Preschool STEM activities

Although opportunities abound to integrate STEM education into preschool classrooms, teachers must help children construct learning connections among the disciplines. For example, in the opening vignette the teacher directs Asia's attention to the shape of the hole made by the drill and creates an opportunity for her to compare the size of the drill bit to the hole it makes.

The following three activities were developed as part of a university/public school partnership to increase STEM learning in urban preschools. Pattern, pendulum, and incline activities ignited intense interest in the children.

Birds sing in patterns

Patterns are important elements of both mathematics and science. Math educators consider recognizing, describing, and extending patterns as key concepts for young children and include these in both national and state content standards (NCTM 2000; Ohio Department of Education 2004).
To help children recognize, remember, and represent melodic patterns, we introduced the standard vocal syllables from music (do, re, mi, and so on). We added corresponding hand signs, a teaching strategy called the Kodály method.

Understanding patterns helps children construct key mathematical relationships: for example, in counting, each number is one more than the previous number, but each odd or even number is two more than the previous odd or even number.

Similarly, patterns occurring throughout science can be observed by children within many contexts, such as in the recurring cycle of day and night, the forward and back motion of a swing, or the songs of birds. Understanding systems, order, and organization is a unifying concept of the National Science Education Standards (NRC 1996), and patterns are a key element in this regard.

Patterns. The concept of pattern as repeating elements can be difficult for young children to understand. Given the diversity of the children in our preschool, we decided it would be best to introduce patterning through multiple modes of learning: auditory, visual, vocal, and movement-related. We chose toy Audubon birds, realistic plush replicas of real birds, as an intriguing way to integrate natural science, technology, and mathematics. A squeeze of the birds activates a microchip that plays the authentic song of each species (as recorded by the Cornell University Lab of Ornithology).

Our preschoolers showed immediate interest in causing the birds to "sing" their birdsongs, but they could not initially name any of the birds nor identify any of their songs. Yet they quickly realized that birds sing in patterns. Some birdsongs are melodic, a short tune that repeats; other birds emit only one tone but in a pronounced, rhythmic pattern.

To help children recognize, remember, and represent melodic patterns, we introduced the standard vocal syllables from music (do, re, mi, and so on). We added corresponding hand signs, a teaching strategy—called the Kodály method—frequently used by music educators to approximate the physical placement of the tones within

<table>
<thead>
<tr>
<th>Audubon Bird</th>
<th>Bird &amp; Song</th>
<th>Representation</th>
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</thead>
<tbody>
<tr>
<td>Black-capped Chickadee</td>
<td></td>
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<tr>
<td>Great Horned Owl</td>
<td>hoo HOO hoo hoo</td>
<td>(steady beats)</td>
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<tr>
<td></td>
<td>clap clap (sh) (sh) clap (sh) clap (sh)</td>
<td></td>
</tr>
<tr>
<td>Northern Cardinal</td>
<td>jeer jeer jeer jeer jeer (steady beats)</td>
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<td>Blue Jay</td>
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<td>Western Meadowlark</td>
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the music scale. For strictly rhythmic bird songs, we clapped the rhythm patterns with the children.

The first bird we introduced was the black-capped chickadee, a bird common to our midwestern area. The bird sings a melodic pattern that alternates the tones so and mi from the music scale. This pattern (interval), which forms the beginning of the familiar tune “Rain, Rain, Go Away,” is easy for young children to sing (Moomaw 1997). We encouraged the children to listen to the song of the chickadee and sing along. At the same time, we modeled the hand signs for the two pitches, which the children quickly copied.

Next, we introduced the great horned owl to accompany Pat Hutchins’s children’s book Good-Night, Owl! which also includes many other bird species. The song of the great horned owl is a single pitch with a distinctive pattern of long and short sounds (see “Audubon Birds with Melodic and Rhythmic Representations,” p. 13). We clapped this pattern with the children.

**Outcomes.** Within a week, many of the children could identify the black-capped chickadee and the great horned owl by their sounds, often giving the hand signs for the chickadee’s song while singing the pattern. The birdcall activities seemed particularly beneficial for Sam, a child with significant language impairment. Although Sam rarely spoke any recognizable words, he could mimic the calls of the birds without prompting. His imitations were so real that the teacher and assistant thought there was a real bird in the classroom!

We introduced the birds during group time, but they were also available during choice time. Over two months, we gradually introduced three other birds. None of the children initially knew the names of the various birds; several could not even verbalize the word bird. Many had difficulty recognizing or repeating visual patterns.

But quickly, every child learned to copy and extend the sound patterns of the birds by singing, clapping, and using the hand signals. On succeeding days, when each bird made its appearance at circle time, many children spontaneously broke into the correct birdsong, complete with Kodály hand signs. A child with language delays was soon pointing to and naming each bird in the Hutchins book.

**Reflection.** Most important, we observed that the children’s learning seemed to generalize to patterning in other contexts, such as extending color patterns. For example, during assessment on the state content standard “Students will copy or extend a simple pattern,” the teacher discovered that many of the children who previously could not complete the task were successful after being exposed to the bird-patterning activities. When asked to extend an alternating pattern of red and blue cubes, the children verbalized the pattern as they added the correct cubes. Sam, the previously mentioned class expert at producing the birdsongs, was one of the successful ones. Prior to the birdsong activities, he was not able to complete this task.

To identify and study birds in your area—and to hear their distinctive birdsongs—visit the Cornell Lab of Ornithology website: www.allaboutbirds.org/guide/search.aspx.

**Physics and engineering interest begins early**

Several children in our classroom were particularly interested in blocks and outdoor play. These seemed ideal for introducing two activities related to physics and engineering: pendulums and inclines. Both activities encourage active experimentation. In addition, both are examples of technology that have a work-related purpose: knocking...
structures down (pendulum) or moving objects faster and more easily (incline). Quantification and measurement were embedded in the activities.

DeVries and Kohlberg (1990, 92–93) offer four important criteria to follow when designing physical knowledge activities for young children.

1. **The child should create the action that causes the phenomenon.** Being the source of the action helps demystify the response of the object and leads children toward scientific, rather than magical, thinking.

2. **The child should be able to vary his or her action.** This helps children form cause-and-effect relationships and construct physical principles.

3. **The result of the action should be observable by the child.** Children must be able to observe the effects of their actions in order to understand causality.

4. **The reaction of the object should be immediate.** This allows children to accurately pair the two events (action/reaction).

**Pendulums.** Our pendulum consisted of a ½-inch-diameter hard rubber ball suspended from a wooden frame (16 in. high and 12 in. wide) mounted on a baseboard. For easy access, we placed the frame on either the floor of the block area or a bench where children could try to knock over blocks, a popular childhood activity (which also fit DeVries and Kohlberg’s first criterion). We read *Bam, Bam, Bam,* by Eve Merriam, to connect the activity to real-life engineering projects.

Children could vary the placement of the blocks, change the direction of the pendulum, and alter the force they used to swing it (criterion 2). They could immediately tell whether they had hit any blocks (criterion 3) and see the reaction of the blocks (criterion 4). Thus, all four criteria of a good physical knowledge activity were met.

**Outcomes.** Predictably, many children placed the blocks too far away from the pendulum. Swinging the ball harder proved ineffective, as the tethered ball only wrapped around the frame. One very inventive child placed a block on top of the frame, realizing that when the pendulum wrapped around, it would hit his block. “I got it!” he proudly exclaimed as his block crashed down.

Some children began to examine the ball and cord more carefully. “It won’t reach,” one child correctly concluded and promptly moved her blocks closer. For children who seemed too frustrated to continue, like the child who insisted the pendulum was “broke,” the teacher intervened with leading questions, such as “How can the cord reach the blocks?” and modeled lining up the cord with the blocks. As children altered the block placement, they began to experience success.

Some children counted the blocks they knocked down, while others continued to swing the pendulum until no blocks were left standing. Their persistence paid off. “They all fell down!” one child proudly announced. “Let’s do it again” was a popular request.

**Reflection.** In their eagerness to knock over the blocks, children explored key concepts related to both physics and geometry. Some children arranged blocks in a horizontal row and discovered that the pendulum changes direction and can reach more blocks if it keeps swinging. One child demonstrated a sophisticated understanding of the pendulum’s movement. “I’ll try it here,” Andre said, placing a block

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**What Is STEM?**

The acronym STEM originated with the National Science Foundation in reference to its education-related programs in the disciplines of science, technology, engineering, and mathematics. The term is now widely used across educational settings. Some educators use the term to refer to the individual disciplines, while others believe that some, if not all, of the disciplines should be integrated to designate a learning activity as STEM (Carnegie Mellon University 2008).

In recent years, educators and policy makers have shown increasing interest in STEM education as children in the United States continue to trail their peers in certain Asian and European countries in science and mathematics (NCES 2009).


**Teacher Resources for STEM-Related Activities**


off to one side of the pendulum. Much to the teacher's surprise, he then swung the pendulum on a diagonal several times until he struck the block. Although Andre didn't use a geometric term such as diagonal, he clearly understood trajectory and adjusted his aim accordingly. This scenario shows that children like Andre, who are nonverbal or have limited language, may display higher-level thinking in physical knowledge experiences than traditional assessment methods can reveal.

The teacher's car always loses

A second physics activity, suitable for outdoors or indoors, involved a variable-slope ramp.

Inclines. Children set up a simple ladder frame and arranged two lightweight boards (4 feet long, 1 foot wide, and ¼ inch thick) at various heights on the frame. They chose identical cars to race down the ramp. The children quickly discovered that the steeper the slope of the ramp, the faster and farther a car traveled. Whenever the teacher was asked to participate in the car races, the children assigned him a low ramp, thus guaranteeing that his car would always lose!

Outcomes. The teacher was particularly gratified by the children's verbal exchanges as they manipulated the cars and inclines. For example, Michael, who had significant speech delays, suggested to his friend Joey, "Let's play this again. You help me." Michael connected two ramps, with the lower ramp overlapping the other, thus creating...
It was evident that all the children were drawing from past experiences as they experimented. Even if they had been absent from school for several days, each remembered that the steeper the ramp, the faster the speed of the car.

The boys then rolled their cars down the ramp. "He jump off!" exclaimed Joey, as his car hit the bump and flew off the side of the ramp. The boys repeated the experiment again and again, each time delighted when the car jumped the ramp.

It was evident that all the children were drawing from past experiences as they experimented. For example, even if they had been absent from school for several days, each remembered that the steeper the ramp, the faster the speed of the car. Children who could not verbalize this relationship would adjust the ramp or point to a higher position for the ramp they intended to use.

**Reflection.** The large, lightweight materials allowed children with physical impairments to participate actively in the experimentation process, a primary goal in an inclusive classroom. Many children who had never before built ramps created their own ramps in the block area.

After about two weeks, when the initial excitement had abated somewhat, the teacher added measurement to extend the children's interest in the experiment. Measurement is an important content area in mathematics (NCTM 2000) and a key element in scientific inquiry (NRC 1996). Children used chalk to mark the stopping points of their cars. In trying to make their cars go farther, they discovered that if the ramp was too steep, the car would bang the ground and not travel far.

**Conclusion**

These experiences confirmed for us that, regardless of ability, young children are ready, willing, and able to engage in STEM activities. In this preschool classroom, children constructed important scientific and mathematical relationships. They explored materials that piqued their scientific curiosity and math discovery. They can build upon these foundational concepts in future educational experiences. Most important, they learned that math and science can be exciting areas to explore.

**References**


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