Pushes, Pulls, and Playgrounds

Learning forces and motion through nonfiction texts and exploration on the playground

By Jodi Lemaster and Vicki Willett

The next time you are on a playground, watch your students as they play. Observing children tossing a ball in a game of catch or pumping their legs to move a swing, it is obvious that they have already experienced and learned to control the basics of pushes and pulls. Through everyday experiences as simple as rolling a ball across the floor, to more complex activities like team sports, children are building a foundational understanding about forces and motion.

Through play, young children have a "unique opportunity to stimulate interest and build concrete, real world experiences upon which more complex, abstract learnings in mathematics and science can be built" (Henniger 1987, p. 169). As children grow, they realize that different actions result in different types of motion. For example, a child can learn through investigation that a light push on a toy car will result in little movement, but a hard push will send the car across the floor. Learning about forces and interactions in kindergarten allows students to plan and conduct investigations comparing effects of different strengths and directions of pushes and pulls on objects (NGSS Lead States 2013, p. 4).

Inspiring students to recognize that forces and motion are a part of their everyday lives was an important consideration in writing this Pushes, Pulls, and Playgrounds unit. Children's engagement in science is shaped by their attitudes toward what they are good at and what they view as important and engaging (OECD 2016, p. 110). Students' capabilities progress as they mature and engage in science, beginning in kindergarten with the ability to plan and carry out investigations (NGSS Lead States 2013, p. 49). Whether they are swinging or kicking a ball, students are naturally curious about motion. It is a great place to begin planning and carrying out investigations.

Nonfiction texts played a significant role in the unit. Carefully chosen portions of nonfiction texts were read at various points of the unit to enhance information on motion and support vocabulary development. Reading nonfiction texts for reference can help children develop better understandings of things they experience and provides a tool for developing comprehension and world knowledge (Duke 2007, p. 14). As Fries-Gaither and Shiverdecker states (2013, p. 9),

> In a true integration of science and literacy, the two disciplines are so seamlessly intertwined that separating them would weaken the overall learning experience. Scientific inquiry, including observations and hands-on activities, instill in students a "need to know," an authentic context for reading and writing.

This comprehensive unit allows students to build on their experiences with pushes and pulls and then apply that knowledge in a scientific way.

Introducing Pushes, Pulls, and Playgrounds

Please note that this unit was taught in Mrs. Willett's first-grade classroom. Though a kindergarten standard in *NGSS*, learning about forces and motion is a first-grade standard in the state where she teaches. As the unit begins, students watch a video of a man practicing with a soccer ball. As the class watches the player, the teacher uses a line of questioning, such as, "How would you describe movement of the ball?" and "Does the ball always move the same way?" to preassess how students describe the movement of the soccer ball. For example, one student mentioned that the ball was moving away from the man. The teacher writes "away from" on the Motion Words chart hanging in the classroom. Throughout the unit, students are guided to notice motion words. When words or phrases were mentioned, they were added to the list.

After viewing the video, students are presented with two photographs of soccer balls: one where the ball is in the air near a player's foot and the other where a soccer ball is sitting still in the grass. Students are once again questioned about the motion of the ball. The teacher prompts the students to analyze how they know that the ball is moving in a picture or how could a ball that is still start to move. Based on student responses, the teacher is able to continue to preassess and look for misconceptions in student understanding of pushes and pulls. The students described the ball moving as "rolling," "kicked," and "dribbled." The picture of the ball in the grass was described as "stopped" and "not moving." One child described the ball as moving because he believed it had been moving and the grass stopped its motion.

Following the discussion, the teacher reads a selection from the nonfiction text *What Is Motion?* (Hyde 2014, pp. 4–5) to clarify the meaning of motion and introduce new terms to add to the motion chart. The terms introduced are ones that students should be familiar with, such as *up, down, jumping* and *spinning*. The list of motion words created during this class period was displayed throughout the entire unit to be used as a reference word wall.

Exploration Through Inquiry

Exploration through guided inquiry is a main component of this unit. The items used in this lesson can be found in most school gymnasiums or purchased from a discount retailer to keep teacher cost low. Students are placed in teams of two to four to investigate the motion of different types of sports items, e.g., baseball, football, tennis ball, hockey puck, and badminton birdie. Each team is given a hula hoop to use as a workspace to explore the motion of their item. The hula hoop helps keep the moving items within a well-defined space for students to focus their observations. Prior to beginning the exploration, students are instructed that their sports items, randomly assigned to each group, should not be taken outside of their workspace and have to stay on a flat surface; no throwing or bouncing was permitted. The instructions set parameters for the exploration and addressed safety concerns while using the items.

Students were given 15 minutes to become experts on the motion of their item inside the workspace. They were given a graphic organizer (Figure 1) to record observations or illustrate the motions they produced with their sports item. Some groups initially moved the items only in straight paths by pushing or pulling. The teacher circulated amongst the groups as she encouraged them to think of different ways to move their item. To further student thinking, she asked, "What could you try to make the ball move differently?" Many of the original responses were to push the ball harder, but as one child noticed, the ball "bounced off the side of the hula hoop." This allowed Mrs. Willett to probe about changing direction and get this response: "If I put my hands in the hoop, I can make the ball go the other way." Higher order questioning evaluating group decisions helped to drive student inquiry through play. Science talk among students motivated them to discover more and think deeper. After 15 minutes, students discovered that they could easily change the path of motion by applying a different strength or direction to their pushes or pulls. Students used the motion word *chart* to help them describe the results that they created within their workspace.

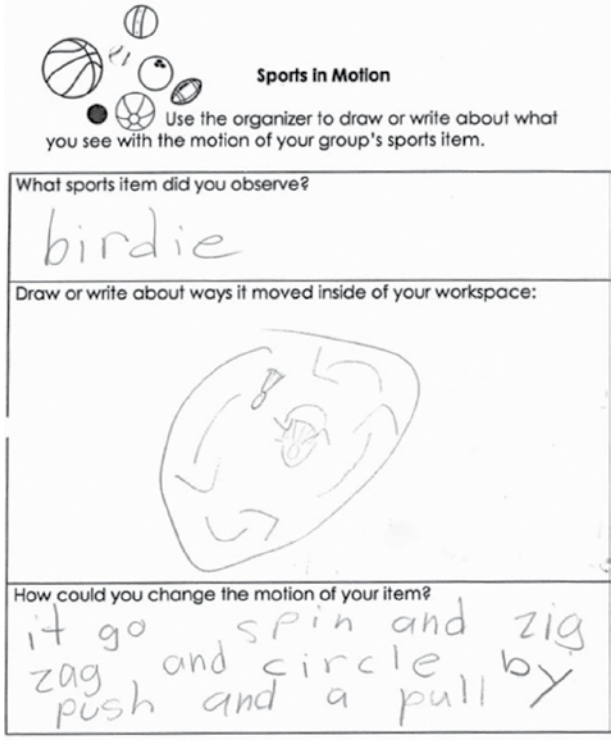
This part of the unit is very adaptable. If a teacher wishes to work collaboratively across grade levels, they could partner with an intermediate classroom. Older students could act as group leaders or scribes for kindergarteners needing assistance. The kindergarteners would still be responsible for the motion exploration and illustrating the results. Items of different sizes and shapes can be used to accommodate a wide range of fine motor skills and meet the needs of students with physical disabilities, and the hula hoop can easily be used on a desktop for students unable to work on the floor.

Differentiation for students ready for acceleration can be addressed by encouraging students to create a series of changes in motion with their item. Depending on the depth of understanding of motion, students could create storyboards or a detailed picture glossary with vocabulary labels and arrows to diagram their findings. Another option for differentiation would be to add a technology component such as a tablet to allow students to verbally record the motions.

Following their initial exploration, students confirmed their findings and expanded their understanding of the motion of objects as the teacher read aloud selected pages from *What Is Motion?* (Hyde 2014b, pp. 6–13). The selected portion of the text introduces concepts such as change in position, back and forth, and circular motion. As the terms are introduced in the texts, they are added to the motion words chart. Following the reading, the students shared ways that they experienced the specific type of motion from the text with their item. "The first time the birdie just fell, but when I spun it, it went in a circle." "The football spun too and went in a circle." "I had the basketball and when I pushed it really hard, it changed direction." Mrs. Willett then added, "Yes, that change of position is *motion*." That was the one statement that was teacher generated that was added to the word wall. Portions of the book *Pushing and Pulling* (Hyde 2014a, pp. 6–14, 18), along with the students' earlier observations, were used to help students define a push and a pull. After the reading was completed, the class worked together to create definitions. Because students experienced motion

FIGURE 1

Graphic organizer.



through the inquiry exploration prior to learning the vocabulary, there was a strong foundation of understanding as terms were introduced through the texts, such as, "Motion is what it is called when something moves and changes its position" and "You need a push or a pull to start motion." Misconceptions over the differences between words such as *push* and *pull* were alleviated because the teacher was able to relate the vocabulary to the experiential learning.

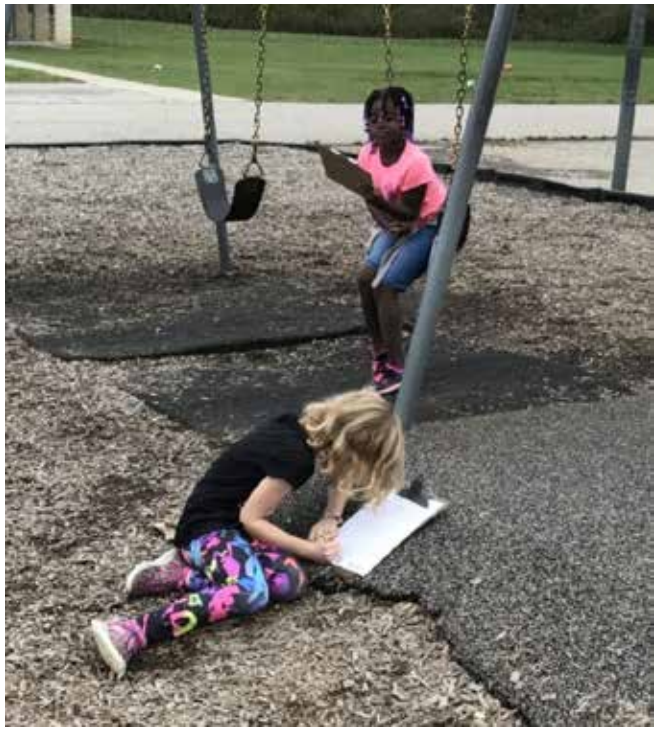
Assessing Student Understanding

Students worked in groups to create posters that illustrated for their classmates how to create specific types of motion with their sports items by using pushes and pulls. The children first talked about what they noticed. "The ball hit my hand and it came back. I want to make it go zigzag." Mrs. Willett responded with the question, "What made the ball come back?" "It hit my hand, but then it stopped." Mrs. Willett: "Is there anything you could try to keep the ball going?" One group member stated, "What if you pushed it back?" The students tried different techniques and settled on if you push the ball to your hand, push it back then back again, it will go zig zag. The groups produced visuals using simple diagrams. During instruction, the teacher noticed the children were having trouble showing motion in their pictures. She modeled the use of arrows to show motion of objects. Students then drew diagrams with arrows and used correct terms to describe the motion that they wanted their peers to create.

Once the posters were completed, they were set at the hula hoop workspaces and the class rotated through the various stations to recreate the motion described by their peers. The work done on the posters combined with the ability of peers to understand the directions allowed the teacher to assess each group's understanding of the motion of the objects. To use this activity as an assessment tool, the teacher observed the students as they read the directions and recreated the motion described on the poster, allowing for assessment of both the group who created the poster and the students recreating the motion. The teacher compiled detailed anecdotal notes throughout the unit, which included information regarding vocabulary use in conjunction with motion of the objects. A rubric was used as a final assessment of student understanding (see NSTA Connection).

Motion on the Playground

The culminating activity in this unit allowed students to explore their playground to find evidence of change in direction or change in speed on equipment that they typically use. Selected pages of the text *Stop and Go, Fast and Slow: Moving Objects in Different Ways* (Silverman 2012, pp. 4–9, 14–17) were used to expand on the idea that objects can move in different directions or with different speeds based on the type and size of the push or pull applied. Students were asked to reflect on examples of change in direction or speed in their earlier explorations. Mrs. Willett asked the students to think back on their original exploration and asked if any of the students would like to share new descriptions. "Mine went fast and then slowed down. It moved in a straight line because I pushed it." "Ours went in a circular motion because we pushed it." "We made ours spin, so it went in a circular motion. We only used pushes."



Above: **A student documents the motion of walking down stairs: "You push with your legs, but your arms help."** ***Right:*** **One child records as the other describes what she does to make the swing move.**

PHOTOS COURTESY OF THE AUTHORS

Students determine how to recreate motion of a ball using peer-created directions.

Students explore the motion of a football within their hula hoop work space.

Students then went out to the playground with a clipboard and a graphic organizer that included a list of motion words. They were instructed to investigate how differing interactions with pushes and pulls affected the motion of the playground equipment. The students were extremely engaged in this activity and despite the temptation to play on the equipment, they stayed on task and were thoughtful in their descriptions of the motion. Students investigated, among other things, how varying the strength of a push on a swing affected whether the swing moved fast or slow and how hitting a tetherball with different strengths affected the resulting motion. As the class explored the playground, the teacher met with small groups to present questions such as, "How are pushes and pulls used to move the playground equipment?" and, "How can items be made to move faster or slower?" Students were asked to demonstrate examples of the changes in motion utilizing the playground equipment based on their responses to the questioning. "Watch me! When I climb up the slide, I push off my foot and use my arms to pull me up. I'm using both!" "I like to swing. The harder I pump, the faster I go." Mrs. Willett asked, "What are you doing when you pump?" "I don't know." Mrs. Willett continued questioning, "What do you do first?" "I kick my legs out." "And that is (teacher pauses)." The child interrupted excited, "That is a push. And when I bring my legs back, I pull."

After they had time to think about how pushes and pulls affected the motion of the playground equipment, the students worked in groups to design and illustrate their own original playground. Students need to draw pieces of equipment or activities using five terms from the motion unit. This activity allowed for differentiation based on student ability. Students could be provided with images of playground equipment to cut and paste or images on a computer program to manipulate instead of drawing their ideas. To assess student understanding and ensure that the motion terms are clearly understood, conferencing with students to allow them time to explain their playground and encourage use of the five terms was an important final step of the unit. Taking the investigation out of the classroom and onto the playground provided students with an opportunity to apply what they had learned to a real-world situation.

The students were tasked to design their perfect motion playground. They could include any equipment or game area they wanted but were told to add motion words to describe how the objects on the playground moved. Students were encouraged to include at least five words. As Mrs. Willett walked around the classroom, she would question student understanding. Young students often can describe what is happening as opposed to writing the word. "Can you tell me about this piece of equipment? How does it move?" "I see children playing a game. What game are they playing? How are they playing it?" As one child described a soccer field, he was very descriptive. "I play soccer. I love soccer and it is motion. When you kick a ball, it moves. When you dribble the ball, it goes zigzag. See the arrows. When the goalie catches a ball to keep the other team from scoring, he pulls the ball in. When he kicks it away, he pushes it. My dad showed me tricks. He can kick it over his head. That is up and down. I don't need to have other stuff on my playground. It is all soccer." Another child drew swings and described pushes and pulls with how the swing moves. She added a slide and wrote "down." She used the word "up and down" to describe the ladder. She added a tetherball and wrote "circle." She drew a balance beam and wrote "zigzag."

Reflection

This unit was successful in teaching the basics of how varying pushes and pulls can cause different outcomes in motion

through play. Some prior knowledge was activated by using familiar objects in the investigations. This allowed students to be successful in exploration of motion and created opportunities to deepen their understanding of pushes and pulls. This was evidenced as students wanted to create a zigzag motion by hitting a tennis ball against the side of the hula hoop. During partner discussion this group was heard to say, "It is like the hula hoop is pushing the ball away. If we can keep pushing the ball on different sides, I bet we can make it go zig zag." As students observed their peers, they began to drive the inquiry process by questioning each other about different results.

They learned and applied new and existing motion words as they played on the playground during recess. It was demonstrated that through the use of inquiry experiences, student's own discoveries provided them the understanding of the changes in motion. They took ownership in the entire unit and connected their experiences with the nonfiction texts, student and teacher-based questioning, and new vocabulary. Students were able to retain information from this unit throughout the school year as other physical science concepts were taught. Any time a book was read that included any type of motion, the children would often interrupt and describe it as a push or pull and recall how they made things do that.

This unit was designed for five 30-minute periods connecting the concepts to the *NGSS* kindergarten standards for forces and interactions (K-PS2-1). Although some kindergarteners may need help with written work, through the use of the motion word chart, detailed student illustrations, and teacher conferencing with small groups during the activities, all students can find success through the experiential activities. Conversations, visuals, and written work enable the teacher to gather evidence of student understanding. The unit provides the teacher with flexibility to adjust the length of the activities to fit classroom needs. The unit design allows for spiraling back within the explorations to ensure all students understand motion. Though separate activities, students used the same words to describe higher-level skills. At first, the children moved the moved the equipment or on the equipment in a traditional way. Children were reminded of the balls and how as they investigated their motion, they found different ways to make them move. Mrs. Willett challenged them to do the same on the playground.

The content in this unit may seem daunting for young children, but our experience confirmed that young students come to elementary school with a wealth of background knowledge on motion. By allowing students to use their curiosity to explore the natural world around them, we, as educators, help them strengthen their foundations in scientific understanding and ways of thinking. So, the next time you are on the playground, encourage your students to think about the many types of motion around them. ●

REFERENCES

Bransford, J., and National Research Council. 2000. *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.

Duke, N.K. 2007. Let's look in a book: Using nonfiction reference materials with young children. *Young Children* 62 (3): 12–16.

Fries-Gaither, J., and T. Shiverdecker. 2013. *Inquiring scientists, inquiring readers: Using nonfiction to promote science literacy, grades 3–5*. Arlington, VA: NSTA Press.

Henniger, M.L. 1987. Learning mathematics and science through play. *Childhood Education* 63 (3): 167–171.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.

OECD (2016), PISA 2015 Results (Volume I): Excellence and Equity in Education, PISA, OECD Publishing, Paris. *http://dx.doi.org/10.1787/9789264266490-en*.

RESOURCES

Hyde, N. 2014a. *Pushing and pulling*. New York: Crabtree Publishing.

Hyde, N. 2014b. *What is motion?* New York: Crabtree Publishing.

Silverman, B. 2012. *Stop and go, fast and slow: Moving objects in different ways*. Vero Beach, FL: Rourke Educational Media.

NSTA Connection

Download the rubric at *www.nsta.org/1903*

Jodi Lemaster ***(jodilemaster@att.net)*** is a Program Manager with NFTI Science ***(www.nftiscience.com)*** at The Ohio State University in Columbus, Ohio. **Vicki Willett** ***(vwillett@lhschools.org)*** is a teacher and Presidential Award for Excellence in Mathematics and Science Teaching recipient at Licking Heights West Elementary, also in Columbus.

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

Standard

K-PS2-1 Motion and Stability: Forces and Interactions

www.nextgenscience.org/pe/k-ps2-1-motion-and-stability-forces-and-interactions

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practice	
Planning and Carrying Out Investigations	Students construct a labeled diagram of a playground, through drawing or using photographs, that has equipment using pushes and pulls.
Disciplinary Core Idea	
PS2.A: Forces and Motion Pushes and pulls can have different strengths and directions.	Students discover motion of objects through exploration of pushes, pulls, strength, and direction.
PS2.B: Types of Interactions When objects touch or collide, they push on one another and can change motion.	Students observe and record how pushes and collisions can change an objects motion or direction.
Crosscutting Concept	
Cause and Effect	Students perform simple tests to compare effects of different types of pushes or pulls on various sports objects

Connecting to the *Common Core State Standards* (NGAC and CCSSO 2010)

ELA/Literacy

CCSS.ELA-LITERACY.RI.K.1 With prompting and support, ask and answer questions about key details in a text.

CCSS.ELA-LITERACY.RI.K.4 With prompting and support, ask and answer questions about unknown words in a text.

CCSS.ELA-LITERACY.W.K.2 Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

CCSS.ELA-LITERACY.W.K.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Mathematics

CCSS.MATH.CONTENT.K.G.A.1 Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to.