



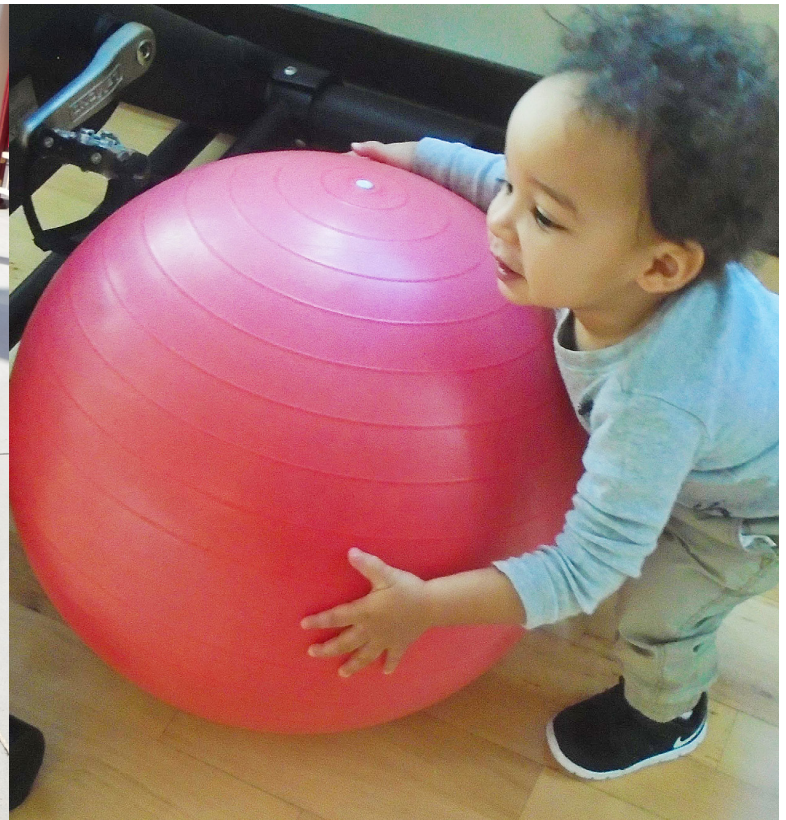
Beyond Bouncing the Ball

Toddlers and Teachers Investigate Physics

Eric Bucher and Marcos Hernández

These days, teachers no longer view themselves simply as purveyors of information who fill children with knowledge. The 21st century approach to thinking promotes the idea that early childhood professionals are not only teachers but also *learners*, discovering limitless possibilities *with* children (Curtis & Carter 2008). More and more, educators are seeing themselves as scientists in action—teacher researchers solving problems and improving practices as they, together with children, investigate the world, uncover new ideas, construct theories, and explore with curiosity. Educators’ dispositions for engaging in inquiry stemming from their interests and those of children are “considered a way of thinking and approaching knowledge ... a way of understanding oneself in relation to the world” (Edwards & Gandini 2015).

However, educators sometimes have anxiety—or even fear—of teaching and learning science concepts with young children, emerging, in part, from attitudes they adopted when they themselves were children. These internalized



perceptions of science are closely associated with how these concepts are taught (Rutherford & Ahlgren 1991). Consequently, some adults may feel uneasy about teaching and learning science.

Whether they have vast, little, or no science experience at all, teachers can avoid potential discomfort they associate with engaging in science if they view their practice as embarking on a mission of learning—one that is not about finding the right answer but about exploring many possible answers.

This approach of exploring possibilities is by no means a new one. It is at the heart of constructivist-based education and Reggio Emilia-inspired practice, approaches that have given rise to the term *teacher researcher*. This article highlights the journey of two teacher researchers who joined with the authors (who are early childhood job-embedded professional development facilitators, supporting professional learning alongside early childhood educators as they work with children) to explore a process of inquiry to strengthen their knowledge about children and about science. Guided by close observation and documentation of children and movement, the collaborators reflect on their experiences as a way of actively participating in a 21st century approach to teaching and learning science.

Early childhood science concepts and movement

Nevis Laboratories at Columbia University describes physics as the “study of matter and energy ... how matter and energy relate to each other, and how they affect each other over time and through space” (2016). Physicists, who study topics like properties of matter, motion, forces, and energy, investigate fundamental questions about the world, like why things change and what rules govern an object’s movement.

Supported by Piaget’s assertion that children’s physical knowledge is connected to their actions on objects and their observations of how objects respond to their actions, Kamii and DeVries (1993) suggest that an innovative, practice-oriented approach to teaching physics in preschool is warranted. Practice with the three fundamental activities key to physical science promotes children’s understanding of physics concepts: the movement of objects; the changes in objects, such as combining water, soap, and cornstarch to produce a bubble solution with different properties from the original ingredients; and activities between the two, such as using tools like light tables with translucent magnet tiles or sand and sieves to better understand the properties of the objects.

The team's study focused on understanding more about children as learners and the ways children comprehend physics in connection to the movement of objects. The movement of objects, simply put, involves actions that make objects move, such as pushing, pulling, rolling, blowing, throwing, swinging, dropping, kicking, or twirling materials (Kamii & DeVries 1993). Performing an action is fundamental to children's understanding. As children explore ways they can move their bodies and make objects move, they strengthen their knowledge about a variety of science concepts and figure out how and why objects move. Through this exploration, children construct logico-mathematical cognitive structures—that is to say, they formulate theories about the relationships among objects, such as thinking that all round objects bounce, and classify the similarities and differences in the properties of objects (Kamii & DeVries 1993).

When choosing materials and experiences to support children's construction of knowledge about the physical movement of objects, teachers can consider four criteria: the child must be able to produce a particular movement on her own; the child must be able to alter her actions; the reaction must be observable; and the reaction must be immediate (Kamii and DeVries 1993).

Teaching and learning science

These theories on physical science knowledge activities helped frame our study of children and movement. In order to begin our experience of teaching and learning in a more meaningful way, we intentionally constructed a set of seven steps to guide us on this journey—(1) Ask questions, (2) Collaborate with colleagues, (3) Structure a system for teaching and learning, (4) Offer materials to children, (5) Document experiences, (6) Reflect individually and with others, and (7) Sustain the process.

1. Ask questions

A study starts with a question. We wondered: What do children know about physics or movement? What will we discover about children and movement? How will we use these observations to inform our actions and interactions?

Reflecting on what we knew about toddler development as it pertains to motion and movement, we noticed that

moving and making things move was interesting and relevant to the children. Once toddlers master walking, their “motor skills grow by leaps and bounds” (Copple & Bredekamp 2009, 66). Soon they exhibit movement in a variety of ways: jumping, throwing and kicking a ball, moving a riding toy forward, pulling toys off a shelf, and carrying as many objects as they can hold from one place to another (Copple & Bredekamp 2009). As children move, they construct knowledge about physics concepts. For example, mobile infants may figure out how to move their bodies in new ways by crawling, rolling, and balancing. Toddlers may continue to knock down a block structure to test whether the outcome stays constant or varies. For children, physics is motion and movement. Thus, the idea to study children and movement became our focus. Our goal was to study and document toddlers' understandings of movement while we concurrently strengthened our own understanding of science concepts associated with movement. As we did this, we hoped to learn from and about the children and about ourselves as early childhood professionals.

2. Collaborate with colleagues

The educators recruited to participate in this journey, Sara and Izabella, work with children ages 1 to 2 years old at an NAEYC-accredited program attached to a corporate client in Phoenix, Arizona, which is focused on supporting children's growth, development, and needs by understanding and responding to children's interests.

Sara and Izabella, the teacher researchers on our team, committed their time and efforts to embarking on this journey. They were strongly supported by the director of the learning center, who actively participated in the research process and provided Sara and Izabella with compensated time during monthly staff meetings to meet with their coresearchers—Eric, a professional development facilitator with early childhood science experience, and Marcos, a professional development facilitator with experience in continuous assessment. Bringing together these diverse perspectives enriched the collaborative experience and enhanced the teacher researcher process of learning with and from each other as professionals. Further, during these meetings, the collaborators studied their observations of toddlers and planned possible avenues for future curriculum and material experiences for children.

3. Structure a system for teaching and learning

As we began our experience, we met together outside of the educators' time with children to reflect on our knowledge about toddlers and movement and to pinpoint behaviors that we associated with thinking like scientists. We took time to identify what we already knew about physical science concepts, what we wanted to know, and how we might go about studying and learning from children. During this time, we looked to resources from the Next Generation Science Standards, *National Geographic* magazine, and the journal *Young Children* to enhance our understandings of physical science concepts.

After our initial meeting we determined that scheduling consistent collaborative documentation study meetings over time was integral to sustaining the momentum of the study. In addition, Eric and Marcos regularly visited the teacher researchers at the center, providing a dependable job-embedded opportunity for the educators to check in and share their ideas and observations, challenges and successes between the collaborative meetings.

4. Offer materials to children

Knowing that balls lend themselves to different kinds of movement and practice with balls meets the four criteria for selecting movement of object activities, we decided to offer the children balls of various textures,

Resources for Studying Movement

Age	Developmentally appropriate materials	What adults and children can do together	Children's literature recommendations
Mobile infants and toddlers	Children's bodies within an open (gross motor) space	Provide spaces both indoors and outdoors where children can dance, twirl, toddle, scoot, balance, climb, slide, and engage in other large motor movements; play music with varying rhythms that promote movement, and dance together; offer a safe, engaging space where children can climb, slide, and take appropriate risks, such as balancing on a beam above a safe fall zone	<ul style="list-style-type: none"> ■ <i>Move</i>, by Elizabeth Verdick and Marjorie Lisovskis, 2013 ■ <i>A Ball for Daisy</i>, by Chris Raschka, 2011 ■ <i>From Head to Toe</i>, by Eric Carle, 1999 ■ <i>Baby Dance</i>, by Ann Taylor, 1998 ■ <i>My Very First Book of Motion</i>, by Eric Carle, 2007 ■ <i>One, Two, Three ... Crawl!</i>, by Carol Thompson, 2013
	Large textured balls	Pass the ball back and forth, varying movements; play indoors and outdoors; find materials a ball can roll down and up; use materials that change the path of the ball, like a wall or shelves	
	Sensory table/bin, water, cups, containers, and spoons (carefully supervise children around water)	Explore the water: pour, flow, splash, swirl, spoon, whisk, stir, fill, dump; talk about the properties of water (What does it feel like? How does it move?)	
	Scarves (opaque and translucent)	Dance to music; cover and uncover objects; twirl and twist; play peek-a-boo	
Children ages 3–5	Marbles, paper towel tubes and other recycled tubes, masking tape, and scissors	Construct systems to move the marble (systems can be attached to a wall or shelves)	<ul style="list-style-type: none"> ■ <i>Watch Me Throw the Ball!</i>, by Mo Willems, 2009 ■ <i>The Book With a Hole</i>, by Hervé Tullet, 2011 ■ <i>Mouse Paint/Pintura de Ratón</i>, by Ellen Stoll Walsh, [1995] 2006
	Sensory table/bin, water, funnels, hoses/tubes, containers, food coloring	Construct systems to move water through hoses/tubes; add food coloring and manipulate water to move through the system in different ways, like creating waves	
	Wooden blocks with grooves, unit blocks, cardboard blocks, round objects	Design and build ramps and pathways for round objects in the block center; invite children to sketch representations of their constructions	

from rubber to wood, and sizes—from balls easy for toddlers to grip with one hand to larger balls that require use of the whole body to hold. In addition to balls, educators can offer interesting recycled items such as Styrofoam balls and other round objects. (See “Resources for Studying Movement.”) We looked closely at how children moved with the balls. During our first few weeks of study, we provided the balls in the outdoor space and inside the toddler classroom. The teacher researchers observed that the toddlers were interested in testing movement with the initial offering of balls.

5. Document experiences

Documentation is instrumental in the teaching and learning process. It captures evidence of the children’s emerging understanding over time that teacher researchers can use to better understand and learn about children and themselves, to engage with families, and to intentionally plan meaningful experiences for children (Wein, Guyevskey, & Berdoussis 2011). Hilary Seitz suggests the power of documentation, noting that “when used effectively, consistently, and thoughtfully, documentation can also drive curriculum and collaboration in the early childhood classroom setting” (2008).

The teacher researchers used a composition journal to document their observations of toddlers’ interactions with balls as well as their own questions and curiosities. Sara explains the process she used: “During activities, I would try to have my notebook ready. I was not writing down large paragraphs, just a few bullet points, a note or two for myself. This came in handy, paired with a few pictures taken from the activity, for inputting documentation and tracking the child’s development.” As they recorded, the teacher researchers categorized their documentation in two columns: objective observations of children’s movement and their own interpretations and questions. The documentation process allowed the teacher researchers to illustrate, and later reflect on, their ideas and theories and generate new understandings—as was the case for Izabella, who suggests that educators should “first observe—find out what the children are currently intrigued by and build off of that. Observe as much as you teach.”

6. Reflect individually and with others

After carefully documenting their observations, Sara and Izabella used their science journals to self-reflect. They made inferences about children’s interests in the materials, posed questions to consider

Documentation of Toddlers and Balls Outside, From Izabella’s Science Journal

Observations	Inferences, questions, curiosities
James started carrying around multiple balls. He rolled them down the slide again, and one got lost. He asked, “Where’s my ball?” After searching for it, he found it and announced to us, “Found my ball!”	<p>James seems to have more exposure to balls than other children. He was the most interested, out of all the children, in the balls. He played with them the entire time we were outside!</p> <p>Why did James choose to roll the ball down the slide? What does that tell me about his understanding of the slope of the slide?</p> <p>Is James captivated by the texture or appearance? Or does he keep using the same ball because he is figuring out if he can make the same ball move in different ways?</p> <p>What questions can we ask James to support his investigation of balls and promote interesting vocabulary words?</p>



researching in the future, and drew attention to their curiosities. (See “Documentation of Toddlers and Balls Outside,” p. 21.) This internal contemplation helped the educators refine their observation skills and strengthen their identities as teacher researchers. When the teachers act like scientists in this way, they think like scientists. Teachers can support development of children’s intuitive science dispositions—behaviors such as observing, exploring, and discovering—and help children see themselves as capable and competent learners when they model and practice the teaching and learning behaviors associated with scientific research (NSTA 2014).

During the collaborative reflecting and revisiting process, the teacher researchers compiled their notes, observations, and photographs and met with the professional development facilitator partners to study the documentation together. They discussed what they learned about children’s movements, asked questions to better understand the children and movement, and created plans for future curriculum and materials experiences:

Sara: I wonder if the rest of the children would be more engaged with the balls if they were in a different environment. Have the balls been offered too much lately? Do the balls need to be rotated to obtain more interest? I wonder what would happen if I had the balls out in the open but didn’t bring attention to them. Would the children naturally be drawn to them? Would this give them a chance to discover the balls at their own pace and create their own conclusions?

Reflections and discussions about the observations and other data collected fueled the team’s curiosity and inspired Sara and Izabella to research further. They offered children the balls in baskets of different depths, set the balls in interesting hidden places around the room, and introduced children to exercise balls to seek answers to their questions. Curtis and Carter (2008) suggest that “when teachers work with curious, questioning minds ... as researchers alongside children, then new knowledge is always under construction”—a phenomenon demonstrated by Sara and Izabella’s experience (9).

7. Sustain the process

The teacher researcher journey is continuous and cycles through questioning, collaborating, exploring, documenting, reflecting, and retesting new theories.

This approach to teaching and learning is sustained when educators continue to see themselves and the children as scientific researchers—as Sara observes, “Children are naturally curious and love to discover—much like a researcher. I look at myself and the children as researchers. When I go into an experience with the children with the mindset of a researcher, the group, including myself, looks at things differently.”

Taking a teacher researcher perspective can help educators see both their teacher and learner roles as complex, dynamic, and evolving over time.

Challenges and failures

Part of 21st century teaching and learning is recognizing that challenges are a part of the learning experience and that failure, though sometimes disheartening, can provide rich opportunities for reflection. Sara addresses this aspect of their inquiry: “For me the biggest challenge was figuring out when to interact and help children problem-solve and when to let children discover for themselves. It was a tricky balance of knowing the children’s development and attention span. I wanted the activities to captivate children and help them discover.” Sara recommends that educators closely observing children should take a moment to self-reflect while participating in activities with them: “I enjoyed making new discoveries and connections with the children.”

Successes and challenges were also part of Izabella’s experience: “At the beginning, the children seemed very interested in collecting the balls and moving while holding them, and it was fun to see this interest transition into them figuring out how they could make the balls move with their bodies. “However, it was a challenge to keep coming up with new ways to keep the children interested in the materials. It was difficult to find a balance between using the balls and doing ball-related activities, and not using the balls. Toward the end, the children seemed to be uninterested in the materials.”

These challenges presented the teacher researchers with an opportunity to consider other possibilities and



plan for a new provocation to study movement with the children. Taking inspiration from the questions they generated during their reflection time, they decided to visit the on-site gymnasium and introduce giant exercise balls to the children's exploration of movement. The picture above shows Callie interacting with intentionally selected materials offered by the teacher researchers to test their theories about sustaining children's interests.

Learning to learn

The process of studying children and movement helped the educators discover not only the many strengths and capacities of the toddlers they serve, but also of themselves as lifelong learners. Sara and Izabella explain how their thinking about children has developed over the course of their study of children and movement:

Izabella: During this experience, I learned that children practice their scientific inquiry skills every single day. For example, they would find a ball, and throw it. When the ball was released, the children would study it as it moved. They watched as it bounced and rolled, and they realized that if they threw the ball a certain way, they could make it bounce and roll. Shortly after they figured this out, they could do it every time. Children learn so quickly! They are like little scientists with new hypotheses, discovering how to solve new problems

each day. When you observe children closely, you can see these processes in action.

Sara: I found that in the moments that I stepped back and observed their thinking process, I learned something new about the children. This is what excited me the most and sparked new discoveries of my own.

Connecting movement experiences to standards

Early experiences with forces—pushes and pulls—can support children as they construct conceptual understandings of science-related core ideas. Published in 2013, the Next Generation Science Standards are a flexible set of grade-level outcomes that help educators to support students to “develop an in-depth understanding of ... communication, collaboration, inquiry, problem solving ... that will serve them throughout their educational and professional lives” (NGSS 2013).

Although these standards are associated with K–12 education, exploration with movement of objects, such as the one described in this article, is a developmentally appropriate way to help younger children construct understandings of fundamental physics principles, creating a foundation for their later formal educational experience with, and understanding of, science. For toddlers, an understanding of physical science might be “I can make things happen with my body,” “When I make an action, there is a reaction,” “When I push, kick, or roll a ball, it moves in the opposite direction from me,” or “When a ball touches a barrier like a wall, it stops moving or changes direction.”

Improving the quality of practice

Participating as a teacher researcher can benefit educators by improving the quality of their practice. To create a comprehensive set of curriculum experiences, Kincheloe (2012) suggests that educators might consider the needs of the student, the community they are in, and disciplinary knowledge, including developmentally appropriate and culturally and linguistically responsive science, language and literacy, and mathematics. He asserts that the act of researching can help educators develop and implement a curriculum connected to the

unique interests and needs of children and the overall culture of their classrooms.

Continuous implementation and testing of new strategies based on careful observations, collaboration, reflection, and discussion can help educators assess children's capabilities and competencies. Teacher researchers can use their expanded knowledge to adapt curriculum experiences to best meet the children's interests and needs, much like the educators in this story did through their journey. This is supported by Copple and Bredekamp, who suggest that these adaptations are needed for educators to achieve the best fit for each child and to work to continually improve quality interactions and experiences (2009).

Conclusion

Through movement experiences, children can strengthen their ability to think more critically, solve real-world problems, and successfully transfer skills across domains through relevant and meaningful experiences (Byrnes 2008). In recent studies, these types of cognitive skills have been associated with the processes of learning, including self-regulation, reasoning, and motivation—skills attributed to success in school as well as in life (Tomasello, Striano, & Rochat 1999; Camilli et al. 2010).

When teacher researchers actively observe children's movement, document their observations, generate questions and ideas, and collaboratively reflect on their findings, they increase their awareness of children's competencies and teach themselves how to be learners. This journey is just beginning, and we look forward to learning more about children, movement, and ourselves as 21st century teacher researchers and teachers and learners of science.

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Authors' Note: The authors thank Bright Horizons early childhood program Lil' Paws and the two teacher researchers who collaborated with them.

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