Merging Motor and Cognitive Development: There's So Much to Learn While Being Physically Active!

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Abstract

Children develop many school readiness skills such as motor and cognitive skills during the preschool years. The development of these skills requires repeated opportunities to practice. Many preschool teachers may not be aware that motor development provides a foundation for cognitive development, and they may be unsure how they can support motor and cognitive development simultaneously for children in inclusive classes. The purpose of this article is to highlight motor and cognitive skills that develop during the preschool years, followed by ideas on how to merge Fundamental Motor Skills (FMS) and Basic Relational Concepts during large and small groups activities. Readers will learn new ways to implement lessons in their classroom that facilitate motor and cognitive development so that children can gain basic conceptual knowledge while also gaining important motor skills.

Keywords: *Basic relational concepts, cognition, disabilities, fundamental motor skills, motor skills, physical activity, preschool*

The preschool years are an important time for establishing physical activity habits and developing critical skills (Gerber, Wilks, & Erdie-Lalena, 2010). Preschoolers (between 3 and 5 years of age) demonstrate rapid growth and changes in neurodevelopmental and physical areas such as motor and cognitive skills (Gerber et al., 2010). Motor development and cognition are two of the five interrelated domains included in discussions about school readiness skills. These five domains are (1) physical health and motor development, (2) cognition and general knowledge, (3) approaches to learning, (4) language development, and (5) socioemotional development (Duncan et al., 2007; National Education Goals Panel, 1997). Skills within each of these domains are related to preschoolers' later academic performance. Among the interactions present across these five domains, there is now emergent evidence to support the bi-directional and reciprocal associations between motor and cognitive development for preschool age children (Cameron, Cottone, Murrah, & Grissmer, 2016; Sparrow, Cicchetti, & Balla, 2005; van der Fels et al., 2015; Wassenberg et al., 2005; Westendorp, Hartman, Houwen, Smith, & Visscher, 2011). This association means that the development of cognition does not occur in isolation but rather it is related to the development of motor skills. For example, researchers have noted that preschoolers who have the necessary fundamental motor skills (FMS) to participate in play and motor activities also have increased opportunities to develop pre-reading and pre-math skills (Iverson, 2010; Oja & Jürimäe, 2002). Thus, teachers can facilitate children's pre-academic outcomes if they simultaneously teach motor and cognitive skills within the preschool curriculum.

Barriers to Merging Motor and Cognitive Skills

Lack of confidence. Preschool teachers have reported inadequate professional development opportunities focused on motor development and/or physical education (Gehris, Gooze, & Whitaker, 2015; Hughes, Gooze, Finkelstein, & Whitaker, 2010). This has resulted in many teachers lacking confidence to implement structured motor programming (Hughes et al., 2010). Many preschool teachers have indicated that play and motor activities are the first activities that they eliminate when there is a need to alter their daily schedules (Favazza et al., 2013).

Lack of policy. Recent studies found that Belgium preschoolers had higher motor competence levels than U.S. preschoolers (Brian et al., 2018). Part of the reason for this is that physical education is included as part of the school curriculum in Belgium (Haerens et al., 2014). On the other hand, U.S. preschools generally believe that motor skills will develop as a result of free play and recess, thus instruction in physical education is not a standard part of the curriculum (Brian, Goodway, Logan, & Sutherland, 2017a, 2017b). A lack of policy requiring structured motor programming in U.S. preschools is therefore another barrier to promoting gross motor development.

Focus on academic outcomes. Across the U.S. there is increased pressure on preschool teachers to meet reading and math learning outcomes (Brian et al., 2017a), yet early childhood programs are often criticized for the fragmented or

isolated teaching of early literacy and early numeracy skills (Welchons & McIntyre, 2017). This "siloed" curricular design might not be meaningful or motivating for young children, especially for preschoolers with delays and disabilities (Welcons & McIntyre, 2017). Children might not be interested in learning content related to math and reading if they see these topics as difficult, and therefore positive outcomes might not be realized. In addition, some inclusive preschool programs are half-day sessions (Barnett, 1995; Currie, 2001), resulting in teachers feeling extremely challenged to focus on school readiness skills within this short period of time, especially when faced with a diverse group of children who have a range of abilities.

Many children with disabilities are less physically active (Pan, 2008) and demonstrate decreased participation in physical activities than their peers (Ng, Rintala, Tynjälä, Villberg, & Kannas, 2014) in inclusive classrooms. Teachers often struggle to engage students with disabilities in motor activities and to create active learning environments (Klavina & Block, 2008). Limited time in the school day, insufficient training on early motor development and physical education, and an increased demand to teach pre-academics has resulted in early childhood teachers looking for ideas on how to simultaneously teach motor and cognitive skills. Prior to offering suggestions for bringing these two domains together, a brief overview of motor and cognitive skills during the preschool years is needed. Therefore, the purpose of this article is to highlight motor and cognitive skills that develop during the preschool years, followed by ideas for merging FMS and Basic Relational Concepts in large and small group activities. It is our hope that after reading this paper readers will have some ideas for creating an engaging environment and providing meaningful opportunities for children to gain basic concept knowledge while also developing important motor skills.

What are FMS?

FMS are the building blocks for more complex motor skills developed during childhood (Payne & Issacs, 2016); they are associated with children's physical activity levels (U.S. Department of Health and Human Services [USDHHS], 2016). FMS are typically classified as object control (e.g., throwing, catching, kicking, rolling, striking) and locomotor skills (e.g., running, jumping, hopping, galloping). These skills are built on the child's stationary skills, which are the capacity to sustain control of the body within its center of gravity and retain equilibrium or balance (Haywood & Getchell 2009). FMS provide the foundation for more complex skills in physical activities or sports (Clark & Metcalfe, 2002). For example, to kick a ball a child must lift one foot off the ground and maintain balance while aligning the kicking foot with the ball. Initially a young child might hold a friend's hand or chair, to support his balance until he can balance independently (Gerber et al., 2010). Children need FMS to participate in sports (e.g., basketball) and games (e.g., playing tag).

Motor development. The World Health Organization Working Group on Infant Growth (WHO, 1994) identified six gross motor milestones that typically develop during infancy and the toddler years, including (1) sitting without support, (2) standing with assistance, (3) hands-and-knees crawling, (4) standing alone, (5) walking with assistance, and (6) walking alone. Typically, children should achieve these six milestones and be able to kick a ball, jump with two feet off the floor, and throw a big ball overhand at around 2 years of age (Onis, 2006). Achieving these six milestones provides the FMS for children's independent movement, thus enabling children to have the freedom to use their bodies to explore, manipulate, and learn from the environment. By the time children start preschool, they continue to learn and refine their FMS and perform multiple complex gross motor tasks simultaneously (such as pedaling, maintaining balance, and steering while on a bicycle). These FMS allow young children to explore and interact with the environment in increasingly complex ways to build their knowledge, thereby facilitating cognitive skills. Thus, FMS are related to how preschoolers engage with their environments, participate in activities and play, learn about their bodies and the space around them, and interact with peers (Favazza et al., 2013).

The preschool years serve as a critical window for children to learn and develop FMS, and these skills then provide increased opportunities for children to participate in typical early childhood activities, such as playing tag and hopscotch (MacDonald, Lord, & Ulrich, 2013). However, FMS may not develop naturally for *all* children. These skills may need to be systematically taught using direct and intentional instruction, practiced, and reinforced during structured physical activities (Goodway & Branta, 2003; Logan, Robinson, Wilson, & Lucas, 2011; Robinson & Goodway, 2009; Valentini & Rudisill, 2004).

The National Association for Sport and Physical Education (NASPE, 2010) recommends at least 60 minutes of structured and 60 minutes of unstructured physical activities daily in order to provide ample opportunities for motor development. These recommendations are supported by the Division for Early Childhood's Recommended Practices (DEC, 2014), which note that the need for educators to provide opportunities for physical activities is critical to improving young children's development and health-related fitness. To meet accreditation requirements, preschool teachers often provide about 30 minutes of unstructured physical activity (i.e., outdoor play or free play in a gym) each day. Although free play provides opportunities for children to engage in movement activities, it does not promote the learning of FMS (Gagen & Getchell, 2006). For example, a 4-year-old boy with autism spectrum disorder might hold a ball and run around the playground, but he may not know how to throw underhand or overhand without direct instruction. To help

preschoolers learn and practice FMS, planned movement activities that are developmentally and individually appropriate should be a routine part of the preschool curriculum. These movement activities should provide opportunities for every student to be engaged, and when carefully planned, other school readiness skills such as cognitive skills can be embedded within these activities.

What are Basic Relational Concepts?

Basic relational concepts represent space (e.g., top, bottom), quantity (e.g., smallest, largest), and time (e.g., before, after) (see Table 1). These concepts are considered the building blocks of critical thinking, problem-solving, learning, and instruction, which are related to cognition (Carroll, 1964; Flavell, 1970). Young children use these relational concepts to explain events, organize their experiences, and describe objects across contexts (Boehm, 2013; Steinbauer & Heller, 1978). Research has shown that when young children were taught basic relational concepts, they showed improvements not only in understanding these concepts but also on standardized achievement tests (Boehm, 2009, Piersel & McAndrews, 1982; Zhou & Boehm, 2001). Not surprisingly, the new Common Core State Standards include basic relational concepts as one of the learning goals in early childhood programs (Bracken & Crawford, 2010). For example, state standards include quantity concepts (i.e., more/less, whole/part, full/empty, some/many), knowledge of sizes and comparisons (i.e., big/small), two-dimensional sizes (i.e., tall/long), and relational concepts (i.e., top/bottom, near/far, above/below, next to, under/over, inside/outside, between, and together) (Bracken & Crawford, 2010).

Basic relational concepts are difficult for many children to grasp because they have no constant referent. For example, the tallest animal in one group may be shortest animal in another group (Boehm,1990; deVillers & deVilliers, 1978), or the longest straw in one group may be in the middle of another group of straws. In addition, basic relational concepts involve abstract thinking with words that address space, quantity, and time. Researchers have noted that preschoolers with disabilities and delays, and children at risk for academic failure often struggle to master spatial, temporal or quantitative relational concepts such as behind, inside, larger, before, or never (Zhou & Boehm, 2001). In general, children struggle to comprehend these concepts because they are related to abstract thought and the development of problem-solving skills (Boehm, 2009). Children's understanding in one context may not translate or generalize to a different context. For example, the terms "high and low" are used to describe a *position in space* and a *sound*. Basic concepts also represent positions that are reversible. Consider a ball that is placed on top of a box of toys. This ball can also be at the bottom of a different pile; the ball is separate from its position in space. Each of these examples can be very confusing to young children. For all of these reasons, basic concepts can be very challenging for some children to learn (see Table 2 for a list of concepts by age and level of difficulty). The following sections provide ideas for addressing FMS in the early childhood curriculum *while simultaneously* facilitating preschoolers' development of basic relational concepts within an already busy preschool day.

Table 1
Concepts by Category and Age Band

Concepts by Category for Children Ages 3-0 to 3-11			
Spatial	**Quantity**	**Time**	**Other**
Top	Empty	Finished	Missing
Down	Full	Before	Another
Under	All		Different
Highest	Smallest		Same
Next	Longest		
Up	Both		
Outside	Tallest		
Nearest	Many		
Across	Most		
In Front	Largest		
Around			
Concepts by Category for Children ages 4-0 to 5-11			
Space	**Quantity**	**Time**	**Other**
Nearest	Smallest	Finished	Different
Across	Longest	Before	Same
In Front	Both	After	
Around	Tallest	Beginning	
Before	Many	End	
Farthest	Most		
Lowest	Largest		
Last	Shortest		
Bottom	Some, but not many		
Together	Last		
Middle	Forward		
First	Backward		
Between			

Boehm, A. E. (2001). *Boehm Preschool Examiner's Manual*. San Antonio, TX: Pearson.

How can Teachers Merge FMS and Basic Relational Concepts?

Supporting FMS and basic relational concepts is important in early childhood classrooms as these skills are related to later academic performance. Early childhood teachers can and should play an important role in helping students learn FMS and basic relational concepts. Additionally, teachers can help students generalize their use of these skills across activities and events. During the preschool years, concept development is supported as children engage in a variety of activities such as counting, comparing quantities and shapes,

Table 2
Concepts in Order of Difficulty by Age Band- English (Standardization Sample)

	3-0 to 3-5	3-6 to 3-11	4-0 to 4-5	4-6 to 4-11	5-0 to 5-5	5-6 to 5-11
Least Difficult	Top	Under	Same	Nearest	Finished	Finished
	Another	Top	Both	Finished	Both	First
	Under	Finished	Finished	Both	Different	Middle
	Missing	Highest	Nearest	Tallest	Same	Many
	Highest	All	Tallest	Same	Bottom	Longest
	Finished	Empty	Largest	Many	Most	Bottom
	Nearest	Missing	Longest	Longest	Many	Same
	All	Down	Different	Largest	Longest	Tallest
	Up	Another	Many	Most	Largest	Both
	Empty	Tallest	Bottom	First	Tallest	Different
	Tallest	Both	First	Different	First	Nearest
	Both	Up	Smallest	Around	Nearest	Most
	Outside	Nearest	Around	Bottom	Smallest	Largest
	Down	Largest	Most	Smallest	Around	Around
	Largest	Outside	Before	Before	Middle	Lowest
	Different	Same	Across	Lowest	In front	Smallest
	Full	Many	In front	In front	Before	Together
	Same	Different	Middle	Middle	Lowest	In front
	Longest	Next	Together	Across	Together	Before
	In front	Longest	Lowest	Together	Across	Farthest
	Many	Full	Between	Some, but not many	Shortest	Last
	Across	Most	Farthest	Between	Farthest	Shortest
	Most	Smallest	Shortest	Shortest	Last	Across
	Smallest	Across	Some, but not many	Farthest	Between	Between
	Around	Around	Last	Last	Some, but not many	Some, but not many
Most Difficult	Next	In front	Least	Least	Least	Least

Boehm, A. E. (2001). *Boehm Preschool Examiner's Manual*. San Antonio, TX: Pearson.

sorting and classifying, and measuring. Similar to FMS, concept development does not occur without planned opportunities for young children to learn and practice these skills. A natural context for addressing relational concepts is during structured physical activities; as children are learning and practicing FMS, they also can learn size and quantity concepts simultaneously (i.e., the number of steps on the slide, which ball to choose to throw when prompted to select "the smaller ball"). Teachers can promote FMS and basic concept development by attending to the environment, their communication style, and how they merge these skills when instructing large and small groups of children.

Create a concept rich environment. Activities that foster children's physical and conceptual development have engaging physical features, such as numbered floor markers in circular and star shapes, various sizes of balls and bean bags, numeracy and literacy posters, and books that promote number and letter sense. Teachers can use features of these materials to teach basic concepts as children engage in physical activities. For example, a teacher might help children learn the concepts of *up, down, over,* and *under* while they toss balls back and forth with their peers or toss bean bags over/under a hurdle (thereby enhancing FMS, basic concepts of space, and social skills).

Teachers' communication style. While a "concept-rich" environment is important, it is only part of the equation. The quality and quantity of a teacher's talk can significantly promote children's concept knowledge (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; Presser, Clements, Ginsburg, & Ertle, 2015). Teacher talk can incorporate concepts of space (e.g., top and bottom, left and right), quantity (e.g., empty and full, smallest and largest), and time (e.g., before and after, beginning and end) thereby enabling students to describe their world using space, quantity, and time sequences. As children hear vocabulary throughout the day that focuses on concepts, they will begin to use these words more regularly during games and interactions with teachers and peers. Teachers also can use these vocabulary words to prompt children: *Place the large balls in the blue basket and the small balls in the white basket as you clean up. Let's have students wearing tennis shoes go before students who are wearing sandals as we gallop back inside.*

Group activities to facilitate basic relational concepts and FMS skills. For a large group activity with a class of 12 students, a teacher can arrange 14 numbered floor markers on the ground in a circle for the students, a teacher assistant (TA), and herself to practice locomotor skills (one component of FMS) and numbers. When the class walks into the gym, the teacher might ask all the girls to find a number between one and six and the boys to find a number between seven and 14. While the students are standing on the numbered floor markers, the teacher and TA might demonstrate

how to jog, jump, hop and gallop in place as well as the concepts of forward and backward as they move in a circle. In addition, the teacher might encourage her students to engage in specific motor behaviors when she calls out the numbers of their floor marker. For example, she might say, "If you are standing on number 1 or 2, jog in place; if you are on number 3 or 4, jump in place." Then, the class might start singing a song to the tune of the "Ants Go Marching" and began jogging forward: *The ants go JOGGING one by one Hoorah Hoorah! The ants go JOGGING one by one Hoorah Hoorah! The ants go JOGGING one by one. This is the way we have some fun, and we all go JOGGING on, and on, and on, and on.* The students and adults then jog around the circle following the floor markers as they repeat the song with jumping, hopping, and galloping. At the end of this activity, the students might walk backwards until they find their original number and they all sit down. In a large group activity such as this one, students not only have fun participating in a moderate to vigorous physical activity, they also have opportunities to learn several locomotor skills (jogging, jumping, hopping, and galloping) and basic concepts related to space (forward and backward), as well as the numbers 1-14.

With respect to the basic relational concept of time, a teacher might take a few moments to explain time sequences such as *before* and *after*, or *start* and *finish* prior to engaging in some motor activities. For example, once all the students are standing on numbered floor markers in a circle, a teacher might say, "*Before* we sing *The Ants Go Marching*, we are going to practice galloping." After the students sing the song to the tune of *The Ants Go Marching* and jog, jump, hop, and gallop, the teacher might ask, "Are we finished?" The students would reply, "We are finished." The teacher might also say, "*After* we finish this game, we are going to clean up." Therefore, during this large group activity students continue to practice FMS (i.e., jogging, jumping, hopping, and galloping) as well as gain exposure the basic concepts of start and finish, before and after.

Small group activities to facilitate basic concepts and FMS skills. During small group activities (e.g., six students in each of two groups), a teacher could create opportunities to help her students further develop FMS and their knowledge of basic concepts. For example, she might arrange two stations: the Snowman Throw and River Jump. These two stations would be created in such a way that students could practice object control, balance, and eye-hand coordination skills. Initially students would be placed in partners so that there are three sets of partners at each of the two stations. For the Snowman Throw, the teacher would prepare three snowman posters that include the quantity concepts of numbers, and she would tape the posters on the wall in a gym or other large room (see Figure 1). The teacher might ask her students to use an overhand throw to toss bean bags at the targeted snowman posters, retrieve the bean bags, and repeat. The teacher can address individual learning needs during this small group activity such as, "*Amy, throw the bean bag at the number between one and three--good job hitting the 2! John, throw the bean bag at the number five. Nice throwing!* A teacher might ask her students to throw the bean bags at the *largest and smallest* numbers on the snowman poster, or at the *top* and *bottom* buttons on the snowman's body. In this Snowman Throw activity, students can learn the FMS of overhand and underhand throw and several basic concepts related to space (i.e., largest and smallest, top and bottom).

Figure 1. Setup for the Snowman Throw

For the second station, a group of students can participate in the River Jump, in which stars are placed in an "S" shape on the floor, three cones (to represent alligators) are interspersed, and five floor-markers represent lily pads (see Figure 2). A teacher might model how to waddle like a duckling then, have children practice waddling. Next, the teacher could model waddling with a little egg placed under her wings (place one bean bag *under* each armpit) by holding her arms straight down at her sides like a penguin, to hold the beanbag in place. Leading the group through the River Jump, the teacher would waddle *between* the stars, walk *around* the cones to protect her "eggs" from the "alligators," place her eggs in the nest (a basket), and leap *onto* each floor marker ("lily pad") as she makes her way to the end of the course. At the end of the River Jump, the teacher would gather the group of students to count how many eggs they have in the nest and cheer to celebrate their success. During this activity students have opportuntities to imitate motor movements (i.e., waddle), use trunk control and their arms to hold onto beanbags, leap and balance. Concepts of space addressed in this activity include *under, between, over,* and *around*. The teacher might ask, "*Where do we place the "eggs" to carry them to the nest? Where do we walk when we are near the stars* (floormarkers)?" Additionally she might encourage her students to say the word *between* as they walk between the

stars. A teacher also might emphasize the concepts of space and time together. For example, she might say, "*Before* we walk *around* the alligators (i.e., cones), we will walk *between* the stars. *After* we walk around the alligators, we are going to leap *over* the lily pads." During these activities, students can be prompted to use relational concept words as they respond to the teacher and talk with their peers.

Figure 2. Setup for The River Jump

Conclusion

Children are unique and have different interests, strengths, and needs. Thus, it is important to plan activities that match children's interests and that can be adapted to their abilities. Children with disabilities or developmental delays might need a modified environment and additional support to develop specific skills. For example, to modify the learning environment, a teacher might change the size, weight, texture or color of bean bags, and adapt an activity into smaller, more manageable steps. By making such changes, all children can have access to classroom activities and can become fully engaged in physical activities, while learning relational concepts.

Early childhood is an important developmental period as preschoolers acquire motor skills and basic relational concepts. With intentional planning, educators can provide ample opportunities to support children in learning these skills simultaneously. Integrating these concepts into authentic motor activities makes them more concrete and fun. Even though structured motor activities may not be a common activity in a preschool teacher's lesson plans, motor activities embedded with relational concepts can easily be added to the daily curriculum. In this way, teachers can create an engaging environment and provide meaningful opportunities for young children to gain a deeper understanding of basic relational concepts while also developing important motor skills.

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