FEATURE

Easy ways to foster spatial reasoning

Austin, who's nearly 5, sits atop a triangle-shaped climber on the playground. His teacher, Ms. Leigh, stands close to his side, ready to help him maintain balance, if needed. About 100 feet away is a duplicate climber. For several days, Austin has run back and forth between the climbers and sat on the top of the triangles for much of his outdoor free play.

He looks at the duplicate climber in deep concentration. After several minutes, he turns toward Ms. Leigh, points at the duplicate climber, and says, "It looks smaller, but it's really the same."

Ms. Leigh asks, "So, both climbers are the same height, even though the one over there looks small?"

Austin nods.

"That's really interesting," says Ms. Leigh. "How did you figure that out?"

"I can climb tall on both of them," Austin says, climbing down.

"Which climber will look small if we stand by the other climber?" asks Ms. Leigh.

Austin runs to the other climber and points to the one he just left. "Now that one looks small, but it's still tall."

"The climber looks like it changes size, but it really doesn't," says Ms. Leigh. "Hooray! You figured out *perspective*. I have some books about perspective that we can read together. "

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Austin's discovery is an example of *spatial reasoning*, an umbrella term for cognitive abilities that enable us think in numerous and creative ways about real or imagined spaces, shapes, and objects (Farmer Kris 2015a; Newcombe and Frick 2010).

Despite the strong links between these abilities and daily activities as well as school success and career choice, spatial reasoning has been largely ignored in educational settings, including early care and education, until recently. Actually, some early education teachers may not have learned about the concept in their teacher education programs (Moss, Bruce, Caswell, Flynn, and Hawes 2017).

Examples of spatial reasoning

We can better understand the concept with specific examples related to teachers and young children.

Moving within and between settings engages multiple spatial abilities. For example, a walking field trip from school to the neighborhood grocery store is a spatial challenge for young children because it requires cognitive abilities that are still developing, such as:

- judging where their body is in relation to other objects and people in the environment,
- avoiding collisions with people and objects,
- determining if they can fit into or through an open space,

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- visualizing the pathway to take,
- distinguishing the pathway to take from the pathways *not* to take,
- estimating the distance from here to there, and
- picturing their destination (Newcombe and Frick 2010).

Inventing a new prop for the dramatic play corner involves spatial abilities, such as:

- visualizing the prop before creating it,
- imagining how the prop will look from different parts of the classroom,
- imagining how the prop would look if it was larger or smaller,
- rotating, mentally, the prop to reveal all aspects of its surface, and
- visualizing how the finished prop will look (Newcombe and Frick 2010).

Solving common spatial challenges in the classroom include the following:

- plotting incidences of cooperative play, aggression, dramatic play, or other behavior on a diagram of the classroom to identify possible relationships between the classroom environment and children's behavior,
- visualizing and then diagramming a room arrangement on graph paper prior to re-arranging the classroom furniture, materials and equipment,
- considering children's body size, average length of children's stride and arm reach when laying out an outdoor obstacle course,
- predicting the possible trajectories of balls when determining the amount of playground space to devote to a ball-toss game, and
- imagining potential areas where the teacher's view of the children might be obstructed while mentally visualizing a different arrangement of the moveable playground equipment.

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Why foster spatial reasoning?

Research offers significant evidence of the need for supporting children's developing understanding of spatial relationships—immediately and for the future.

Greater math competence. Research has found a powerful link between spatial reasoning and mathematics competence in students of all ages. Children who are more adept at spatial reasoning are better able to master basic math concepts (magnitude and counting, for example) in preschool as well as more complex concepts (word problems, algebra, calculus, and advanced mathematics) in middle school and beyond (Moss et al. 2017).

One research group (Wolfgang, Stannard, and Jones 2001), for example, found that 4-year-old children who created complex block structures representing a play theme (such as a castle, zoo, barnyard, space station) demonstrated greater knowledge of mathematics and achieved higher grades in both middle school (seventh grade) and high school.

When compared to peers who create basic block structures, complex block builders appear to practice spatial reasoning longer and more often. Their building strategies reflect in-depth spatial reasoning (Caldera, McDonald Culp, O'Brien, Truglio, Alvarez, and Huston 1999):

- They choose blocks with deliberation.
- They study placement, moving blocks around or returning them to the shelf.
- They rotate and flip blocks before placing them in a structure.
- They use more symmetrical placement.
- They integrate greater numbers of complex block shapes.
- They use greater innovation in placement.

Choice of career. Research has found a consistent predictive link between competency in spatial reasoning and the choice of a STEM career (science, technology, engineering, and mathematics) for both boys and girls. This link is due, in large part, to the foundational nature of spatial reasoning. That is, mastery of most subjects in school—math, art, geography, science, language, and physical education—is greatly aided by frequent practice of spatial reasoning (Moss et al. 2017).

In addition to the link to a STEM career, children's adeptness in spatial reasoning can predict their future creativity, innovation, and success in a STEM career (Farmer Kris February 2016; Moss et al. 2017). This is true for both boys and girls.

BUILDING STRATEGIES REFLECT IN-DEPTH SPATIAL REASONING.

Gender neutrality. Contrary to decades of previous thought, proficiency in spatial reasoning is not biologically determined. Proficiency is gained through experience and training (Moss et al. 2017).

This means there are no meaningful innate gender differences between girls' and boys' capacities for becoming proficient in spatial reasoning. Research supports this conclusion; gender differences are largely nonexistent during the preschool years when boys and girls play experiences are more similar (running, climbing, building with blocks, assembling puzzles, cutting art materials with scissors).

Gender differences become apparent during elementary school and beyond. These differences are related to varying experiences with materials and activities that foster spatial reasoning—specifically:

- Traditionally, boys are given materials and activities that boost spatial reasoning.
- Spatial toys are marketed primarily to boys.
- Boys are more often encouraged to play spatial games such as T-ball and soccer.
- Boys are more often allowed by their parents to explore their environment, regardless of how dirty they get (Farmer Kris February 2016).

How to support the development of spatial reasoning

Although educators disagree somewhat about when a child is first able to engage in spatial reasoning, they do agree about the numerous ways to foster spatial abilities in early childhood classrooms. Additionally, a child's proficiency in spatial reasoning is not lost after moving to higher levels. It can be applied to new experiences from elementary school through college (Newcombe and Frick 2010).

Most activities that encourage spatial reasoning are already familiar to young children and early childhood teachers. How well those activities further children's competence, however, depends on teachers' involvement. In other words, children will learn more when teachers, to the extent possible, do the activities with the children and use spatial vocabulary while doing them (Moss et al. 2017).

Activities

Teachers need little additional preparation time to provide young children with opportunities to enhance spatial reasoning skills, both indoors and outdoors.

Language

Starting with toddlers, use spatial vocabulary as you interact with children throughout the day. Here's a list of common spatial words from www.firstschoolyears.com:

aboard	at	next to
about	away	on
above	behind	onto
across	below	opposite
against	beneath	out
ahead	beside	outside
along	between	over
alongside	beyond	round
amid	by	through
amidst	close to	together
among	down	toward
amongst	in	under
apart	in between	underneath
around	inside	up
aside	into	within
astride	near	

Manipulatives

Take a fresh look at the manipulatives or table toy center. Encourage individual children to engage with put-together and take-apart materials such as puzzles, interlocking plastic blocks (LEGOS®), parquetry blocks, nesting toys, and sewing frames. Note how games such as lotto, checkers, cards, and board games encourage children to work together and manipulate objects in space.

Tangram, a seven-piece Chinese puzzle from ancient times, can be especially effective in enhancing spatial ability because, unlike jigsaw puzzles, it can be rearranged into many different shapes.

Blocks

Provide a full array of unit blocks, including blocks with complex shapes (arches, T-shapes, levers) and various lengths. Encourage children to build complex structures by describing the constructions with spatial words, and modeling how to add complexity to the structures.

Remember that household objects such as cardboard boxes, paper towel rolls, and Styrofoam packing shapes can be stacked and balanced into interesting structures.

As children play with blocks, suggest a problem to solve. Using animal figures, for example, you might say: "Those are ferocious looking animals. Can you build a zoo with fences and walls to keep them inside?"

Point out the boundaries of a space and what's occurring there. For example: "You've surrounded the plastic people with unit blocks. What are they doing? What is outside the space?"

Book or library center

Engage children with spatially oriented books, such as *Big Bug* by Henry Cole. This book, designed for children 2 to 6 years old, opens with a big ladybug spread over two pages. But the next page show the ladybug closer to its real size on a leaf.

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For a list of spatially oriented books, see *15 Picture Books That Support Children's Spatial Development Skills*, at ww2.kqed.org/mindshift/2015/12/18/15-picture-books-that-support-childrens-spatial-skills-development/.

Outdoors

Offer building materials such as large appliance boxes, scrap lumber, and bricks. Set up a tunnel or an obstacle course. Draw attention to spatial features. You might say, for example: "That wooden box is part of the obstacle course. Are you going to crawl through it? How can you find out if you're taller or the same size as the box?"

Encourage active exploration of familiar (classroom, playground) and unfamiliar (neighborhood grocery store) environments. You might say, for example: "How would you get inside this space? Are the store's windows the same size and shape as the windows in our room?"

Compare spaces and settings you encounter on a walk or other field trip with familiar spaces and settings. For example: "Let's stop walking for a moment and look at this school's playground. What is its shape? Is this playground the same shape as ours? What do you see on this playground that is like what we have on our playground? What's different about the two playgrounds?"

After school

When you care for children after school, you recognize their needs for a change of pace, a healthy snack, and perhaps a supportive environment for doing homework. But often children need stimulating activities and opportunities to delve into their interests.

Although TV, computer, and other screen time is best limited, you can allow 6- to 8-year-olds with occasional opportunities to pair up and play spatially challenging 3-D video games. One is Minecraft, a game about placing blocks and going on adventures. Research has found that playing action videos can help eliminate gender differences in spatial abilities (Farmer Kris February 2016).

For names and brief descriptions of nonviolent and challenging games, see the article by Raja, Caldwell and Connolly in the reference list below.

Map making

Another challenging activity for school-agers (5- to 8-year-olds) is map making. Producing a guide that enables someone to arrive at a desired location requires the mapmaker to:

- consider the perspective of the user,
- provide information that allows the user to orient himself or herself to the setting,
- indicate the correct pathway,
- include permanent landmarks, important cross-roads, and visible, accurate labels along the path-way, and
- add details that help the user to identify and stay on the correct pathway (Thommen, Avelar, Zhinden Sapin, Perrenoud, and Malatesta 2010).

One model for getting children started comes from Thommen et al. (2010).

1. Ask children to draw a freehand map of the route they take from home to school every day. Inform the children their map is to be used by a friend who wants to take the same route tomorrow. In other words, the friend will start at the child's house and follow the map to school.
2. Allow 30 to 60 minutes to complete the maps.
3. While children are engaged in another activity, move from one child to another, asking the child to tell you about the map. Write on the margin the child's description of the map, including any spatial words or indications of perspective. Label the map with the child's name and the date.
4. Save the maps and repeat the activity in two or three months. A comparison of the child's current map to the previous one can yield information about gains in spatial relations and perspective.

Look for the following features as you view them:

Maps of children 5 to 7 years old typically:

- indicate that children as young as 5 years old understand the task and can draw their way from home to school;
- reflect their egocentrism (Children tend to include elements that are meaningful to them, such as flowers and pets, but not very helpful to someone else.);
- represent a route as a line directly connecting the two places (home and school); and
- do not include permanent landmarks, such as buildings, or legends.

Maps of children 8 or 9 years old typically:

- reflect development in perspective-taking ability;
- include some elements that help with orientation and navigation by age 8, but these are often limited in quality, clarity, and quantity;
- include at least one stable landmark and at least one crossroad by age 8;
- are more complex, detailed, and accurate by age 9;
- are more helpful to the user because they more accurately represent routes; and
- include legends as well as more landmarks and crossroads by age 9.

References

Caldera, Yvonne M., Anne McDonald Culp, Marion O'Brien, Rosemarie T. Truglio, Mildred Alvarez, and Aletha C. Huston. 1999. Children's play preferences, construction play with blocks, and visual-spatial skills: Are they related? *International Journal of Behavioral Development*, 23, 855-872.

Farmer Kris, Deborah. December 2015a. Steps to Help Foster a Preschooler's Spatial Reasoning Skills, *Mind/Shift*, https://ww2.kqed.org/mindshift/2015/12/16/steps-to-help-foster-a-preschoolers-spatial-reasoning-skills/.

Farmer Kris, Deborah. December 2015b. 15 Picture Books That Support Children's Spatial Development Skills, *Mind/Shift*, https://ww2.kqed.org/mindshift/2015/12/18/15-picture-books-that-support-childrens-spatial-skills-development/.

Farmer Kris, Deborah. February 2016. Can Teaching Spatial Skills Help Bridge the STEM Gender Gap? *Mind/Shift*, https://ww2.kqed.org/mindshift/2016/02/22/can-teaching-spatial-skills-help-bridge-the-stem-gender-gap/.

Moss, Joan, Catherine D. Bruce, Bev Caswell, Tara Flynn, and Zachary Hawes. January 2017. Five Compelling Reasons for Teaching Spatial Reasoning to Young Children, *Mind/Shift*, https://ww2.kqed.org/mindshift/2017/01/20/five-compelling-reasons-to-teach-spatial-reasoning-to-young-children/.

Newcombe, Norma S., and Andrea Frick. 2010. Early education for spatial intelligence: Why, what, and how. *Mind, Brain and Education*, 4, 102-111.

Raja, Tasneem, Maggie Caldwell, and Matt Connolly. September 2013. 10 Nonviolent Video Games That Kick (Metaphorical) Butt, www.motherjones.com/media/2013/09/12-totally-kick-ass-violence-free-

video-games/.
Firstschoolyears.com. n.d. Spatial Prepositions, (free worksheets and resources for teachers, parents, and pupils), www.firstschoolyears.com/literacy/sentence/grammar/prepositions/resources/Spatial%20Prepositions%20word%20bank.pdf.
Thommen, Evelyne, Silvania Avelar, Veronique Zhinden Sapin, Silvia Perrenoud, and Dominique Malatesta. 2010. Mapping the journey from home to school: A study on children's representation of space. *International Research in Geographical and Environmental Education,* 19, 191-205.
Wolfgang, Charles H., Laura L. Stannard, and Ithel Jones. 2001. Block play performance among preschoolers as a predictor of later school activities. *Journal of Research in Childhood Education*, 15, 173-180. ■