Not All Preschool Math Games Are Created Equal

Sally Moomaw

"I need three hearts to fill my board."

"I have two cats, and you have two cats. We have the same!"

"You moved too far. That's not fair. You got four, but you moved five. See–one, two, three, four is here, and one, two, three, four, five is here."

These are the voices of preschool children engaged in math discussions. They are solving math problems, reasoning with their peers, and communicating mathematically. Their excitement about math comes from playing teacher-made math games—a routine part of their curriculum that artfully channels the children's play into math explorations.

Preschool teachers are math teachers

Preschool teachers are also math teachers who play a key role in children's mathematical development during the crucial early years. Longitudinal research indicates that children's math knowledge in preschool and kindergarten is a strong predictor of later mathematical success (Krajewski & Schneider 2009) and later overall academic success (Duncan et al. 2007).

Most early childhood educators are well aware that play is an important and natural mode of learning for young children (Trawick-Smith 2012). In keeping with this understanding, research shows that playing math board games increases young children's understanding of number concepts. The improvement is often particularly noticeable when children from lower socioeconomic environments are given opportunities to play math games because they may not have had this opportunity at home (Ramani & Siegler 2008; Whyte & Bull 2008).

Math games are clearly important. Yet, for too many teachers, an important piece of information about implementing those games has been missing. There are many different types of games—from counting games like Hi Ho Cherry-O to path games such as Chutes and Ladders—and teachers who have introduced these and other math games to their preschool classrooms have noted that the difficulty levels vary widely. Teachers may wonder, How do various types of games differ in difficulty? Which types of games are most appropriate for young children? How can teachers support children's math development to help them progress to more difficult types of games? Recent research offers teachers important guidelines for determining when to introduce various types of math games (Moomaw 2015).

Types of math games

This article focuses on four types of math games that have long been recommended for preschool and kindergarten classrooms: manipulative, grid, short-path, and long-path games (Kamii 2000; Moomaw 2011).

Manipulative games

Math manipulative games have two components: a die, a spinner, or cards with dots to represent small quantities; and small objects (counters) to represent these amounts. With each turn, children must solve a new math problem by creating a set of counters that equal the dots. Frequently, game play involves children comparing their results after each player takes a turn.

Children progress along a developmental trajectory leading to increased conceptual understanding of quantification when playing this type of game (Kamii 2000; Piaget 1952). At first, children create a group of counters that looks about the same as the number of dots, an approach referred to as *global approximation*. With experience, and sometimes through adult or peer modeling, children discover that they can match one counter with each dot. This important leap in thinking is called *one-to-one correspondence*. Eventually, children understand that when they count a group of objects, the last number word used represents the total amount of objects in the group). This concept is called *cardinality*. Children who understand cardinality use a counting strategy to determine the number of objects to take when playing a manipulative game. However, young children can be expected to make errors in counting until they understand that number words must be said in a particular order, and that one—and only one—number word must be applied to each object being counted (Gelman & Gallistel 1978).

Teachers can be creative in making a variety of math manipulative games. Along with a die, spinner, or cards to provide a new number for each turn, teachers could:

- Use a toy animal with a flat back as a base for balancing small cubes. They can determine how many blocks the animal can support before they all fall down.

- Create animal enclosures from small boxes and provide small toy animals to use as counters.
- Provide ice cube trays and interesting counters to fill each hole. This encourages one-to-one correspondence.

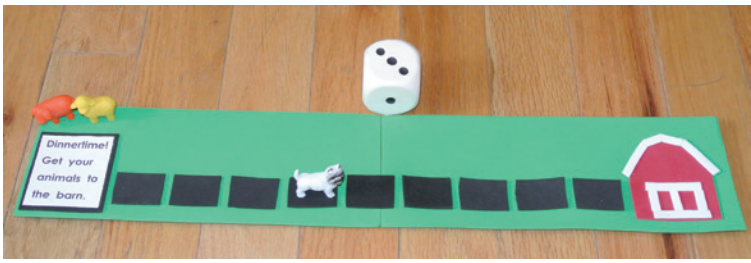
Grid games

Grid games are the easiest type of board games. Each player has a game board with rows of boxes or stickers forming a grid. While similar to some manipulative games, such as the ice cube game mentioned earlier, grid games have a flat surface. It is a bit more challenging for children to align one counter with each space on a flat grid board (one-to-one correspondence) than to insert an object into each box on an ice cube tray. Teachers may start with small grids, such as two rows of five spaces each, and slowly move up to five rows of five or six spaces each. Teachers who make grids themselves can customize them to engage individual children; one grid game might have children place frogs onto lily pads, while another might encourage children to collect one toy dog for each doghouse picture.

Short-path games

Path games consist of a game board with clearly defined spaces that form a path, a small object for each player to advance along the route, and a die, a spinner, or cards with dots to represent quantities. With each turn, children attempt to move as many spaces as dots, with the goal of reaching the end of the path.

Short-path games provide a transition between grid games and games with longer, more complex paths. In short-path games, each player has an individual board with one straight path limited to about 10 to 12 spaces. One example is of a short-path game in which farm animals move along spaces toward a barn. Teachers may notice that some children who counted when



playing manipulative or grid games revert to a matching (moving one space per dot) strategy when transitioning to path games. Unlike placing one toy frog on each lily pad in a grid game, moving along the spaces on a path does not leave a visible trail and thus is more abstract. This transition is important, though, because the path simulates a number line in which each space is one more than the previous space. Construction of the concept of a number line is critical to children understanding the number system.

Long-path games

Long-path games have one shared game board and a distinct object for each player to move along the path. Because long-path games have many more spaces (typically 25 to 40) than short-path games, children can roll two dice or draw two cards, which introduces the concept of addition to their gameplay.

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Teachers can use poster board to create this larger type of game. For a class that loves trains, the path could be a train track along which players move small engines of different colors. Another class might like to move toy pets along a path to a veterinary office. The beauty of teacher-made games is that they are inexpensive and can be tailored to meet the needs of specific groups of children.

The teacher's role

Teachers should have three goals in mind when they interact with children playing math games:

- **Assess the child's current understanding of quantification (global, one-to-one correspondence, or counting).** If the child counts, note any errors, such as counting an object more than once, skipping a space, or saying the number words in the wrong order.
- **Model a quantification strategy** that is just above the child's current thinking. If the child is at the counting level and makes an error, model accurate counting *when it is your turn*.
- **Support and encourage mathematical dialogue** so that children can express their thinking and listen to others do the same. This allows children to learn from each other and provides teachers with opportunities to better understand their current mathematical thinking.

The following two vignettes provide examples of how children may respond to various math games and how teachers can vary their responses based on the goals of assessing, modeling for, and supporting children.

> As Mr. Mike read a story to several children in his preschool class, he kept a careful eye on Sadie and Ben as they played a manipulative game nearby. Sadie had a bowl of toy camels, and Ben had a bowl of plastic turtles. They took turns rolling a die with one to four small stickers per side to determine how many animals to place in their habitats.
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> Sadie rolled first and correctly counted four dots on the die. Next, she counted four camels and put them into a box labeled "camels." Ben then rolled the die, which showed three dots. Each time he pointed to a dot, he placed one turtle into the habitat box labeled "turtles." As the children continued playing, Mr. Mike observed that Sadie again counted the dots on the die and selected a corresponding number of camels, while Ben continued at the one-to-one correspondence level by matching one turtle to each dot.

As Ben began his third turn, Sadie commented, "Why don't you just count the dots? It's faster."

Looking confused, Ben counted the dots on his die, but then matched one turtle to each dot. Mr. Mike realized that that although Ben could count the dots, he did not understand that the last number he counted represented the total, and that he could use this information to count an equivalent set of turtles.

At lunch later that day, Mr. Mike sat at Ben's table and modeled cardinality with the food items.

"I wonder how many carrots I have," Mr. Mike commented. "Let's see—one, two, three, four—I have four carrots. Let's all count our carrots and see how many we each have." From his earlier observation and assessment, Mr. Mike understood that Ben needed support in understanding cardinality, and that, through dialogue, he and the other children could provide models for using counting to find the total.

In the coming days, Mr. Mike planned multiple opportunities to model the use of counting to quantify items. He also noted that the zoo game was too easy for Sadie, because she had mastered cardinality with small quantities. To challenge her, he created a new version of the game that incorporated two dice so that Sadie and other more advanced children could work with larger numbers and begin to combine sets—a transition into addition.

Four-year-old Simon played a farm-themed short-path game with his teacher, Ms. Priya. On his first turn, Simon drew a card with three dots and moved his cow three spaces along the path. On his second turn, Simon drew a card with two dots. "I got two!" he exclaimed, but instead of moving forward two spaces, he said "one" while tapping the space on which the cow was already standing, and "two" as he moved it forward one space.

Ms. Priya noted that Simon's error—counting the space his cow already occupied (i.e., the last space he counted on his previous turn)—was one that other children in the class also made. On her next turn, Ms. Priya thought aloud to model for Simon: "My card has three dots. My donkey is already on this space, so I'm going to move him forward one, two, three spaces." She also tapped the donkey on each space as she moved it forward. Simon watched, but during each turn he continued to re-count the space his cow already occupied.

Wondering whether there might be another strategy to help children understand why they should move forward when they begin a new turn, Priya thought to herself: *I wonder if the children would re-count the space they were standing on if they used their bodies as the movers on a path made of carpet squares.*

The next day, Ms. Priya attached a poster of a barn to one wall of her classroom and created a path with the mats her class normally used for group time. "This time you get to be the animals in the game," she told the children.

The children took turns rolling a large foam die and hopping a corresponding number of spaces toward the barn. Ms. Priya observed that the children did not hop again on the mat they already occupied. After several weeks of play, many children had transferred this learning to the regular path game—they no longer re-counted a space from a previous turn.

When playing path games, children commonly make the counting error that Ms. Priya observed (Gelman & Galistel 1978; Moomaw & Hieronymus 2011). In fact, children in first grade often make the same error when they are introduced to adding on a number line (Moomaw 2011). For this reason, it is important to spend time helping children construct a solid understanding of counting along a path, which serves as a simulated number line. Ms. Priya understood that simply telling children not to re-count a space from a previous turn would not help them understand why this was a problem or progress in their understanding that when counting, each item or number along a number line is counted one and only one time. Knowing that this is a crucial concept, Ms. Priya persisted until she designed a game that better supported the children's learning.

Selecting math games

To develop the most effective curriculum, teachers must select or create math games that match the developmental levels of the children. Recent research indicates that preschoolers tend to find short-path games a little more difficult than grid games, and long-path games significantly harder than short-path games

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(Moomaw 2015). During the study, many children skipped or re-counted spaces on the long-path game, and one-third of the children moved in a random fashion along the path. The results suggested that the short-path game was more appropriate for children who were confused by the long path.

The following suggestions for teachers are based on both research and teacher-reported experiences.

Three-year-olds

Begin with simple math manipulative and grid games. They provide children with a concrete way to represent number. Start with small quantities, such as a die with one to three dots per side, which can be made with a one-inch cube and round stickers. As children progress, introduce a simple short-path game. Be prepared for some initial confusion. For example, children who move three spaces on their first turn may want to start from the beginning if they roll a two on their second turn, because moving forward two additional spaces looks like they moved five spaces (from the start) rather than two. Remind children that in this game, they get to move *forward*. The teacher might say, "Look, my animal is on this space. Now I get to move two *more* steps along the path."

Four-year-olds

Depending on children's previous experiences, teachers may begin by offering both grid games and short-path games. One study found that 4-year-old children do almost as well with short-path games as grid games (Moomaw 2015). As the year progresses, introduce a long-path game, first with one die and later with two dice, as children master larger quantities.

If the games are based on a common topic, children at various developmental levels can play games related to the topic.

Five-year-olds

Teachers can begin with grid and short-path games, but, depending on the children's responses, may soon introduce long-path games. There are usually developmental differences even in age-based classes, often due to the different opportunities children have had to learn about numbers and counting. Providing games of varying difficulty can accommodate this range. Many 5-year-old children begin to add by playing long-path games with two dice.

Mixed-age groups

Teachers of mixed-age groups may decide to use manipulative, grid, and path games. If the games are based on a common topic, such as ocean life, then children at various developmental levels can play games related to a popular topic in the classroom. Children should never be restricted from a particular game just because the teacher does not think they are ready for it. Rather, consider introducing them to a game that better supports their math development once they have finished with the game they selected.

Conclusion

The development of mathematical understanding is readily apparent when children participate in math games. Teachers can observe as children progress from global approximation to one-to-one correspondence to counting. As children begin to count, teachers can scaffold their attempts throughout the day, as Mr. Mike did when counting carrots. Teachers can also invent new games to develop children's thinking, as Ms. Priya did by having children play a life-size game using carpet squares.

As children play math games, they construct many mathematical relationships. Teachers can foster math discussions that make children's learning more explicit. For example, when children move three spaces and then two more spaces, they can see that they have moved five spaces altogether. Openly discussing this while the children are playing the game helps children develop a mental number line and begin to understand the operation of addition. Teachers can also support math discussions among children as they monitor their peers and check for errors, defend their own actions, carefully observe more advanced problem solvers, and compare sets to see who has more, less, or the same amount. With practice, children become mathematicians who uncover the knowledge and enjoyment of playing with numbers.

References

Duncan, G.J., C.J. Dowsett, A. Claessens, K. Magnuson, A.C. Huston, P. Klebanov, L.S. Pagani, L. Feinstein, M. Engel, J. Brooks-Gunn, H. Sexton, K. Duckworth, & C. Japel. 2007. "School Readiness and Later Achievement." *Developmental Psychology* 43 (6): 1428–46.

Gelman, R., & C.R. Gallistel. 1978. *The Child's Understanding of Number*. Cambridge, MA: Harvard University Press.

Kamii, C. 2000. *Young Children Reinvent Arithmetic: Implications of Piaget's Theory*. 2nd ed. New York: Teachers College Press.

Krajewski, K., & W. Schneider. 2009. "Early Development of Quantity to Number–Word Linkage as a Precursor of Mathematical School Achievement and Mathematical Difficulties: Findings from a Four-Year Longitudinal Study." *Learning and Instruction* 19 (6): 513–26.

Moomaw, S. 2011. *Teaching Mathematics in Early Childhood*. Baltimore, MD: Brookes.

Moomaw, S. 2015. "Assessing the Difficulty Level of Math Board Games for Young Children." *Journal of Research in Childhood Education* 29 (4): 1–18.

Moomaw S., & B. Hieronymus, 2011. *More Than Counting: Math Activities for Preschool and Kindergarten*. Standards ed. St. Paul, MN: Redleaf.

Piaget, J. 1952. *The Child's Conception of Number*. New York: Norton.

Ramani, G.B., & R.S. Siegler. 2008. "Promoting Broad and Stable Improvements in Low-Income Children's Numerical Knowledge Through Playing Number Board Games." *Child Development* 79 (2): 375–94.

Trawick-Smith, J. 2012. "Teacher–Child Play Interactions to Achieve Learning Outcomes in Preschool: Risks and Opportunities." In *Handbook of Early Education*, eds. R. Pianta, S. Barnett, L. Justice, & S. Sheridan, 259–77. New York: Guilford.

Whyte, J.C., & R. Bull. 2008. "Number Games, Magnitude Representation, and Basic Number Skills in Preschoolers." *Developmental Psychology* 44 (2): 588–96.

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