Encouraging Preschoolers' Emerging Mathematics Skills

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Young children today are entering rigorous primary school settings that emphasize accountability and standards. In mathematics particularly, kindergartners encounter more academic content than ever before. Further, studies show that early mathematics concepts—for example, knowledge of numbers and ordinality (that numbers can indicate the order of objects)—are strong predictors of later mathematics learning (Duncan et al. 2007; Ramani & Siegler 2008; Siegler & Ramani 2009). This means that attention to early mathematics is paramount. However, a study of preschool classrooms finds that mathematics is intentionally taught only 2.5 percent of the day (Stipek, Schoenfeld, & Gomby 2012). It is crucial that educators offer many math readiness opportunities that address each young child’s unique interests and needs and are grounded in developmentally appropriate practice.

This article gives teachers of preschool-age children (3–5 years old) ideas for mathematics activities and strategies for initiating mathematics discussions during play and everyday life. The activities focus on three mathematics content areas that promote children’s emerging math skills and future school success: (1) patterning, especially linear patterns; (2) counting and number sense; and (3) spatial awareness and block building. These three areas represent the big ideas in both the recommended preschool standards from the National Council of Teachers of Mathematics (2000) and the Common Core State Standards for Mathematics, which have been adopted in more than 48 states and US territories (CCSSI, n.d.). Math discussions that accompany the activities can be especially powerful in promoting mathematical understandings. We provide examples of math talk to use with children as they navigate through activities and through the day.

Supporting children’s mathematics through talk

Teachers can support children’s mathematical development by drawing explicit attention to the mathematics inherent in the activities children engage in. Through the use of discourse strategies such as narrating, asking open-ended questions, and revoicing, teachers can encourage children to reflect and help them to further develop their mathematical understandings. Teachers can use these strategies in almost any situation to draw children’s attention to the mathematical nature of everyday objects and activities, whether during play or during planned activities.
Narrating

Playing board games fosters mathematical understandings, as the next section, “Linear Patterns,” describes. One strategy for promoting understandings is to describe the action while interacting one-on-one with children. For example, a teacher might say to a Candy Land player, “Sarah, you picked a card with a yellow square, and then you moved your piece forward along all these colors till you reached this yellow spot on the board. Can you show me how you did that?” Or a teacher can ask an Uno Moo player, “Tashawn, when you saw the green chicken in the barn door, you decided to play the green cow. How did you know to do that?” Narrating the activity gives children a step-by-step replay of their actions, allowing them to reflect on their thinking and increase their ability to replicate the actions or adapt them for a future activity.

Asking open-ended questions

Another useful conversational strategy is to ask open-ended questions that encourage a child’s critical thinking about the activity at hand (again, Candy Land): “How did you know how far to go with your piece?” or “What color would be good for you to draw next? Why?” or “What color do you wish I would draw next? Why?” Open-ended questions encourage children to talk about their decision-making strategies in the game, allowing the teacher to better understand the children’s approaches to both context-specific and general problem solving.

Revoicing

In a classroom setting where teacher interactions are with a group rather than one-on-one, revocing is an effective strategy (Chapin, O’Connor, & Anderson 2009). When revocing, the teacher rephrases or summarizes aloud a child’s thinking to share it with the rest of the children. The intent of revocing is to ensure that all the children understand that child’s thinking. The teacher would then ask follow-up questions:

**Mr. T:** Abena, can you tell us about the dinosaur groups you made?

**Abena:** They are big and small.

**Mr. T:** So you are saying that this pile has dinosaurs that are big and this pile has dinosaurs that are small? (pause) What made you decide to put this dinosaur in the small pile?

**Abena:** It’s smaller than this big one here.

Linear patterns

Linear patterns are a core sequence of numbers, objects, motions, or sounds that repeat with a definitive pattern (for example, odd, even; red triangle, blue circle, red triangle, blue circle; clap, clap, stomp, clap, clap, stomp). They are not only a precursor to counting but also part of early algebraic reasoning. Identifying and creating linear patterns helps children engage in problem-solving as well. Research shows that creating and analyzing linear patterns encourages mathematical success as children progress from preschool to kindergarten and even first grade (LeFevre et al. 2010). Preschoolers can gain better understandings about patterns through teacher interactions when they play board games and participate in countless other engaging activities.

Patterning and board games

For preschool-age children, research finds positive relationships between playing numerical board games and numerical ability. Playing linear numerical board games (in which children select a card, roll a die, or spin a spinner, through the use of discourse strategies such as narrating, asking open-ended questions, and revocing, teachers can encourage children’s reflection and further develop their mathematical understandings.
and then move their piece a number of spaces along a game path) enhances both counting and number identification. In addition, these games increase children's understanding of the relational size of numbers (Ramani & Siegler 2006; Siegler & Ramani 2009). Whether played at home or in school, games like Candy Land, Uno Moo, and hopscotch encourage mathematical thinking by allowing children to create and represent patterns (for example, drawing and completing a hopscotch course), identify attributes in patterns (such as the colors in Candy Land or the colors or types of animals in Uno Moo), and examine relationships within patterns (if a Candy Land card shows two red squares, the player moves further along the board than if it had one red square). Children enjoy these games, and teachers can capitalize on this by offering multiple opportunities to play them and by talking with children while they play.

**Patterning and everyday objects and activities**

Teachers can initiate mathematical discussions about objects children encounter throughout the day. These objects could include the lids of containers, buttons used to create a design, or stones collected outdoors. Teachers may offer pattern or attribute blocks, which are specifically designed to encourage thinking about patterns. All of these materials have certain attributes that are similar (they are all buttons, they all have holes) and attributes that are different (some buttons are large, some are small; some lids are round, some are rectangular).

While play and exploration with such materials help develop mathematics understandings, intentionally asking children mathematical questions while they explore builds a deeper understanding of the characteristics of each set of objects. For example, Feng is playing in the dramatic play area where there are plastic pennies, nickels, and dimes stored in a jar. He dumps out the coins on the rug in the middle of the classroom and then moves his hands through the pile, exploring the different sizes. His teacher begins a discussion about these coins by first narrating Feng's actions—“Feng, I see that you poured all of the coins into one big pile on the carpet”—and then extending the conversation by asking open-ended questions: “How can you tell which type of coins you have in the pile?” “Is there any way that you can change the pile so that you can see which type of coins you have?” “How is this pile of coins different from this other pile of coins that you made?” “How are these two piles the same?”

**What Research Shows about Counting and Number Sense**

It may seem obvious that counting plays a significant role in future mathematics success. Indeed, research confirms what parents and teachers have believed for years: it is important for children to have plenty of counting practice as part of their school readiness experiences. Jordan and colleagues (2009) examine the relationship between early number competence and mathematics achievement from kindergarten through third grade. Examples for number competence include the ability to count, to make number comparisons, and to complete calculations. The study finds that high levels of early number competence have a positive impact on children's mathematics achievement in later years.

Similarly, in a three-year longitudinal study (age 5 through a mean age of 8 years and 8 months), Krajewski and Schneider (2009) examine the relationship between the roles of counting and understanding of quantity and mathematics achievement at the elementary level. The authors divided understanding of number into two levels. Level 1 consists of basic numerical skills, or understanding number and word sequences. Level 2 consists of linking number words with quantities, including the ability to compare quantities and understand cardinality—the idea that a quantity can be represented by a number. Their findings indicate that success with level 1 topics predicts success with level 2 topics, which in turn predicts mathematics achievement in fourth grade.

Because early math competencies and understandings predict mathematics achievement in the elementary grades, bolstering preschoolers' counting and other mathematical understandings is essential.
Teacher interactions encourage children's development of mathematical process skills. For example, teachers can ask predictive questions during everyday activities like setting the table: "How many plates do you think we will need for everyone to have one plate at lunchtime?" Many children approach counting with a one-by-one scenario, meaning they bring one plate to the table at a time rather than counting out a set and bringing them all to the table together. By inviting them to think about objects as sets rather than individual items, teachers can help children make connections to more advanced counting principles, like cardinality.

Some simple structured activities can effectively promote children's development of counting skills and number sense. One type involves patterns and pattern recognition. With smaller amounts, children often can tell "how many" before they are actually able to count. Young children learn to associate an amount with a recognized visual pattern on their fingers or in arrangements of objects. Teachers and adults can build on this knowledge by using familiar (and unfamiliar) patterns of dots on paper plates (see "Dot Plate

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Gelman and Gallistel's Principles of Counting

Gelman and Gallistel (1986) identify five principles of counting.

**Three how-to-count principles**

**One-to-one principle.** Children who exhibit the one-to-one principle when counting can separate objects into two sets: those they have counted and those they have not. As they count and move an object from one set to the other, they can tag each object in a one-to-one correspondence with a unique, designated word—commonly the number words that children memorize.

**Stable order principle.** Children display the stable order principle when they say the same number words, or tags, in the same order every time they count. Rote counting, simply reciting the number word sequence, is indicative of the stable order principle.

**Cardinality principle.** This last presupposes the other two principles. Children who demonstrate an understanding of cardinality (the idea that a quantity can be represented by a number) recognize that the last word used when counting indicates the number of objects in the set being counted.

**Two what-to-count principles**

**Abstraction principle.** This principle states that any collection of objects can be counted. Children recognize they can count sets of objects that are the same, like spoons in the drawer, as well as sets of objects that are not the same, like all silverware in the drawer—forks, knives, spoons, and so on. Eventually, children come to understand they can count nontangible things, like sounds, steps they take while climbing stairs, or even the number words themselves.

**Order-irrelevance principle.** Children who recognize that objects can be counted in any order as long as every object is counted once, and only once, display knowledge of the order-irrelevance principle.
Examples”), holding them up one at a time and asking children, “How many dots do you see?” and “What does the pattern look like?” It is important to use multiple arrangements of representations for each number, so that children become familiar with different patterns. For some of these patterns, children may have to count the dots to determine how many are on the plate—especially as the numbers increase.

Another way to help children develop number sense and counting is by asking them to compare quantities. For example, the teacher can display a dot plate for the number 5 and invite children to draw or use manipulatives (plastic counters, discs, cubes, dinosaurs, and such) to make one of the following: a set with fewer (less) objects than the dot plate, a set with the same number of objects as the dot plate, or a set with more objects than the dot plate. After children have created their sets, it is important to ask them to explain how they determined that their set has less than, the same as, or more than the target number. For children, verbalizing their thinking not only clarifies it in their own minds, as they are forced to reflect on their thinking, but also makes their ideas public for the other children in the group to consider.

Spatial awareness and block building

"Block building should be understood to be a part of the geometry curriculum that should not be missed by anyone" (Smith 2009, 195). Block building helps children develop spatial sense, understand how shapes fit together, and learn to decompose a whole object into smaller pieces.

Developing preschoolers’ spatial sense through block play helps build the foundation for later math success in the primary years and beyond (Hanline, Milton, & Phelps 2010). From a study examining the relationship between construction-type play with LEGOs and later school achievement, Wolfgang, Stannard, and Jones (2003) report similar findings about the positive predictive relationship between levels of preschool block play and middle school and high school mathematics achievement.

Block building

Early experiences with blocks include carrying, stacking, and moving blocks around. Children are often enthralled with building towers and watching them (or making them) fall. Using the strategy of narrating or asking open-ended questions about the observed actions introduces proxim-
Beyond shape-sorter toys

As children progress beyond shape-sorter toys, a next step is giving them many different two-dimensional shapes and asking them to sort them into piles of shapes that are the same. As mentioned in the patterning discussion, it is important to help children learn to recognize characteristics of shapes and understand what makes shapes similar and different. To support mathematical thinking in this area, narrating and questioning strategies are appropriate: "Can you show me another shape that is similar to this one?" or "I noticed you put all of these shapes together. Can you tell me why?" or "Where would this shape go in your pile?"

Conclusion

We hope this article sheds light on the many opportunities during teacher-led activities and informal play for supporting children's mathematics development and, in turn, their school readiness. Although these are just a sample of the types of activities useful in engaging children in mathematical thinking, remember that almost any activity young children engage in can be mathematical. The key is recognizing math activities' potential and capitalizing on it by talking with children as they play. Narrating, using open-ended questions, and revoking are universally helpful strategies for supporting the development of children's mathematical thinking.

References


